PHENOLOGY RESEARCH AND OBSERVATIONS OF SOUTHWEST ECOSYSTEMS SYMPOSIUM (PROSE)

U.S.A. National Phenology Network (USA-NPN) &
Southwest U.S. Region, American Society of Photogrammetry & Remote Sensing (SW-ASPRS)

October 1st, 2010
Santa Rita Room, Student Union Memorial Center, University of Arizona, Tucson, AZ

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KEYNOTE SPEAKER

DR. RAFE SAGARIN, ASSISTANT RESEARCH SCIENTIST, INSTITUTE OF THE ENVIRONMENT, UNIVERSITY OF ARIZONA: **OBSERVATIONAL ECOLOGY AND PHENOLOGY IN AN ERA OF GLOBAL CHANGE;** rafe@email.arizona.edu

Ecology has entered into an exciting period driven by both the urgency of large scale ecological problems and startling new ecological findings that are being shared broadly beyond the scientific community. Both of these factors are well represented by observational approaches to ecology that are reemerging after a long period of deference to manipulative experimental approaches. Observational ecology examines ecological patterns and processes using data gathered in situations where nature has not been purposefully manipulated. Observational ecology reflects on the work of early naturalists, but is greatly enhanced by technological advances in remote sensing, microscopy, genetics, animal-borne sensors and computing. Once dismissed as merely “exploratory”, observational ecology has demonstrated capability in scientifically testing hypotheses by correlating variables, comparing observed patterns to existing models, exploiting natural experiments, and simulating experiments within large data sets. It can often be used where experimental manipulations are not possible due to logistical or ethical constraints. Observational ecology can be used in a standalone fashion, but is strengthened when reconciled with experimental manipulations to isolate fine-scale ecological processes and modeling approaches to help define key hypotheses. Phenology and citizen science exemplify the new observational approaches to ecology in that they rely on local and traditional knowledge, can be built around simple observations of nature but enhanced with new technologies, and open the door to a much more inclusive science.

LUNCHEON SPEAKER

DR. GARY NABHAN, RESEARCH PROFESSOR / SOCIAL SCIENTIST, SOUTHWEST CENTER, UNIVERSITY OF ARIZONA: **CITIZEN SCIENCE, ETHNO-PHENOLOGY, AND CLIMATE CHANGE;** gpnabhan@email.arizona.edu

For some ecological phenomena, a handful of scientists' eyes and ears are insufficient to capture the data necessary to guide resource management decisions. The participation of citizen scientists, when properly oriented and engaged, provides an option that may work in some but not ecological settings. Their involvement may add more than data, including historic perspectives and alternative hypotheses to test the data against. In this brief discussion, I will highlight the Desert Alert and Migratory Pollinators citizen science efforts that I guided while still at the Arizona-Sonora Desert Museum in the 1990s, and the more recent Tumamoc Trekkers spring wildflower watch on Tumamoc Hill. While each effort was unique, comparisons might suggest some features of citizen science to embrace, and others to avoid.

ABSTRACTS OF PRESENTED PAPERS (LISTED ALPHABETICALLY BY FIRST AUTHOR)

PATTERN RECOGNITION FOR TIME SERIES ANALYSIS OF PHENOLOGICAL DATA

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Empirical Mode Decomposition (EMD) is an algorithm for time series analysis. The EMD puts no assumptions on the mathematical form of the data. The EMD mimics the human eye in looking for the peaks and valleys in time series, and in separating the higher and lower frequency components. Once separated, the frequency components can potentially be interpreted as responses to underlying cyclic environmental processes. The presentation will have two parts: A brief overview of the mathematics of the EMD, and examples from phenology. The examples will show a range of problems likely to be encountered in the analysis of phenological data. These include data sets that are partial, short, or noisy. The EMD can extract non linear trends. This allows the EMD to assist in deciding whether a phenological time series implies, for example, a trend toward early spring. A number of examples are constructed from data in the archive of the USA National Phenological Network (USANPN). These examples are chosen because they illustrate the mathematics of the EMD, and because they are likely to be of use in analyzing phenological data from the USANPN. Audience participants are encouraged to make suggestions for additional data for analysis. For lecture notes, documentation, and scripts, use the ftp site to retrieve ReadMe_PROSE. Follow instructions in the Read Me file. FTP site (Internal USGS): ftp://ftpint.usgs.gov/pub/wr/ca/menlo.park/rchampion/
FTP site (External USGS):ftp://ftpext.usgs.gov/pub/wr/ca/menlo.park/rchampion/

SUMMER MONSOONS DRIVE THE ONSET OF FLOWERING ACROSS SKY ISLANDS ELEVATION GRADIENTS

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Changes in plant and animal phenology have been explored across the globe in recent years as important indicators of ecosystem response under changing climate conditions. The focus of these studies has been almost exclusively on the spring and autumn seasons; studies exploring summer phenology are few in number. In the Sky Islands region of the southwestern USA, summer (July-September) may be the most appropriate season to investigate for understanding how the phenology may change into the future, as the majority of high-elevation plants flower in the summer. In addition, the mechanisms driving summer phenology at low elevations may be independent from those driving spring phenology. To better understand how flowering phenology of plants of Sky Islands may respond to changes in the summer monsoon season, we used a species-rich data set spanning 26 years to determine species relationships with precipitation and temperature for months coincident with summer flowering. Our data were collected across a 1200-m elevation gradient, allowing us to explore the consistency in relationships with climatic variables across a moisture gradient encompassing xeric desert scrub to mesic pine forest communities. Onset of summer flowering was heavily influenced by July precipitation, regardless of elevation or life form, demonstrating the critical importance of soil moisture to trigger summer flowering in this region. Summer temperatures for the southwestern USA are predicted to increase markedly in coming decades, though little is known about how summer precipitation patterns may change. A key implication of increasing temperatures is a decrease in available soil moisture. At all elevations, many species may be expected to flower later in the spring under the decreased soil moisture conditions associated with warmer temperatures. However, impacts on summer flowering may be greater at higher elevations, due to the greater sensitivity of mesic plants to water stress.

THE EFFECTS OF TEMPERATURE ON MUTUALIST ATTENDANCE IN AN ANT-PLANT INTERACTION

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Mutualism is often a complex interaction among multiple species, each of which may respond to temperature differently. We studied the thermal ecology of the mutualism between the fishhook barrel cactus, *Ferocactus wislizeni*, and its common ant defenders, asking (1) how temperature affects the frequency of ant attendance and (2) how temperature affects the interspecific distribution of ants on the plants. Plants tended by *Crematogaster opuntiae*, *Solenopsis aurea*, and *S. xyloni* have higher fruit-set than plants tended by *Forelius pruinosus*. We measured surface temperature and the number of ants foraging (a measure of partner effectiveness) on 12 plants, each occupied by a single ant species. We tested for an interspecific difference in thermal activity. To investigate the thermal tolerance of each ant species, we conducted critical thermal maximum experiments. Ant activity on the plant was significantly correlated with surface temperature, with a maximum peak in activity at moderate temperatures and a decline at colder and hotter temperatures. There was no evidence for an interspecific difference in temperature at maximum activity (ANOVA, $P = 0.3064$). There was a significant difference in the average temperature at which the ants were active (Tukey-Kramer HSD). There is an interspecific difference in the distribution of ants on plants in response to average plant temperature (ANOVA, $P < 0.0001$). *F. pruinosus* occupies hotter plants than *C. opuntiae* and *S. aurea*, but not *S. xyloni* (Tukey- Kramer HSD). These results may be sufficient to explain observed differences in ant attendance and the effect of temperature on partner effectiveness. Extremely little is known about the thermal ecology of species interactions; further research is essential to understand how they will respond to rising temperatures worldwide.

CROSSING THE AMERICAN SOUTHWEST: PHENOLOGICAL PATTERNS OF AVIAN MIGRATION AND STOPOVER HABITAT

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Avian migration phenology and plasticity of habitat use across large ecological-elevational gradients are poorly understood for Neotropical passerines, particularly in arid mountain regions of the southwestern United States. Migration patterns are closely linked with temporospatial factors such as regional plant phenology and distribution of dominant vegetation communities, factors highly responsive to climate change. The Madrean Archipelago in southern Arizona, USA, provides vital "stepping stones" for millions of migratory birds, linking migration corridors of the Sierra Madre Occidental with the Sierra Nevada and Rocky Mountains. We examined comparative 1) temporal abundance and 2) plasticity of habitat use of migratory birds during spring migration across an elevational gradient of five vegetation communities: montane conifer forest, pine-oak and oak woodland, mesquite, and lowland riparian forest, and 3) temporal and spatial correlations of bird and plant phenology. We surveyed 43 point-line transects across three mountain ranges and two rivers seven times between 1 March and 15 May in 2009 and

2010, which represented a dry and a wet year, respectively. Avian species exhibited a range of plasticity of habitat use, with low plasticity species primarily associated with high elevation forest and high plasticity species associated with riparian forest. In the wet year, peak migration of migrants was temporally coupled with peak flowering of plants, however we detected significantly lower numbers of many species, suggesting that migration was more spatially dispersed, with some birds taking alternate migration routes. In the dry year, peak migration was decoupled from peak flowering of plants, resulting in greater concentrations of birds in habitats with potentially lower quality. Montane and riparian forests are extremely vulnerable to climate change. Further decoupling of migration and plant phenology and degradation of stopover habitat may threaten the migration success and annual survival of many passerine bird species of western North America.

MONITORING IMPACTS OF TAMARIX LEAF BEETLES (*DIORHABDA ELONGATA*) ON THE LEAF PHENOLOGY AND WATER USE OF *TAMARIX* SPP. USING GROUND AND REMOTE SENSING METHODS

NAGLER, PAMELA L.[1], TIM BROWN, KEVIN R. HULTINE, CHARLES VAN RIPER III, DANIEL W. BEAN, R. SCOTT MURRAY, SUSANNA PEARLSTEIN, AND EDWARD P. GLENN

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Tamarix leaf beetles (*Diorhabda elongata*) have been released in several locations on western U.S. rivers to control the introduced shrub, *Tamarix ramosissima* and related species. As they are expanding widely throughout the region, information is needed on their impact on *Tamarix* leaf phenology and water use over multiple cycles of annual defoliation. We used networked digital cameras (phenocams) and ground surveys to monitor the defoliation process from 2008-2010 at multiple sites on the Dolores River, and MODIS satellite imagery from 2000 to 2009 to monitor leaf phenology and evapotranspiration (ET) at beetle release sites on the Dolores, Lower Colorado, Carson, Walker and Bighorn Rivers. Enhanced Vegetation Index (EVI) values for selected MODIS pixels were used to estimate green foliage density before and after beetle releases at each site. EVI values were transformed into estimates of ET using an empirical algorithm relating ET to EVI and potential ET (ET_o) at each site. Phenocam and ground observations show that beetle damage is temporary, and plants regenerate new leaves following an eight week defoliation period in summer. The original biocontrol model predicted that *Tamarix* mortality would reach 75-85% over several years of defoliation due to progressive weakening of the shrubs each year, but over the early stages of leaf beetle-*Tamarix* interactions studied here (3-8 years), our preliminary findings show actual reductions in EVI and ET of only 13-15% across sites due to the relatively brief period of defoliation and because not all plants at a site were defoliated. Also, baseline ET rates varied across sites but averaged only 329 mm yr^{-1} (23% of ET_o), constraining the possibilities for water salvage through biocontrol of *Tamarix*. The spatial and temperol resolution of MODIS imagery were too coarse to capture the details of the defoliation process, and high-resolution imagery or expanded phenocam networks are needed for future monitoring programs.

POST-FIRE EROSION AND IMPLICATIONS OF PHENOLOGY IN A COLD DESERT

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Wildfire frequency and duration have increased in recent decades as a function of climate change in the western USA. In northern cold desert regions of the USA there is an increasing prevalence

of large dust storms initiated on recently burned surfaces that otherwise experience very little erosion. In this presentation, I'll begin with background on regional scale interactions of phenology, hydrology, wildfire, and soil erosion, and discuss similarities and differences in these interactions for cold desert of the northern Great Basin in comparison to warm desert of the SW USA. I'll present my recent research at wildfires in cold desert sagebrush steppe that describes the role of vegetation and hydroclimate in controlling the timing and duration of erosion events. Results demonstrate that relatively small presence of vegetation and/or moisture was required to limit post-fire erosion events. The re-emergence of herbaceous and grass vegetation, and specifically whether it occurs immediately following wildfire or is delayed through the late-fall and winter dormant season, appears to be extremely important in controlling the magnitude and persistence of erosion events. This research sets the stage for future work to examine how changing climate and fire regimes might affect the length of time that soils remain bare following fire throughout cold desert of the western USA.

INTRODUCING THE USA NATIONAL PHENOLOGY NETWORK

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Introducing The USA National Phenology Network" is a 13 minute long documentary film which overviews the history, importance and purpose of phenology in the United States. The film introduces the relatively young USA National Phenology Network and entices viewers to become involved with the network.

CITIZEN SCIENCE IN SUPPORT OF VEGETATION INDEX AND PHENOLOGY RESEARCH

WHITSITT, SEAN[1], ARMANDO BARRETO, SUNDARESH RAM, HUSSAIN AL-HELAL, MARIBEL HUDSON, JONATHAN SPRINKLE, AND KAMEL DIDAN

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Vegetation indices (VIs) are simple transformations of images into proxy measures of greenness and vegetation health and change over time. They are also used to derive information about the land surface phenology status, providing extensive spatial coverage and direct support for global ecosystem models. These measurements however contain large uncertainties and errors. A new suite of mobile devices, equipped with geo-location, image capture, and transmission capabilities could aid with vegetation phenology observations and documentation. The iPhone, with its wide distribution and array of sensors, can contribute significantly to the field of citizen science. In this project we are developing an end-to-end system for the collection, processing, and visualization of land surface vegetation phenology. The system consists of a client-server application and a Google Earth based visualization model. The client side (an iPhone app) intuitively guides the observer to capture up to three images per location: a close-up image of leaves, flowers, or fruits, an individual plant image, and a panoramic landscape image. The iPhone automatically embeds location, orientation, date/time, and other metadata with the images and allows the observer to add text comments. The images are then transmitted to the server, where they are validated, post-processed, archived, and made available to the interactive visualization system. The images are separated into primary colors and processed into a greenness index comparable to the classical VI. These measurements are then plotted against satellite based VI time series to aid in their validation and the characterization of the location phenology. With this effort we hope to recruit global observers into contributing to the field of land surface vegetation change detection and characterization.

Abstracts of Presented Posters (listed alphabetically by first author)

PHENO-MET: Integrating Vegetation Phenology with Abiotic Drivers and Satellite-Based Signals of Greenness

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Challenges for vertical integration of plant- or field-based phenology and satellite-based measures remain; this is especially true for arid and semi-arid southwestern U.S. ecosystems due to high amounts of exposed bare soil, broad spatial extent, and inaccessibility of many areas. We set out to document phenological patterns of plant functional groups in an arid savanna ecosystem to (1) explore relationships between plant phenological events and abiotic or climatic drivers (e.g., precipitation, temperature, soil moisture) and (2) facilitate the link between field observations of phenological events to remotely sensed depictions of land surface phenology. Since 18 Mar 10, we have made 32 sets of weekly field observations at the Jornada Basin LTER in southern New Mexico for 93 individuals of 12 species across four research sites ranging from 1315 to 1410-m in elevation. We have observed that species-specific phenological events are generally synchronous with considerable variation across study sites. We are implementing NPN monitoring protocols for grasses, deciduous and broadleaf evergreen shrubs. In addition to weekly field observations, we are collecting hyper-spatial imagery from an unmanned aerial vehicle (UAV) system six times throughout the growing season. UAV imagery in conjunction with field surveys of vegetation cover will enhance our ability to quantify the species-specific contribution to vegetation greenness discernable with Landsat Thematic Mapper imagery. We present our conceptual approach to improve the linkages between field observations and remotely-sensed imagery as well as to understanding the abiotic triggers of plant phenological responses.

H85: Evapotranspiration: Modeling, Applications, Scaling, & Remote Sensing

Bunting, Daniel P.[1], Edward Glenn, Shirley A. Kurc, Russell L. Scott, and Pamela Nagler

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A common goal for water resource managers is to ensure long-term water sustainability for increasing human populations in the arid and semi-arid southwestern United States. In these areas, estimating evapotranspiration (ET) at watershed or river-reach scales is critical in determining an amount of water that can be apportioned for human needs (i.e. agriculture, municipal use) while still maintaining healthy riparian vegetation and wildlife. ET measurements are often made on local scales (< 1 km^2) that may not represent an entire watershed. Larger watershed scale estimates are necessary in decision making, but scaling up ET is often problematic in semi-arid regions. This is in part because pulse-type precipitation, typical in these areas, leads to pronounced spatial and temporal variability in both moisture availability and vegetation green up. Traditional methods of scaling up ET often do not account for this variability (e.g. crop coefficients do not account for seasonal variability and have often led to gross overestimates of ET losses). Incorporating this temporal and spatial variability is

critical for providing accurate estimates of ET losses. High-resolution satellite data is now available and provide spatially distributed remote sensing products (e.g. Normalized Difference Vegetation Index NDVI, Enhanced Vegetation Index EVI) that account for temporal and spatial variability in vegetation dynamics. These remote sensing products, in combination with micrometeorological data, can be used to create empirical models for improving ET estimates at larger scales. Using this approach, we estimated ET at five sites, chosen to represent a gradient in vegetation across the southwestern United States. We correlated Moderate Resolution Imaging Spectroradiometer (MODIS) EVI values to both MODIS nighttime surface temperatures (T_s) and flux tower ET. Our main objective is to use these strong relationships to create a unique empirical ET model for each vegetation type. Future research includes applying these empirical models to large river-reaches across the southwestern United States. Total annual ET can be estimated at river-reach or watershed scales provided that each region is classified appropriately and surface area is known. This approach is expected to improve accuracy of ET estimates at large scales.

NATURE'S NOTEBOOK: THE USA NATIONAL PHENOLOGY NETWORK'S PLANT AND ANIMAL OBSERVING PROGRAM

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The USA National Phenology Network (USA-NPN) brings together citizen scientists, government agencies, non-profit groups, educators and students of all ages to monitor the impacts of climate change on plants and animals in the United States. Phenology is the study of recurring plant and animal life cycle events such as leafing and flowering of plants, maturation of agricultural crops, emergence of insects, and migration of birds. Many of these events are sensitive to climatic variation and change and are simple to observe and record. Using standard observation protocols, participants in the USA-NPN monitoring program, Nature's Notebook, collect key information on plant and animal phenology. The USA-NPN also makes data visualization and decision support tools as well as education materials available to all. The network harnesses the power of people and the Internet to collect and share information, providing researchers and decision makers with far more data and information than they could collect alone. The USA-NPN is seeking participants in Nature's Notebook to monitor plant and animal species found across the United States. We are enthusiastic to collaborate with educators, researchers, citizen science networks, conservation groups, and individuals to expand our network of phenology observers. This poster will highlight resources available to individuals and organizations interested in cooperating with the USA-NPN and tracking plant and animal phenology.

IDENTIFYING VEGETATION LIFEFORMS IN THE SANTA CATALINA MOUNTAINS USING LIDAR AND MULTISPECTRAL DATA: PRELIMINARY RESULTS

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Phytophenology traditionally uses in-situ observations of individual plants, resulting in a limited understanding of the community composition. On the other hand, satellite-based land surface phenological observations generally provide community-wide timing and vegetation cover information. Synergistic use of LIDAR (light detection and ranging) and multispectral data can overcome this gap to characterize site-specific canopy cover and structural characteristics. Integrated analysis can provide high resolution three-dimensional modeling of the ecosystem across a large spatial extent. This project explores the applicability of using 1 m LIDAR and 1m multispectral National Agriculture Imagery Program (NAIP) data to identify plant lifeforms. Lifeform classification was performed for a series of ecosystems along a five-mile transect across a 4,158 ft (1,200 m) elevation gradient in a semi-arid ecoregion of the Santa Catalina Mountains near Tucson, Arizona, USA. A regression tree method classification was performed with the canopy closure and canopy height model (CHM) developed from LIDAR data and normalized difference vegetation index (NDVI) greenness values to identify four types of lifeforms: trees, shrubs, cactus, and grasses. We plan to assess the accuracy of these results with field observations. The multi-sensor approach and classification method can further inform land cover classification results and complement field based phenological observations with satellite based information about the abundance and presence of certain lifeforms.

CONTINUOUS MONITORING OF DYNAMIC PULSE-DRIVEN PHENOLOGICAL PHASES IN A SEMIARID SHRUBLAND

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An advanced onset of spring phenology has been well documented in the literature, generally citing increasing springtime temperatures as the primary cause. Importantly, a majority of these studies have been conducted in ecosystems where energy is the major limiting factor to growth. Lacking are studies in semiarid or arid ecosystems that cover over a third of the Earthâ€™s land surface, where water is the major limiting factor. Climate change will inevitably affect energy- and water-limited systems differently; therefore, understanding the mechanisms controlling phenology in both systems is imperative. Phenology in semiarid or arid ecosystems is particularly sensitive to precipitation inputs delivered as discrete pulses. Most of these precipitation events are small (e.g. < 5 mm), wetting only the top few centimeters of the soil and then quickly lost to evapotranspiration. Only rare large precipitation events (e.g. > 10 mm) are capable of wetting the root zone beyond the depth of evaporative demand and becoming available for plant phenological activity. Global climate models are generally predicting changes in the interannual variability of precipitation, with semiarid areas worldwide projected to experience changes in the timing, frequency, and magnitude of precipitation. If these changes impact timing and location of plant available water, what will be the effect on the phenological activity of these pulse-dominated ecosystems? The objective of this study is to understand triggers of phenological activity in an expansive shrubland ecosystem of the southwestern United States. We present results from three years of daily micro-meteorological and phenological data collected from a creosote-bush dominated shrubland site within the Santa Rita Experimental Range, southern Arizona. Our site is equipped with an eddy covariance tower providing estimates of ecosystem-scale water and carbon fluxes and associated m icro-meteorological variables including precipitation and soil moisture at multiple depths. Additionally, three phenology cameras (i.e. pheno-cams) distributed within the footprint of the eddy provide a daily record of phenology. We show that spring phenological events (flowering and green-up) are consistent and tend to be associated with an energy trigger, whereas summer phenological events (repeat flowering and repeat green-up) are more dependent on the timing and amount of monsoon precipitation. Additionally, our study demonstrates the high value in continuous monitoring of phenological events alongside micro-meteorological instruments.

REMOTE SENSING SHOWS RESTORATION TREATMENTS AFFECT POST-FIRE RESPONSES OF FORESTS IN THE JEMEZ MOUNTAINS, NEW MEXICO

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Wildfire events in the southwestern US have increased in severity and spatial extent in recent decades, modifying forest ecological processes and causing substantial economic losses. In this research we evaluated how vegetation communities respond to variation in forest wildfire severity, climate conditions, and pre-fire restoration treatments. We selected three wildfires that occurred in Bandelier National Monument (New Mexico) between 1999 and 2007 and three adjacent non-burned control areas. We used interannual trends in Normalized Difference Vegetation Index (NDVI) time series derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) as vegetation response variable, and topographic, climate and fire severity (LANDSAT based) data products as explanatory environmental variables. We applied parametric (ANOVA, T-tests, Multiple Linear Regressions- MLR) and non-parametric tests (Classification Regression Trees- CART), to assess the impact of environmental variables and restoration treatments on post-wildfire vegetation growth. From ANOVA analyses (t-test in one case), two out of our three cases present significant differences ($P < 0.05$) between control areas and non-treated post-fire sites when assessing differences in NDVI post-fire trend; control areas and pre-fire treated areas showed no significant differences ($P > 0.05$) . From MLR and CART results, we found that elevation and its derivates are significant drivers of post-fire vegetation trends. Our analyses for these three fires indicate that pre-fire restoration conditions (restored, non-restored) constitute key factors that modify post-fire vegetation trends, indicated by slower recovery rates of non-restored burned areas in comparison to restored burned areas, relative to the control areas as the baseline conditions. These findings also suggest that pre-fire restoration treatments contribute towards the mitigation of fire impacts, as these restored areas show trends similar to the control areas, but different behavior when compared to burned non pre-fire treated areas. Further research will be conducted by applying this framework to other fire events in the southwestern US.

LONG-TERM MONITORING OF THE SAGUARO CACTUS AT SAGUARO NATIONAL PARK

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The iconic cactus of the American Southwest and Saguaro National Park, the saguaro, has been monitored at the park since 1941. Saguaros are believed to be strong indicators of climate conditions because they are limited by winter freeze events. This poster presents preliminary results from the 2010 Saguaro Census at the park. This census, conducted every 10 years, provides data on the population structure and abundance of saguaros in the Tucson Mountain and Rincon Mountain districts of the park. Preliminary results of the 2010 census indicate that the population is continuing to grow in both districts of the park, with dramatic increases in some areas.

AERIAL PHOTO CLASSIFICATION FOR MONITORING THE SPREAD OF *ERAGROSTIS LEHMANNIANA* IN A SEMIARID ARIZONA GRASSLAND

SUGG, ZACHARY[1], SUSAN MORAN, CHRISTOPHER SCOTT, AND WILLEM VAN LEEUWEN
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Invasion by exotic grasses is a common threat to biodiversity in grassland ecosystems. Phenological variation can be a key consideration in efforts to characterize and monitor the spread of invasive grasses. This study investigated a transition from a vegetation assemblage historically dominated by diverse native grasses to a near-monoculture of non-native *Eragrostis lehmanniana* (Lehmann lovegrass) at the Kendall semiarid grassland site in the USDA-ARS Walnut Gulch Experimental Watershed in southeastern Arizona, USA following a multi-year drought. Supervised classification of a 1m aerial photograph of the Kendall site acquired in October 2009 was performed based on phenological differences in vegetation color, in addition to pattern and texture. Overall classification accuracy was 75%. In 2002, vegetation measurements showed no record of *E. lehmanniana* growing at the site, but image classification revealed that *E. lehmanniana* had become dominant in over 56% of the total land area of the scene in 2009. Classification revealed spatial variations not evident from transect measurements alone, including substantial areas previously dominated by native grasses that remained uncolonized by *E. lehmanniana*. Return visits to the site near the peak of the 2010 growing season revealed the presence of native grass species in uncolonized areas. The phenological traits of these species will have methodological implications for the appropriate timing of both transect measurements and aerial photo acquisition for achieving the different but closely related goals of characterizing the *E. lehmanniana* invasion and assessing the stability of native grasses.