UROC Undergraduate Research Opportunities Consortium

Abstract Review

August 2014

The University of Arizona
Graduate College

UROC

Undergraduate Research Opportunities Consortium

19th Annual Undergraduate Research Opportunities Consortium (UROC) Conference

Summer Research Institute
Minority Health Disparities (MHD)
Maximizing Access to Research Careers (MARC)
Hooked on Photonics
Integrated Optics for Undergraduate Native Americans
Biosphere 2 - Research Experience for Undergraduates
Biosphere 2 - Environmental Science Internship Program
Student Affairs Research Program
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CAT Vehicle / Electrical and Computer Engineering Research Experience for Undergraduates

Biosphere 2 - Research Experience for Undergraduates

Director: Mitchell Pavao-Zuckerman, PhD Co-Director: Katerina Dontsova, PhD

UA's Biosphere 2 facility is the site of this NSF funded Research Experiences for Undergraduates site for summer research experiences. By using a multidisciplinary approach (involving disciplines such as hydrology, geology, geochemistry, ecology, biology, physics, engineering, and atmospheric sciences) research teams focus on understanding how earth systems respond to environmental change. Open to freshmen, sophomores, and juniors.

Miranda Bandeli

Biosphere 2 - Research Experience for Undergraduates

Rutgers University

New Brunswick, New Jersey

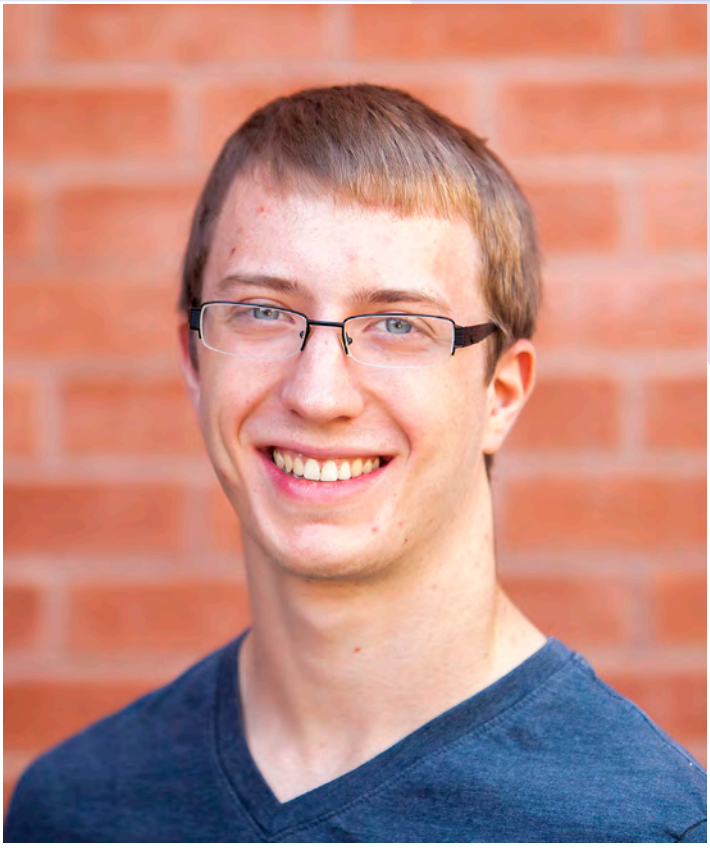
PI: Dr. Rafe Sagarin

How density impacts the effectiveness of hermit crabs as biocontrol within the Biosphere 2 Ocean

Abstract: With plans to redesign the Biosphere 2 Ocean habitat into a living model of the Gulf of California, a complete drainage of the ocean has been set to occur. The ocean is currently suffering from a massive overgrowth of algae and a significant amount needs to be removed before the draining begins. In order to do so, 5,000 red legged hermit crabs (Clibanarius digueti), a common species in the Sea of Cortez, were released into the ocean in the spring of 2014; however, after several months few changes were seen. One explanation for the lack of algal removal is that the density of crabs was too low for them to make any significant changes within the 2.6 M liter ocean. In order to test the hypothesis that density has an effect on the ability of hermit crabs to remove the algae, two experiments were created within the shallow end of the B2 Ocean. Considering the conditions of the B2 Ocean, each experiment reflected a different diversity of algae and the three treatment densities were calculated based on similar, smaller scale lab projects. Treatments included a control plot without any crabs, a low density plot with 20 crabs, and a high density plot with 80 crabs. After analyzing data collected over the course of the experiment, it is evident that there is a correlation between hermit crab density and the decrease in algal presence. The high density plots experienced a larger decrease in algae coverage than the low density plots.

Jonathan Barta

Biosphere 2 - Research Experience for Undergraduates



Whitworth University
Spokane, Washington

PI: Dr. Peter Troch

USING SULFUR HEXAFLUROIDE TO QUANTIFY THE GAS LEAKAGE RATE WITHIN THE LANDSCAPE EVOLUTION OBSERVATORY (LEO) AND THE DIFFUSION COEFFICIENT OF THE CRUSHED BASALT

Abstract: In order to understand the biological processes taking place on an experimental hillslope with vegetation, it is important to know the amount of gasses such as oxygen and carbon dioxide being produced and consumed. When studying the gas exchange rates in a closed system like the Landscape Evolution Observatory (LEO), one must take into account gas that is being lost or gained from other sources. Aside from biogeochemical processes, gas concentrations in the LEO atmosphere may change due to leakage to the outside environment and diffusion into the soil. To quantify these fluxes, two constants must be determined experimentally: the gas leakage constant L and the coefficient of diffusion for the hillslope soil. To accomplish this, a tracer gas, sulfur hexafluoride, was injected into the sealed east bay chamber and syringes were used to take samples periodically from the airspace and from the hillslope soil. The relative sulfur hexafluoride concentrations were then analyzed with a SRI 8610c gas chromatograph. By analyzing both the the airspace concentration decay as well as the concentration in the soil, the chamber's leakage constant was determined to be -2.35×10^(-5) s^(-1) and the soil diffusion coefficient was also determined. Once these values are experimentally quantified, they can be used in equations to quantify the rate of gas leakage and soil diffusion of more important gases such as carbon dioxide and oxygen.

Peter Ibsen

Biosphere 2 - Research Experience for Undergraduates

City College of San Francisco

San Francisco, California

PI: Dr. David Moore

LEAF REFLECTANCE IN GMO POPLAR TREES AS A FUNCTION OF TRANSPIRATION AND PHOTOSYNTHESIS.

Abstract: As temperature increases the photosynthetic potential of a leaf reaches an optimal level then quickly decreases due to heat stress. Leaves mitigate this heat stress through two physiological processes, two of which are transpiration and alteration of reflecting capabilities of chlorophyll. In observing these adjustments, one can ascertain when a plant, community or landscape is experiencing heat stress.

Using an experimental plantation of poplars, analysis was conducted on wild-type and genetically modified (GM) trees. The GM trees had the capacity to produce the compound isoprene, hypothesized to protect against heat stress, removed. One geneotype had GM process applied, but retained isoprene making capacity (empty-vector)

Physiological measurements were made with the Li-COR 6400 portable photosynthesis system. Leaf reflectance was determined by hyperspectrometer and analyzed with NDVI (R675 & NIR895), blue and red-edge wavelengths (495nm and 695nm). Leaf temperature was verified by FLIR camera and thermocouples with control defined by artificial leaf of similar size/color. Ambient conditions were measured by meteorological tower on-site.

NDVI was found to increase as photosynthesis decreased in wild-type trees, while positive correlations between photosynthesis and blue and red-edge wavelength appeared in each variety. Isoprene knock-outs exhibited inverse shifts in reflectance response compared with wild-type and empty-vector trees.

Measures of the relationship between reflectance, transpiration, and photosynthesis across isoprene and non-isoprene emiting trees will yield new insight into the role of isoprene as a modulator of heat stress. Furthermore, we are identifying new avenues for remote sensing of heat stress among varieties of individuals with varied biochemical capacities.

Natasha Krell

Biosphere 2 - Research Experience for Undergraduates

College of the Atlantic

Bar Harbor, Maine

PI: Dr. Shirley A. Papuga

Dynamic pulse-driven flowering phenology in a semiarid shrubland

Abstract: Elevated springtime temperature has been convincingly linked to an increasingly earlier onset of phenological activity. Studies highlighting this phenomenon have generally been conducted in ecosystems where energy is the primary limiting factor. Importantly, phenological studies in semiarid ecosystems where water is the major limiting factor are rare. In semiarid ecosystems, the timing of phenological activity is also highly sensitive to discrete moisture pulses from infrequent precipitation events. The objective of this study is to identify the triggers of flowering phenology in a semiarid creosotebush-dominated ecosystem. Creosotebush (Larrea tridentata) is a repeat-flowering evergreen shrub that is the dominant species in three of the North American deserts. We present results from five years of daily meteorological and phenological data collected within the Santa Rita Experimental Range, southern Arizona. Our site is equipped with an eddy covariance tower providing estimates of water and carbon fluxes and associated meteorological variables including precipitation and soil moisture at multiple depths. Additionally, three digital cameras distributed within the footprint of the eddy provide daily images of phenological activity. Our results highlight substantial interannual variability in flowering phenology, both in spring and summer flowering. We show that spring flowering activity tends be associated with energy triggers (e.g. temperature, growing degree days), whereas summer flowering activity tends to be associated with moisture triggers (e.g. large precipitation events, deep soil moisture). Our study suggests that changes in frequency and duration of precipitation events will impact timing of phenological activity resulting in important consequences for vegetation dynamics and pollinator behavior.

Katherine Kuklewicz

Biosphere 2 - Research Experience for Undergraduates

Skidmore College
Saratoga Springs, New York

PI: Dr. Craig Rasmussen

Soil organic carbon redistribution after forest fire using thermal analyses, Valles Caldera, New Mexico

Abstract: The frequency and severity of wildfire in western conifer forests is expected to increase with continued climate change induced warming and drying. The effects of wildfire on carbon cycle processes, and particularly surface soil organic matter composition and post fire erosive redistribution is poorly understood. The recent Thompson Ridge wildfire event in 2013 in the Valles Caldera, part of the Jemez-Catalina Critical Zone Observatory, provides the opportunity to track post-fire changes in surface soil organic matter composition over time relative to pre-fire conditions. Here we applied thermal analyses to quantify changes in surface soil organic matter composition, with a focus on charred materials, across a range of hillslope and convergent landscape positions. It was hypothesized that the fraction of charred material would increase post-burn in all surface soils, with a subsequent decline in hillslope positions and a gain in convergent positions as surface material was eroded and deposited in water gathering portions of the landscape. Our results confirmed that charcoal increased directly after the fire in all samples, but a clear signal of erosive redistribution was not observed, suggesting that the movement of charcoal throughout a landscape is more complex than the simple hypothesis put forward here. Future work will expand the spatial distribution of samples in a systematic fashion that better captures variation in topography and erosive versus depositional areas of the landscape.

Shanti Penprase

Biosphere 2 - Research Experience for Undergraduates

Carleton College
Northfield, Minnesota

PI: Dr. Jon Chorover

The effects of rock type and landscape position on solution chemistry of soils in the Biosphere 2 Desert Site of the Santa Catalina Mountains Critical Zone Observatory

Abstract: As near surface ground water moves through soil, it continuously interacts with surrounding rock and soil matter. However, how this water's chemistry fluctuates based on localized conditions such as rock type and landscape position is not fully understood. This study examined the role these two factors play in altering soil water chemistry by analyzing samples collected from schist and granite field sites within the Biosphere 2 Desert Site of the Santa Catalina Mountains Critical Zone Observatory. Each field site was situated along a Zero Order Basin (ZOB) and fitted with 7 Zero Tension Lysimeters (ZTL). Samples were collected following rainstorms from July 2011-July 2013. The granite site had 4 convergent zone and 3 divergent zone ZTLs while the schist site had 3 convergent and 4 divergent zone ZTLs. Each solution sample was analyzed for major anions, cations, pH, EC, and organic and inorganic carbon content. We hypothesized that soil water taken from the schist site would have higher solute concentrations than the granite site because schist weathers more easily. It was also hypothesized that soil water from convergent positions would have higher solute concentrations than those from divergent positions due to a longer flow path. Comparisons between Schist Convergent (SC) and Granite Convergent (GC) and Schist and Granite indicate data are consistent with these hypotheses for multiple elements. Results also indicate higher solute levels for Schist Convergent (SC) relative to Schist Divergent (SD). Thus, rock type and landscape position influence the chemical composition of soil water at these two sites.

Andrew Pfeiffer

Biosphere 2 - Research Experience for Undergraduates

Northwestern University

Evanston, Illinois

PI: Dr. Greg A. Barron-Gafford

Photosynthetic response of poplars to climatic stressors

Abstract: We examined the interacting effects of dominant climate stressors--vapor pressure deficit (VPD) and temperature--on photosynthesis. Specifically, we tested whether or not plant production of the terpene isoprene imparts heat and water-stress tolerance. Within an experimental common garden of poplars (Populus) at Biosphere 2, we measured four separate genetic lines - two that retained isoprene production capacity and two that had this gene "knocked out". VPD was altered at temperatures of 30, 35, and 40C to present both heat and aridity stresses. Maximum photosynthetic capacity (Amax), the VPD at which Amax occurred (VPDopt), and the VPD range between Amax and ninety percent of Amax (Ω90) were calculated to quantify how VPD differentially affected the lines. Amax was significantly lower in knockout lines than in control lines. Moreover, the difference in Amax between lines increased from 19.3% at 30C to 28.4% at 35C to 39.0% at 40C, indicating that trees without isoprene production are less equipped to handle hot and dry conditions. Ω90 and VPDopt response were not the same, though. Isoprene knockouts had significantly higher VPD optimums (1.9749 vs. 1.6451 kPa) compared to isoprene-producing lines. Although maximum photosynthesis is diminished without isoprene production under water and heat stress, isoprene knockout lines were still fairly active at a high VPD and under a wide range of VPD conditions. Beyond advancing our basic understanding of plant ecophysiology, these results will inform the potential use of poplars as a source of biofuel production across a range of current and projected climate conditions.

Alma R. Provencio

Biosphere 2 - Research Experience for Undergraduates

Villanova University

Villanova, Pennsylvania

PI: Dr. David Breshears

Shifts in energy balance resulting from pinyon tree die-off in New Mexico can influence weather patterns?

Abstract: Recent modelling studies have suggested a correlation between afforestation in North America and decreased precipitation in the Amazon forests of Brazil. This decrease in precipitation could negatively influence plant biodiversity; the results of these models could have important implications and therefore, more studies are needed to validate these results. In this research we hypothesized that tree die-off might also have adverse effects on energy balance and subsequent climate. We measured near ground air temperature, near ground relative humidity with small data logging weather stations and net radiation with a two component net radiometer in three experimental plots near Albuquerque, New Mexico. These plots included trees that died recently of natural causes, trees that were girdled (i.e. killed by removing bark from around the tree base), and trees that remain alive. Preliminary results suggest that near ground temperature and relative humidity differ across these three experimental plots. More importantly, results indicate changes in the energy balance across these plots. These findings suggest that near ground microclimate can be affected by changes in tree density and spatial patterns and such changes can lead to alterations in the balance of energy. Although this study is small in scale and focuses on Pinyon pine woodlands in New Mexico we believe that large scale tree die-off, predicted to occur as climate warms, could cause adverse effects on forests in other parts of the world such as the Amazon rain forests of Brazil.

Chelsea Stern

Biosphere 2 - Research Experience for Undergraduates

State University of New York

Albany, New York

PI: Dr. Mitchell Pavao-Zuckerman

RAIN BASIN DESIGN IMPLICATION ON SOIL MICROBIAL ACTIVITY AND N-MINERALIZATION IN A SEMI-ARID ENVIRONMENT

Abstract: Rain basins have been an increasingly popular Green Infrastructure (GI) solution to the redistribution of water flow caused by urbanization. This study was conducted to examine how different approaches to mulching (gravel vs. compost and gravel) influence the water availability of rain basins and the effects this has on the soil microbial activity of the basins. Soil microbes are a driving force of the biogeochemical process: N-mineralization, which influences the ability of a basin to retain nitrogen. In this study we sampled 12 different rain basins, differing in design, at Biosphere 2, Arizona. Samples were collected pre- and post- monsoon to determine how the design of basins mediates the transition from dry to wet conditions. Soil abiotic factors were measured, such as moisture content, soil organic matter (SOM), texture and pH, and were related to the microbial biomass size within the basins. Field and potential N-mineralization were measured to determine if the basins were leaking or retaining nitrogen. We found that pre-monsoon basins with compost had higher moisture contents and that there was a positive correlation between the moisture content and the soil microbial biomass size of the basins. Pre-monsoon data also suggests that N-mineralization rates for basins with compost were higher than those with only gravel. Post-monsoon samples are currently being run to determine if this pattern continues for soil with higher moisture contents.

Valentina Vavages

Biosphere 2 - Research Experience for Undergraduates

Tohono O'odham Community College

Sells, Arizona

PI: Dr. Katerina Dontsova

Effects of Mycorrhizae on Root Architecture

Abstract: Mycorrhizae are fungi that are naturally in the soil. This beneficial fungus has been helping plants for at least 500 million years. Since the beginning with symbiosis the presence of mycorrhizal fungus in plants have sustained its ability to withdraw nutrients and store water in stressful soil conditions. This type of relationship has generated a second root system for plants and in return the fungi receive carbon and sugars transferred from the plant. This is particularly relevant in fresh mineral substrates where plants have to cope with low nutrient levels. An experiment was set up to determine the influence of mycorrhizae on root architecture in fresh mineral substrates and in a number of root architecture measurements of grass infected and not infected with arbuscular mycorrhizae grown in basalt and rhyolite. Using the image analysis software WinRHIZO 2009, I was able to calculate the total root length, surface area, average diameter, root volume, number of tips and branching angle. Results for the grass roots with mycorrhizae compared to non-mycorrhizal treatment show a small increase in the length, length per volume, number of links, and surface area of the roots. However, measured differences in six variables between mycorrhizal and non-mycorrhizal treatments were not statistically significant. In contrast with past data I have concluded that although mycorrhizae is an all-natural fungi that may benefit plants the possibility of greater effects depends on the environment in which they are growing.

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SUMMER RESEARCH INSTITUTE (SRI)
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Instructors: Jose Manuel Cortez, Renee Reynolds
Sponsors: University of Arizona; Graduate College; The Partnership for Native American Cancer Prevention (NACP) training program, a collaboration between Northern Arizona University and the University of Arizona Cancer Center, funded by the National Cancer Institute; College of Medicine – Office of Diversity and Inclusion; Health Resources and Services Administration (HRSA) Centers of Excellence; Western Alliance to Expand Student Opportunities (WASEO).

MINORITY HEALTH DISPARITIES SUMMER RESEARCH PROGRAM (MHD)
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Sponsors: University of Arizona; Graduate College; Western Alliance to Expand Student Opportunities (WASEO).

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Sponsors: National Science Foundation (NSF). Funding for this research was provided by the NSF Grant No. CHE 0851730

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Sponsors: National Science Foundation (NSF) Engineering Research Center for Integrated Access Networks (ERC CIAN). Funding for this research was provided by the NSF Grant No. #EEC-1359163

BIOSPHERE 2
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Sponsors: National Science Foundation Research Experiences for Undergraduates Program

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Sponsor: National Science Foundation Research Experiences for Undergraduates Program

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Sponsors: Partnership for Native American Cancer Prevention (NACP) Training program, a collaboration between Northern Arizona University and the University of Arizona Cancer Center, funded by the National Cancer Institute