BIOSPHERE 2
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Sponsors: National Science Foundation Research Experiences for Undergraduates (NSF REU) Program.

| POSTER | BIOSPHERE 2 |
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|  | **EVELIN ESCOBEDO**<br>*Desert Agrivoltaics: A Novel Ecosystem Approach to the Food-Water-Energy Nexus*<br>UCLA, Environmental Science<br>Mentor: Greg Barron-Gafford<br>**Abstract**<br>Agrivoltaic systems involve producing food and renewable energy at the same time and on the same land area using raised solar photovoltaic (PV) panels. This type of installation has not been examined in a semi-arid environment, such as the southwestern drylands of Arizona, which is an ideal location for PV energy production and the setting of this experiment. However, this region of the United States is also projected to experience significant warming, which is not favorable for either crop yields or solar panel efficiency (every 1°C increase in temperature decreases PV panel performance by an average of 0.6%). Therefore, the ecosystem services provided by collocating PV panels and cropland should be studied in efforts to mitigate global |

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| | climate change, decrease land competition, maximize food production and water use, and improve renewable energy production in arid lands. This study compares the performance of chiltepin peppers, jalapeño peppers, and tomatoes under full sun and under solar panels by using a portable photosynthesis machine to evaluate leaf-level ecophysiology, including biochemical limitations to carbon assimilation, water-and light-use efficiencies, and relative stomatal limitation |
|  | **ALICIA FISCHER**<br>*Geochemical differences in petrocalcic and calcic horizons due to soil parent material in Southeastern Arizona*<br>Colby College, Geology<br>Mentors: Craig Rasmussen and Christopher Shepard<br>**Abstract**<br>Petrocalcic and calcic horizons are quintessential features of arid and semiarid regions and store significant amounts of soil carbon. Past studies identified the source of calcic and petrocalcic horizons as calcium-rich dust, linking calcic horizon formation to dust input. To date, there are few previous studies that explicitly test this hypothesis. Further, throughout Southeastern Arizona (SEAZ), a number of locations contain little calcium, despite significant soil development throughout the Quaternary period. We tested this widely accepted hypothesis by comparing the geochemical properties of petrocalcic and calcic horizons originating on different parent materials in SEAZ. We collected petrocalcic and calcic horizons sourced from basalt, rhyolite/andesite, limestone, and mixed alluvium and measured color, pH, electrical conductivity (EC), and loss on ignition (LOI) for each soil sample. We determined the bulk elemental content using portable x-ray fluorescence. Using a principal component analysis (PCA), we found geochemical differences between the calcic horizons due to parent material. We observed notable differences in pH, EC, and LOI between the samples, likely stemming from their different parent materials. We calculated dust input for each sampled horizon using titanium and zirconium concentrations and constant Ti:Zr values for dust and parent material. We found that many horizons contained a significant dust fraction, but generally limes tone and rhyolite derived samples had the lowest contributions from dust. Thus, while dust is a significant factor in calcic and petrocalcic horizon formation, other factors such as parent material partially explain the formation of petrocalcic and calcic horizons. |

**ELIZABETH HOWARD**

*Carbon uptake in granular basalt is mitigated by added organic carbon.*

Catawba College, Biology/Environmental Science
Mentor: Joost van Haren

**Abstract**

Soils represent a large, and potentially long-term, storage component of the global carbon budget. Accurate projection of the response of soil respiration –the release of CO2 from soils generated either through root respiration or microbial respiration –to rainfall events remains one of the largest uncertainties in global carbon cycling models. Similarly poorly represented in models is the uptake of CO2 by basalt soils. In an attempt to address these unknowns, we have investigated how the addition of carbon influences the negative CO2 flux observed after wetting basalt. At Biosphere 2 we have constructed a large scale environmentally controlled experiment known as the Landscape Evolution Observatory (LEO). The objective of LEO is to observe the interactions between water, microbes, and climate in the formation of soil and landscapes utilizing granular basalt as a young soil. Previous studies show that water addition to the LEO soil leads to considerable CO2 uptake and that the addition of plants does not alter this response. In this study, we conducted soil incubations to investigate the effect of varying soil arbon content on CO2 fluxes. During incubat ions we measured CO2 emissions from two types of soil (granular basalt and sand soil) mixed with seven (0, 5, 10, 25, 50, 75, 100%) different proportions of Kalso prairie. The carbon content varied from nearly zero in the basalt to ~6.5% in the Kalso Prarie soil. Other parameters that influence soil CO2 fluxes such as pH and microbial community were taken into account. In conclusion, our experiments confirm that unweathered basalt will consume CO2 when wetted, whereas added carbon will cause a strong pulse of CO2 following water addition. This supports our hypotheses that the carbon content is a large contributor and that maturation of basalt flows will lead to a shift in the carbon dynamics from inorganic to organic dominated. Likewise, these transitions would be expected to be present during soil formation after primary succession and even after anthropogenic alteration to landscape function.

**JASMIN JIMENEZ**

*Soil Microbial Activity Responses to Fire in a Semi-arid Savannah Ecosystem Pre- and Post-Monsoon Season*

New York University, Environmental studies
Mentor: Rachel Gallery

**ABSTRACT**

Extracellular enzyme activities (EEA) of soil microorganisms can act as important proxies for nutrient limitation and turnover in soil and provide insight into the biochemical requirements of microbes interrestrial ecosystems. In semi-arid cosystems, microbial activity is influenced by topography, disturbances such as fire, and seasonality from monsoon rains. Previous studies from forest ecosystems show that microbial communities shift to similar compositions after severe fires despite different initial conditions. In semi-arid ecosystems with high spatial heterogeneity, we ask does fire lead to patch intensification or patch homogenization and how do monsoon rains influence the successional trajectories of microbial

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| | responses? We analyzed microbial activity and soil biogeochemistry throughout the monsoon season in paired burned and unburned sites in the Santa Rita Experimental Range, AZ. Surface soil (5cm) from bare-ground patches, bole, canopy drip line, and nearby grass patches for 5 mesquite trees per site allowed tests of spatiotemporal responses to fire and monsoon rain. Microbial activity was low during the pre-monsoon season and did not differ between the burned and unburned sites. We found greater activity near mesquite trees that reflects soil water and nutrient availability. Fire increased soil alkalinity, though soils near mesquite trees were less affected. Soil water content was significantly higher in the burned sites post-monsoon, potentially reflecting greater hydrophobicity of burned soils. Considering the effects of fire in these semi-arid ecosystems is especially important in the context of the projected changing climate regime in this region. Assessing microbial community recovery pre-, during, and post -monsoon is important for testing predictions about whether successional pathways post-fire lead to recovery or novel trajectories of communities and ecosystem function. |
|  | **DAVID LITWIN**<br>*Evaluating the effectiveness of ERT for assessing subsurface structure at the Landscape Evolution Observatory*<br>University of Illinois Urbana-Champaign, Civil Engineering<br>Mentors: Peter Troch and Antonio Meira<br>**Abstract**<br>The structure of the subsurface plays an important role in mediating interactions between microbiology, geochemistry, and hydrology in the critical zone. In particular, it controls the space available for air, water, and life, and thus affects geochemical properties, which in turn influence hydrologic properties. These interactions are greatly informed by increasing our understanding of the subsurface. This may be accomplished with a variety of destructive and non-destructive methods. Geo-electrical techniques are commonly used for non-destructive measurements of water content, solute concentration, and general substrate properties, though they are rarely used to capture details of subsurface structure. However, under proper conditions, electrical resistance tomography (ERT) shows promise for this task. The large scale of the Landscape Evolution Observatory (LEO) at Biosphere 2 and its interdisciplinary focus are especially well suited to test the ability of ERT to derive patterns of subsurface structure that can be linked with hydro-ecological patterns. Here we propose a method that takes advantage of this controlled environment in order to determine the spatial distribution of porosity in the LEO hillslopes. This method is based in a simple application of the principles of electrical current flow in soils and shows promising results when idealized scenarios are considered. However, it must be tested for robustness against the inherent errors in modeled or measured data. This study presents a synthetic experiment designed specifically to characterize the influence of error in the measured variable (electrical resistance) on the retrieved porosity fields. |

**JOHN MERAZ**

*Measuring which types of VOCs are emitted from trees in the rainforest biome at Biosphere 2.*

Arizona State University, Biological Science
Mentors: Laura Meredith and Till Volkmann

**Abstract**

Rainforest trees and soils play an important role in VOC or volatile organic compound emissions. Terpenes ($C_{10}H_{16}$) a class of 10 carbon molecules, are the most abundant type of hydrocarbons emitted from rainforest trees. Some VOCs absorb infrared radiation at wavelengths at which water isotope measurements are made using laser spectrometers, which is not usually a problem for ambient sampling, but may significantly affect observed water isotope ratios from soil and plant sample s measured using equilibrium methods. There is thus a need to characterize volatile emissions from soil and plant samples and develop better methods to account for VOC interference during water isotope measurements. In this study, we collected branch and leaf samples from plants from the Biosphere 2 Rainforest. Soil was gathered from the nearby. Volatile concentrations were measured using the FTIR Analyzer in a closed circulatory system with sulfur hexafluoride ($SF_6$) used as a tracer gas to test for leakage. We determined that the different types of tree species emit different kinds of volatiles, such as isoprenes, alcohols, and aldehydes. This study will help build understanding of which volatiles are emitted and develop new methods to test for water isotopes and gas fluxes in clear and precise data measures.

**MAGGIE NG**

*Tree mortality due to heat waves: Development of a multispectral approach for non-destructively detecting increasing tree seedling stress during a heat waves experiment*

Hampshire College, Ecology
Mentors: David Breshears and Darin Law

**Abstract**

Large-scale tree die-off events in response to drought and warming are a global phenomenon of increasing concern in association with climate change. Recent research suggests that heat waves may be a trigger of mortality for mature trees during hotter droughts. Consequently, experiments are needed to examine if tree species mortality is exacerbated by heat waves. We are developing an experiment to study the relationship between tree mortality and heat waves for seedlings of piñon pine (Pinus edulis), a species which has experienced recent widespread die-off and has been a focus of hotter-drought-related mortality. To conduct this experiment, a non-destructive method is needed to determine the degree of tree stress in a group of seedlings as a function of time. Our objective is to develop such an approach using multi-spectral data. We obtained estimates of the Normalized Difference Vegetation Index (NDVI) for tree seedlings in various stages of stress and browning using a multispectral camera. We documented a significant relationship between NDVI and observed percent brown. This correlation then enabled us to develop a relationship between percent brown and estimated plant water potential. Our results indicate that NDVI can yield accurate data on both the transition from greening to browning that accompanies mortality and provide an estimate of plant water stress, thereby

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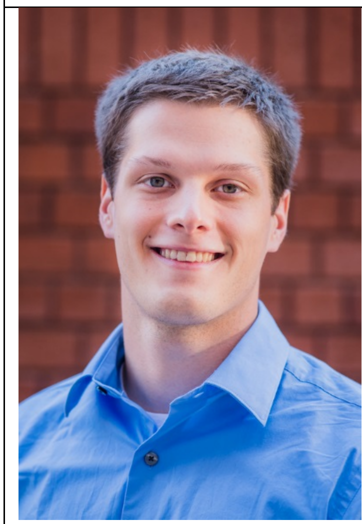
| | enabling a non-destructive measurement of plant condition for use in future heat wave experiments. |
|  | **HARRISON RAUB**<br>*Evaluating the effects of fire on semi-arid savanna ecosystem productivity using integrated spectral and gas exchange measurements*<br>Muskingum University, Environmental Science and Biology<br>Mentors: William Smith and Rachel Gallery<br>**Abstract**<br>Drylands account for ~40% of the land surface and have been identified as increasingly important in driving interannual variability of the land carbon sink. Yet, understanding of dryland seasonal ecosystem productivity dynamics –termed Gross Primary Produ ctivity (GPP) –is limited due to complex interactions between vegetation health, seasonal drought dynamics, a paucity of long-term measurements across these under -studied regions, and unanticipated disturbances from varying fire regimes. For instance, fire disturbance has been found to either greatly reduce post-fire GPP through vegetation mortality or enhance post-fire GPP though increased resource availability (e.g., water, light, nutrients, etc.). Here, we explore post-fire ecosystem recovery by evaluating seasonal GPP dynamics for two Ameriflux eddy covariance flux tower sites within the Santa Rita Experimental Range of southeastern Arizona: 1) the US-SRG savanna site dominated by a mix of grass and woody mesquite vegetation that was burned in May 2017,and 2) the US-SRM savanna site dominated by similar vegetation but unburned for the full measurement record. For each site, we collected leaf-level spectral and gas exchange measurements, as well as leaf-level chemistry and soil chemistry to characterize differences in nutrient availability and microbial activity throughout the 2017 growing season. From spectral data, we derived and evaluated multiple common vegetation metrics, including normalized difference vegetation index (NDVI), photochemical reflectivity index (PRI), near-infrared reflectance (NIRv), and MERIS terrestrial chlorophyll index (MTCI). Early results suggest rates of photosynthesis were enhanced at the burned site, with productivity increasing immediately following the onset of monsoonal precipitation; whereas initial photosynthesis at the unburned site remained relatively low following first monsoonal rains. MTCI values for burned vegetation appear to track higher levels of leaf-level nitrogen content upon monsoonal onset, but requires further validation by leaf-level chemistry. This work suggests that the integration of spectral, gas exchange, and soil measurements could be a powerful framework toward advancing our understanding of fire-ecosystem productivity feedbacks across spatiotemporal scales. |

**MYCHAL THOMPSON**

*Dissolved organic matter characterization in stream water during spring snow melt in the La Jara catchment, Villa Caldera National Preserve NM.*

Navajo Technical University, Environmental Science and Natural Resources
Mentors: Jon Chorover and Yaniv Olshansky

**Abstract**

Dynamics of dissolved organic matter (DOM) in stream waters are important indicators for internal processes in the critical zone, such as decomposition of soil organic matter, water flow paths, potential for metal mobilization and nutrient distribution. In this study we used Fourier transform infrared spectroscopy (FTIR) to quantify DOM molecular changes of stream water samples collected during spring snow melt at the La Jara catchment located in the Jemez Critical Zone. Our results show decrease in amide associate peaks (wavenumbers 3550, 1640 and 670 cm-1).This trend corresponded to decrease in the ratio between carboxylic (wavenumbers 1680, 1600 and 1410 cm-1) to aromatic (wavenumbers 1622, 1490, 955 cm-1) peaks suggesting either flush of compounds accumulated prior to spring snow melt, or increased decomposition of plant derived material in the soil that allow it to be transported to the stream. Aliphatic component peaks decrease from beginning to middle of sampling period, then increase back toward the end of snowmelt. This may indicate contribution of microbial derived matter to the stream. O-Alkyl peak (wavenumber 1150 and 1073 cm-1) varied without pronounced trend during the spring snowmelt. Variation in DOM composition during spring snow melt provide evidence for internal processes occurring in the critical zone during spring snow melt. Further analysis of these changes may corroborate with other stream water indices such as the concentration-discharge relations of solutes in stream.

**EUNICE VILLASENOR IRIBE**

*The effects of different $CO_2$ and temperature treatments on plants grown in LEO soil*

Arizona State University, Environmental Science
Mentors: Katerina Dontsova

**Abstract**

Mineral weathering is an important process in soil formation. The interactions between the hydrologic, geologic and atmospheric cycles often determine the rate at which weathering occurs. Elements and nutrients weathered from the soil by water can be removed from soils in the runoff and seepage, but they can also remain in situ as newly precipitated secondary minerals or in biomass as a result of plant uptake. Here we present data from an experiment that was conducted at the controlled environment facility, Ecotron Ile-de-France (Saint-Pierre-les-Nemours, France) that studied plants grown in the same heterogeneous basaltic soil high in basaltic glass as used to simulate soil in the Biosphere 2 Landscape Evolution Observatory (LEO). The experiment used 3 plant types: velvet mesquite (Prosopis velutina), green spangletop (Leptochloa dubia), and alfalfa (Medicago sativa), which were grown under varying temperature and $CO_2$ conditions. It was theorized that the plants grown under conditions that were warmer and had a greater $CO_2$ concentration in atmosphere would have greater nutrient concentrations as more mineral weathering would occur. The data collected showed that the treatments affected the nutrient for each plant type differently with

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| | some responding more to an increase in temperature and some to the increase in $CO_2$. The results presented here can be used as a reference for further experiments conducted to study plants uptake and the mobility of weathered elements during soil formation as a result of climate change. |