THE UNIVERSITY OF ARIZONA
GRADUATE COLLEGE

Undergraduate Research Opportunities Consortium

UROC

Abstract Review

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Biosphere 2 - Research Experience for Undergraduates

Director: Katerina Dontsova, PhD

UA's Biosphere 2 facility is the site of this NSF funded Research Experiences for Undergraduates 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.

Laurel Marie Brigham

Biosphere 2 - Research Experience for Undergraduates

University of California San Diego

San Diego, California

PI: Dr. Joost Van Haren

CARBON DIOXIDE EFFLUX FROM THE STEMS OF TROPICAL LEGUMES AND NON-LEGUMES

Abstract: Drought and rising temperatures as a result of climate change could greatly reduce carbon uptake by tropical rainforests; therefore, it is important to better understand how these factors affect individual aspects of the forest carbon cycle. This summer I focused on the amount of CO_2 released by tropical trees. After the assimilation of CO_2 into sugars, trees can allocate the sugars to multiple locations; a dominant portion goes to the stems, where it is used for growth and cell maintenance. Both processes produce CO_2 through respiration, which leaves the stem through the bark. I investigated how stem CO_2 efflux differs between a species of legume (***Clitoria racemosa***) and a species of non-legume (***Phytolacca dioica***) in the tropical rainforest biome of Biosphere 2 in Oracle, Arizona. A flexible chamber was strapped to each tree and the CO_2 that diffused across the bark was measured with a LI-7000. A 4-week long drought was imposed in an effort to simulate future conditions resulting from global warming. My results indicate that increased temperatures and decreased soil moisture led to a significantly higher CO_2 efflux in legumes at first, but the effect tapered off as the drought continued. No change was found for the non-legume species. The legume family, Leguminosae, represents a significant portion of the flora of the tropical rainforest; thus, rising temperatures could lead to a more rapid release of CO_2 into the atmosphere during the initial stages of a drought from a substantial portion of the tropical rainforest.

Jake Cawley

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Oregon State University

Corvallis, Oregon

PI: Dr. Peter Troch

LANDSCAPE EVOLUTION OBSERVATORY –COOLING SYSTEM RESPONSE

Abstract: This project measures the efficacy of the cooling system within the Landscape Evolution Observatory (LEO), which is located in Biosphere 2 in Oracle, Arizona. LEO is comprised of three identical artificial landscapes, which are designed to emulate zero-order basins. Each bay features a basaltic tephra soil with a surface area of 330 m^2, 330 m^3 volume and 10° average slope surrounded by 10,107.8 m^3 of air. The cooling system is comprised of three air-handlers (26 m3 s-1 flow capacity; two with 40 kW fans and one with a 60 kW fan) and one mechanical chiller (330 kW/450hp). Air temperature data was collected at one-minute intervals using twenty-four HMP60 sensors at various heights and positions over the slope. Starting at 9 am, the 60kW motored fan was applied and each following hour another aspect of the cooling system was added—the 40kW fan, then another 40kW fan, and finally the mechanically chilled air. The temperature data was plotted and analyzed to produce response functions. From these, statistics were generated that will provide insight into cost-effective temperature management strategies. Additionally, this data will allow a more precise understanding of control capabilities. This is critical to prepare for future experimentation and the introduction of plant species into LEO.

Emilia Caylor

Biosphere 2 - Research Experience for Undergraduates

University of Houston, Downtown

Houston, Texas

PI: Dr. Craig Rasmussen

SECONDARY CLAY MINERAL FORMATION FROM VARIOUS LITHOLOGIES IN THE VALLES CALDERA, NEW MEXICO

Abstract: Understanding outcomes that underlying parent rock has on soil formation is important in pedology. The primary objective of this study is to examine how the secondary mineral formation in soil colloids is affected as they are transported through surface flow at various landscape positions vs the effects of different lithologies on secondary mineral formation. The soils that were collected and analyzed came from Valles Caldera, lithology of the area includes porphyritic rhyolite, hydrothermally altered tuff, and sandstone that formed post caldera collapse. Located in a semi-arid to sub-humid region of New Mexico, the Valles Caldera- a mixed conifer catchment- lies within the JRB-CZO, ranges in elevation from 2060m to 3433m, and has an annual precipitation from 480mm to 850mm. The soil pits in this study are categorized into three groups based on their landscape position; well drained hill (WDHS), poorly drained hill slope (PDHS), and poorly drained convergence (PDC). Based on these different landscape positions, different secondary mineral formation is expected to be seen. Quantitative and qualitative X-ray diffraction were executed to quantify and identify the different clay minerals found in samples. Minerals/groups found in these soils include quartz, illite, andesine, microcline, feldspar, Fe-oxides, kaolinite, and smectite. The results demonstrated variation among the categories such percentages of smectites, feldspars, and kaolinite; Smectites decreased with drainage, potassium feldspars increased as drainage became poor, and kaolinite decreased from the WDHS to the PDHS but increased in PDC. These results demonstrate variance in secondary mineral formation that follows the variance in parent material.

Alana Lorraine Dixon

Biosphere 2 - Research Experience for Undergraduates

University of Southern Mississippi

Hattiesburg, Mississippi

PI: Dr. Thomas Meixner

CO2 FLUX IN FINE AND COARSE SOILS OF INTERMITTENT RIVERS AND EPHEMERAL STREAMS (IRES)

Abstract: While arid and semi-arid regions cover 1/3 of the Earth's land surface, the soil biogeochemistry of IRES are not as well understood as their perennial counterparts. This project looks at trends in CO_2 respiration in soils in 2 urban and 2 rural ephemeral washes from Tucson and Tombstone, Arizona given two different water treatments. Fine soils are thought to have higher soil respiration rates according to the "inverse-inverse texture" hypothesis. Measurements were taken of soil moisture, pH, electrical conductivity and particle size using a Laser PSA and soil organic matter content via loss on ignition. Soil sample incubations were conducted for rainfall levels of (5mm [average] and 25mm [above average]). CO_2 concentration ($[CO_2]$) was measured using an infrared gas analyzer. Soils were wet on the 6th day after taking CO_2 measurement. CO_2 was measured twice each day for 3 days, then once every 2 days. Preliminary results show the 46% fine particle soil had the highest average $[CO_2]$ for the first 3 measurements in both trials. The 30% fine particle soil had a higher $[CO_2]$ than the 15% fine particle soil which had a higher $[CO_2]$ than the 38% fine particle soil. Measurements from the 46% fine particle soil supported the hypothesis that fine and neutral soils will have higher average and peak CO_2 flux rates than coarse and acidic soils. However, measurements from more coarse soils did not conform to the hypothesized trend. These results may be used to improve understandings of nutrient cycling in IRES.

Tom Hartvigsen

Biosphere 2 - Research Experience for Undergraduates

SUNY, Geneseo

Geneseo, New York

PI: Dr. Shirley Papuga

ON CALCULATING DRYLAND VEGETATION INDICES USING NEAR-REMOTE SENSING TECHNIQUES

Abstract: Decreases in precipitation events in semi-arid environments across the globe are predicted over the next few decades. In order to assess how precipitation events affect shifts in phenology, we looked at a Creosote bush-dominated shrub land near the Santa Rita mountain range south of Tucson, Arizona. Digital images of a sample bush were taken at 12:00 pm every day of 2014 using Phenology Cameras. Before classifying the images, a specific region of interest was chosen that contained a comprehensive view of the plant community. This same region of interest was then extracted from each image. By creating a classification tree, using specified training data, sections of each image were categorized into leaves, stems, and flowers. Proportions of each plant status were recorded throughout the year. From the images, using a predefined equation, Greenness Indices were derived for each image. These indices correlated with the Normalized Difference Vegetation Index recorded by the Moderate Resolution Imaging Spectroradiometer project. This implies that the method can be used to demonstrate how precipitation events affect phenological triggers, especially in areas that are not visible to satellites and aircraft, such as the understories of forests.

Hannah Joanne Maier

Biosphere 2 - Research Experience
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University of Michigan
Ann Arbor, Michigan

PI: Dr. Kevin Bonine

BEHAVIORAL RESPONSE OF HERMIT CRABS (*CLIBANARIUS DIGUETI*) TO DISSOLVED CARBON DIOXIDE

Abstract: CO_2 induced ocean acidification is currently changing the population dynamics of marine organisms. This can involve increased stress in populations, and alteration in individual physiology, which can eventually be expressed through an organism's behavior. If sustained, CO_2 induced ocean acidification has the potential to cause major impacts on marine food chains, including on services they provide.

The purpose of this study was to understand whether and how ocean acidification affects the behavior of hermit crab Clibanarius digueti, a crustacean inhabiting the littoral zone. We hypothesized that an increase in dissolved carbonic acid would modify grazing and individual movement, because an increase in acidification alters the normal chemical composition of the water and potentially the physiology of C. digueti.

A model tidal pool experiment consisting of two tanks (control and treatment) inhabited with seven living C. digueti was set up in the Ocean Biome of Biosphere-2. Each tank was also provided with uninhabited shells: two Turbo fluctuosa and four Cerithium sp. Gaseous CO_2 was dissolved into treatment tank and measured as dissolved CO_2 by using a NaOH titration. Additionally, water conditions were characterized for UV- light and temperature. Two trials were run in this experiment with tanks and treatments interchanged each trial.

We found a marked treatment effect on C. digueti behavior. The population experiencing increased CO_2 performed daily shell changes after first day of exposure for each of the 4-day trials, as compared to individuals unexposed to dissolved CO_2, that experienced no shell changes. From this study we conclude that the behavior of C. Digueti can be a good indicator of changes in dissolved CO_2. This would allow us to better interpret patterns in marine animal behavior as response to climate change.

Elizabeth Parra

Biosphere 2 - Research Experience for Undergraduates

University of Texas, El Paso

El Paso, Texas

PI: Dr. Greg A. Barron-Gafford

Effects of drought conditions on the photosynthetic performance of poplars (*Populus sp.*)

Abstract: Poplars are an important agro-forestry product used for both biofuel and paper production. Importantly, all poplars are not created equal – some have the potential to produce isoprene, a compound thought to aid plants under temperatures and water stress conditions. Our project observed how drought conditions modulated photosynthetic rates in two lineages of Populus trees, those that produce isoprene and those that have had isoprene gene knocked out. We measured leaf-level photosynthesis and temperature from the two lineages under high and low water exposure in a common garden experiment. We found that both lines had similar photosynthetic rates over the range of temperatures and water exposure levels measured. However, afternoon measurements were, at times, inconsistent with plants of the same treatment measured in the morning. Soil moisture and leaf water potential of the poplars showed the differentials irrigation had not actually yielded differences in the treatment conditions among the trees . Photosynthetic rates were then measured in the morning and afternoon to determine if the time of day influenced photosynthetic performance, even though conditions were controlled at the leaf level. Morning measurements showed that poplars reached higher rates of photosynthesis, but ultimately decreased faster than observed in the afternoon measurements. Ultimately, our experiment showed that isoprene did not aid in photosynthesis under heat stressed conditions and that the common garden setting was not able to currently induce a water stress condition in the plants. Further research is needed to determine if drought conditions can be implemented at the common garden.

Shelby Redfield

Biosphere 2 - Research Experience for Undergraduates

Middlebury College

Middleburry, Vermont

PI: Dr. Jon Chorover

CONCENTRATION-DISCHARGE RELATIONSHIP OF AL, TRANSITION METALS, AND RARE EARTH ELEMENTS REVEAL COLLOIDAL VS. DOC COMPLEXATION INFLUENCES ON METAL TRANSPORT IN STREAM WATERS

Abstract: The Concentration-Discharge relationships of solutes in stream waters during high-volume storm events are of interest when studying the influences on weathering. While the base cations (Na, K, Mg, Ca) have been widely characterized in terms of concentration-discharge relationship, little is known in regards to Al, transition metals, and rare earth elements, which typically demonstrate a positive concentration-discharge relationship, unlike their cation counterparts. We performed a cascade-filtration (at 1.2µm, 0.4µm, and 0.025µm) on stream water samples collected during a storm event at the Marshall Gulch site of the Santa Catalina Mountains-Jemez River Basin Critical Zone Observatory and used standard stream water analytical techniques to determine concentration-discharge relationships. This technique yielded positive concentration-discharge relationships for Al, transition metals, and rare earth elements. This positive relationship suggests either complexation with dissolved organic carbon or colloidal transport.

Alexandra Salinas

Biosphere 2 - Research Experience for Undergraduates

St. Mary's University

San Antonio, Texas

PI: Dr. Katerina Dontsova

ROOT DEVELOPMENT DURING SOIL GENESIS: EFFECTS OF ROOT-ROOT INTERACTIONS, MYCORRHIZAE, AND SUBSTRATE

Abstract: A major driver of soil formation is the colonization and transformation of rock by plants and associated microbiota. In turn, substrate chemical composition can influence the capacity for plant colonization and development. In order to better define these relationships, a mesocosm study was set up to analyze the effect mycorrhiza, plant density and rock have on root development, and to determine the effect of root morphology on weathering. We hypothesized that plant-plant and plant-fungi interactions have a stronger influence on root architecture and rock weathering than the substrate composition alone. Buffalo grass (***Bouteloua dactyloides***) was grown in a controlled environment in columns filled with either granular granite, schist, rhyolite or basalt. Each substrate was given two different treatments, including grass-microbes and grass-microbes-mycorrhizae and incubated for 480 days. Columns were then extracted and analyzed for root morphology, fine fraction, and pore water major element content.
Preliminary results showed that plants produced more biomass in rhyolite, followed by schist, basalt, and granite, indicating that substrate composition is an important driver of root development. In support of our hypothesis, mycorrhizae was a strong driver of root development by stimulating length growth, biomass production, and branching. However, average root length and branching also appear to decrease in response to high plant density, though this trend was only present among roots with mycorrhizal fungi. Our hope is that the results can be applied to agricultural research in order to promote the production of crops on traditionally un-arable land.

Helen Siegel

Biosphere 2 - Research Experience for Undergraduates

College of Wooster
Wooster, Ohio

PI: Dr. Guo-Yue Niu

PARAMETER CALIBRATION OF MINI-LEO HILL SLOPE

Abstract: The mini-LEO hill slope, located at Biosphere 2, is a small-scale catchment model that is used to study the ways landscapes change in response to biological, chemical, and hydrological processes. Previous experiments have shown that soil heterogeneity can develop as a result of groundwater flow; changing the characteristics of the landscape. To determine whether or not flow has caused heterogeneity within the mini-LEO hill slope, numerical models were used to simulate the observed seepage flow, water table height, and storativity.

To begin a numerical model of the hill slope was created using CATchment Hydrology (CATHY). The model was then brought to an initial steady state by applying a rainfall event of 5mm/day for 180 days. Then a specific rainfall experiment of alternating intensities was applied to the model. Next, a parameter calibration was conducted, to fit the model to the observed data, by changing soil parameters individually. The parameters of the best fitting calibration were taken to be the most representative of those present within the mini-LEO hill slope.

Our model concluded that heterogeneities had indeed arisen as a result of the rainfall event, resulting in a lower hydraulic conductivity downslope. The lower hydraulic conductivity downslope in turn caused in an increased storage of water and a decrease in seepage flow compared to homogeneous models. This shows that the hydraulic processes acting within a landscape can change the very characteristics of the landscape itself, namely the permeability and conductivity of the soil. In the future results from the excavation of soil in mini-LEO can be compared to the models results to improve the model and validate its findings.

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Coordinator: Donna Treloar, MA
Instructors: Andrew Huerta, PhD, Renee Reynolds, ABD, Joanna Sanchez-Avila
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Coordinator: Stephanie Adamson, Holly Lopez
Sponsors: University of Arizona; Graduate College; Western Alliance to Expand Student Opportunities (WAESO).

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PIs: Nasser Peyghambarian, PhD
Sponsors: University of Washington/National Science Foundation (NSF). Funding for this research was provided by NSF Grant No. CHE-1156598.

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PI: Allison Huff Mac Pherson, DHEd, Robert Norwood, PhD
Coordinator: Ameé J. Hennig, Daniel Lamoreaux
Sponsors: National Science Foundation (NSF) Engineering Research Center for Integrated Access Networks (ERC CIAN). Funding for this research was provided by the NSF Engineering Research Center No. EEC-0812072.

BIOSPHERE 2
PI: Katerina Dontsova, PhD
Sponsors: National Science Foundation Research Experiences for Undergraduates Program.

STUDENT AFFAIRS RESEARCH PROGRAM (STAR)
Coordinator: Nura Dualeh, MA
Instructors: Andrew Huerta, PhD, Renee Reynolds, MA, Joanna Sanchez-Avila
Sponsors: University of Arizona; Graduate College; Division of Student Affairs; Western Alliance to Expand Student Opportunities (WAESO).

UROC-PREP
Coordinator: Donna Treloar, MA
Instructor: Andrew Huerta, PhD
Sponsors: University of Arizona; Graduate College, Western Alliance to Expand Student Opportunities (WAESO).

CAT VEHICLE PROGRAM/ ECE REU
PI: Jonathan Sprinkle, PhD
Coordinator: Nancy Emptage
Sponsor: National Science Foundation Research Experiences for Undergraduates Program

RESEARCH IN OPTICS (RiO)
PI: R. John Koshel, PhD
Coordinator: Melissa Sarmiento Ayala, MEd
Sponsor: National Science Foundation (NSF)
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