Biosphere 2

Jovon Jojola

“How Solar Has Changed Today’s Garden ”

ABSTRACT: For this project, we utilized two study sites located in Tucson, Arizona: The first site is at Manzo Elementary School and the second is at Biosphere 2. At both sites we grew the same plants: tomato, eggplant, and cowpea. We compared the growth of the plants, as well as fruit and vegetable yield of the plants that are grown underneath PV Panels opposed to the plants that are grow in the open. We also conducted measurements of the rate of photosynthesis within the plants using the Li-Cor 6400. We found that at the Manzo site the plants had a higher rate of photosynthesis in the open than under the agrivoltaic setting. At Biosphere2, this was also true for tomatoes and eggplants, for cowpeas where the plants in the agrivoltaic setting were photosynthesizing at a higher rate than in open. The Manzo site has yet to be harvested due to the plants still producing. These results will be linked back to our other metrics of PV panel performance and irrigation water use efficiency to assess the overall impacts of this co- location.

Erin M. Magoffie

“Accessible Science and Technology: Augmented Reality Simulations Improve Visitor Experience at Biosphere 2”

ABSTRACT: Improving science communication and STEM education outcomes is an important task, requiring ongoing effort and innovation. We tested the viability of augmented reality (AR) technology to improve the visitor experience at Biosphere 2, an iconic facility for Earth systems science and informal public STEM education. To make Biosphere 2 research more accessible to its 100,000 annual visitors, we developed AR simulations using data collected from current experiments at the University of Arizona facility, revising and improving the AR experiences via informal interactions with pilot visitor groups. Then, we assessed the user-friendliness of the AR simulations and their value as a tool to improve learning outcomes and foster positive attitudes towards science (which we combined into a ‘visitor experience’ metric) by creating and administering surveys to four target audiences: 1) prior to engagement with staff or AR, 2) following staff-guided tour experience, 3) after engagement with AR science simulations, and 4) following BOTH AR engagement and staff-guided experiences. Visitors gave the user-friendliness of the AR simulations a positive rating. Overall, visitors who interacted with the AR simulations had the highest combined information retention rates and percent positive attitude towards science, except for visitors over 65 years old. Augmented reality technology has the potential to be a valuable complement for engaging visitors with research projects, and virtual manipulation of key variables improves information retention and attitudes toward science, especially for younger audiences. Biosphere 2 will continue to refine and expand the engagement of visitors with AR -based science interactions.

Michael Hitzelberger

"Coupling Hydrologic Processes and Geochemical Weathering Patterns in a Fully Controlled Basaltic Soil Lysimeter "

ABSTRACT: The University of Arizona's Landscape Evolution Observatory (LEO), at Biosphere 2, is a series of three large artificial hillslopes containing basaltic tephra soil. A scaled-down analog of LEO (Mini-LEO) with dimensions of 2m (L) x 0.5m (W) x 1m (H) and a 10o slope is uniformly packed with tephra basalt (<2mm in particle size) and used to examine hydrologic response of the hillslope to rainfall during incipient soil formation. In this study, solute chemistry of water samples was examined to infer geochemical weathering patterns and relate them to fluctuations in discharge rates in Mini-LEO. Solute chemistry analysis was performed on discharge water samples from the toe-end of the slope. Mini-LEO was subjected to a rain cycle every other day for 36-days; each cycle consisted of two 3-hour rains at a rate of 13 mm/hr with a 2-hour break in between. Samples for geochemical analysis were collected at the beginning (1st cycle), middle (10th cycle), and the end (16th cycle) of the experiment, and analyzed for cations and anions using ion chromatography. Chemical concentrations in solution were plotted as a function of measured discharge rates from the Mini-LEO slope at the time the sample was taken. Results indicated that flux of most major cations was limited by formation of secondary minerals. During the 16th cycle, secondary mineral formation was inhibited, resulting in chemostatic weathering patterns. When limited by rates of secondary mineral formation, cations showed greater congruence (greater percentage of elements remaining in solution after initial dissolution) during higher discharge rates.

Violeta Keifer

“Weathering in the deep critical zone: Mineralogical controls on aqueous geochemistry in the deep subsurface”

ABSTRACT: The critical zone (CZ) is the thin living skin of the Earth’s surface extending from the top of the vegetative canopy to impermeable bedrock, where processes interact to support life. CZ observatories (CZO) have been established to illicit interdisciplinary Earth surface science research with the specific goal of understanding how CZ dynamics affect the evolution of CZ structure, and the impact humans will have on the future Earth system. Recent research at the Jemez River Basin Critical Zone Observatory (JRB-CZO) has indicated that a deep groundwater reservoir likely resides in the fractured rhyolitic bedrock, and that longer residence time water contributes significantly to stream flow. However, the structure and composition of the deep CZ has been poorly defined because of a lack of direct measurements. We conducted a set of kinetic dissolution experiments on extracted core samples. Subsamples from cores collected from two deep-drilling sites (to 35 m, with differing geology) at the JRB-CZO were reacted in batch mixed reactors with DI water that was pre-equilibrated with the atmosphere. Samples were sacrificed at a range of time steps and solutions were analyzed for major and trace solutes. Results suggest that mineralogical differences in the two cores drive corresponding differences in reaction rates and the time evolution of solution chemistry. These results indicate that antecedent weathering and mineral assemblage (both primary and secondary) in deep CZ exert primary control on aqueous geochemistry, and therefore regulate kinetics and thermodynamics or pore water evolution during transport within the deep critical zone.

Violet Eagle

"Community Level Physiologic Profile: Microbial Responses to Experimental Warming in Semi-arid Soils"

ABSTRACT: Semiarid grasslands worldwide are facing woody plant encroachment, a process that dramatically alters carbon and nutrient cycling. This change in plant types can influence the function of soil microbial communities with unknown consequences for soil carbon cycling and storage. We used soils collected from a five-year passive warming experiment in Southern, AZ to test the effects of warming and substrate availability on microbial carbon use. We Hypothesized that substrate addition would increase the diversity of microbial substrate use, and that substrate additions and warming would increase carbon acquisition, creating a positive feedback on carbon mineralization. Community Level Physiological Profiling (CLPP) of microbial activity was conducted using Biolog EcoPlateTM assays from soils collected in July 2018, one week after the start of monsoon rains. Two soil types common to Southern AZ, were amended with one of four treatments (surface juniper wood chips, juniper wood chips incorporated into the soil, surface biochar, or a no-amendment control) and were randomly assigned to a warmed or ambient temperature treatment. We found that surface wood chips resulted in the highest richness and diversity of carbon substrate use with control soils yielding the lowest. Substrate use was positively correlated with the total organic carbon but not with warming.

Janie Neftali Paz

“Analysis of Tree Stem Respiration in Diverging Environments”

ABSTRACT: Stem respiration is an important, but relatively poorly understood, component of ecosystem carbon cycling. To better understand the relationship between stem respiration and biological, chemical and environmental drivers, we measured stem respiration (CO_2 flux) of trees from five species in diverging environments (Biosphere 2 and UA campus). We hypothesized that CO_2 fluxes would be positively related to mitochondrial activity (more CO_2 production), temperature (greater respiratory activity), and wood density (higher density of mitochondria). Wood pH should negatively affect CO_2 fluxes, because with increasing pH more CO_2 remains in the tree sap as bicarbonate. We only found a strong correlation with the mitochondrial activity.

Phoenix Spivey

"Cell Count and Viability Within the Rainwater Supply of the Landscape Evolution Observatory"

ABSTRACT: The Landscape Evolution Observatory (LEO) located in the University of Arizona's Biosphere 2 facility consist of three artificial landscapes that can be manipulated to observe how different processes impact soil, water, plants, and microbes within each hillslope. Before initiating large-scale experiments, tests are conducted on a smaller scale using miniLEO, a miniature model of the landscapes. Currently, plants are being seeded on miniLEO to gain insight on the effects of plant variability on the landscape which can guide future experiments on LEO. With miniLEO acting as a reference, it is important that the system is similarly set up to LEO for comparable results. There is a concern with how the water supply for LEO and miniLEO may impact microbial communities within these systems, for example as a source of water-borne microbes, and if the impacts are shared or distinct between the two systems. To determine what locations are contributing microbes to the systems, we use flow cytometry and cell viability assays. As anticipated, we found that microbial abundance is lowest after treatment by the reverse osmosis system, that microbial populations become elevated after the reverse osmosis treatment due growth in the infrequently flushed water system, and that microbial abundance is reduced at each treatment point. Results indicate that water flow from the first rain decreased the microbial abundance and ratios of the systems in the subsequent rain event. Possible sources of microbial introduction for LEO include sprinklers and tanks, and points between the tanks and sediment filter inlet for miniLEO.

Luke Wilson

"Can You Take the Heat? Climate Envelope Development for *Pinus edulis* Seedlings"

ABSTRACT: Identifying the environmental conditions under which trees will persist or die is necessary to reduce uncertainty regarding forest health and terrestrial carbon cycling under a changing climate. The mechanisms of how trees die are becoming clear, but the environmental conditions under which trees can persist under very high temperatures associated with heat waves have not been documented, with or without the occurrence of hydrologic drought and associated low soil moisture levels. We selected Pinus edulis, arguably the most studied species in regard to drought and widespread tree mortality, to evaluate this relationship. We deployed P. edulis seedlings (~8 mm diameter at soil level and ~200 mm tall) to five different temperature conditions in the field ranging from average temperatures of 17°C to 32°C, subdivided into four watering treatments (initially only, initially and one week later, initially and through two weeks later, and initially and through three weeks later). Seedlings were placed in cover shelters that prevented rainfall, increased temperatures about 2oC over ambient, and resulted in high values of relative humidity. Mortality was estimated as 90% foliar browning and was measured twice a week. Time to mortality significantly and negatively correlated with average site temperature, with tree most seedlings dying before soil moisture was depleted. These results suggest that heat waves can trigger tree seedling mortality and that the effect increases with warming. Improving projections of tree seedling survival is important for improving management of forests and associated terrestrial carbon under changing climate.