Letter from the Director

Over two years have elapsed since the University of Arizona took over management of Biosphere 2 (B2). I am excited and inspired by the growth of our unique organization. Our mission, to serve as a center for research, outreach, teaching and life-long learning about Earth, its living systems, and its place in the universe is clearly evident in the highly focused research and outreach activities currently taking place at B2.

B2 aims to find solutions to the problems presented by global climate change. Our unique campus has become a model of human systems now used by scientists and industry to research and demonstrate the viability of smart grid technology. We are also in the process of designing a long-term experiment inside B2 to study how environmental conditions and biological colonization of landscapes affect complex interactions of soil and hydrology evolution. Through scientific collaborations and cutting-edge research, B2 Earthscience has been successful in attracting national and international recognition and we are proud of the science that is developing.

With respect to our mission in education and outreach, the Arizona Center for STEM Teachers (ACST) at B2 was created through a three-year, $1.5 million grant by Science Foundation Arizona (SFAz) to establish a resource and training center that will expand the quality and retention of science, technology, engineering and mathematics (STEM) teachers in Arizona. Thirty-five STEM teachers convened this past July at B2 for the first Summer Institute of the Arizona Center for STEM Teachers, and we think the event was transformative.

As we move ahead, I wish to re-affirm our dedication to excellence in interdisciplinary research programs that address themes of water and climate, energy and sustainability as well as science and society. Along the way we are committed to training the next generation of graduate students who will truly transform the scientific process.

I look forward to seeing B2 established as one of the premier research and educational centers in the world.

Travis Huxman
Director
Biosphere 2

Biosphere 2 Visitor Admissions Continue to Rise

Visitors continue to flock to Biosphere 2 in record numbers. In its second year, attendance has increased over 33 percent with a total of 60,534 visitors (first year total was 45,520).

UA Phoenix Mars Mission Lander Mock-Up on Display at Biosphere 2

Visitors to Biosphere 2 (B2) during the 2009-2010 visitor season should be prepared for an “out of this world” experience! That’s because B2 is home to a full-size mock-up of the Phoenix Mars Lander until May 2010. Phoenix was the successful UA-led mission to Mars in 2008 that found unequivocal evidence of water on the red planet, something essential to future human visits to Mars. It was also the largest single research grant ever awarded to the University of Arizona.

More history was made when the UA hosted mission control for the mission, which no university had ever done previously for a NASA mission.

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STEM Collaboration Inspires Authentic Inquiry

The soul of science is inquiry. How do things work? What does our environment consist of? How did we get here? Where are we headed? These are just a few of the innumerable questions science seeks to answer.

Yet at times in teaching science, that sense of wonder and discovery is absent. Often it’s because teachers lack the content expertise to make science truly come alive. That’s why the Arizona K-12 Center was particularly excited to partner with the Arizona Center for STEM Teachers at their inaugural Summer Institute for Arizona’s Science, Technology, Engineering and Math (STEM) teachers at Biosphere 2 (B2).

The first Arizona Center for STEM Teachers Summer Institute, A State of Wonder, was held at the University of Arizona’s B2 Institute at B2 in Oracle, beginning July 8th. For 18 days, a cohort of 35 fourth- to eighth-grade teachers immersed themselves in the world of science. Selected from over one hundred applicants, these teachers represented a diverse range of experience, from those just beginning their practice to more seasoned educators.

The Institute offered a rich array of opportunities for bringing science alive in the classroom. Working side by side with researchers from the University of Arizona, participating teachers were exposed to the science that surrounds us. For example, they learned to assess water quality and conservation in a manner they can easily apply in school. They studied leaf sizes of plants to determine rate of growth and other characteristics. Insect traps were created to survey the area’s insect life and to identify their behavior patterns at different times of day.

Collaborating with the University of Arizona and Science Foundation Arizona’s STEM Education Center, the Arizona K-12 Center’s role was to support the Lead Teachers and provide technology training for the participants.

“The Arizona K-12 Center is absolutely central to the success of this program,” says Pierre Meystre, Director of the B2 Institute. “Not only have they been key in the selection and recruitment of the lead teachers, but they also offered superb technical training. I believe strongly that the collaboration between B2 and the Arizona K-12 Center will increase significantly in the future and develop into a very powerful tool in support of Arizona STEM Teachers.”

State of Wonder at the Biosphere

One defining aspect of the Institute was that it was a program designed by teachers for teachers. The team of teacher leaders focused the content on addressing realistic classroom capabilities. The result was a program that participants could immediately connect with.

“Everything the teachers did and learned they can apply in their classes,” says Sarah Baird, one of the teacher leaders. “It was exciting to see them get engaged and refocused on teaching science.”

In addition to working with scientists, the teachers gained important knowledge from one another as well. The Institute offered ample opportunity for quality conversation among participants on standards and how they can provide authentic teaching in science, rather than resorting to cookie cutter experiments. Each teacher prepared a digital presentation in the form of a movie, slideshow or podcast which they shared at the end of the Institute on what they learned, which they will ultimately use with their students as well.

“This was different than any experience these teachers have ever had,” says Baird. “We sent them home with everything they needed including knowledge, materials and resources to introduce this content into their classrooms. They were already good teachers when they got here. They left energized, informed and eager to apply the new ideas they picked up.”

The Institute was funded in part by Science Foundation Arizona with the goal of providing STEM training for 300 teachers over three years. Pending funding approval, plans are in the works for next year’s Institute, which will focus on K-3 grades.

“Teachers need more support in STEM areas,” says Darcy Renfro, Executive Director of Science Foundation Arizona’s STEM Education Center “and we’re working to make that available. The participants of this Institute were so enthused they wished it could have been even longer.”

Knowing how precious time is to teachers, that is quite an endorsement.

This article was originally featured in the Arizona K-12 Center August/September 2009 Newsletter.
Biosphere 2 hosts Cleveland High Schoolers

Seventy-eight high school sophomores from Cleveland-based MC2STEM High School spent a week living in residence and conducting research at Biosphere 2 (B2) in early September. The high school is a project-based, year-round, open enrollment school that emphasizes (STEM) curriculum—science, technology, engineering and mathematics.

The innovative high school, now in its second year, is the first Ohio STEM school to receive state financial support and partnerships critical to the development of STEM education. It serves Cleveland Metropolitan School District students who live in the inner city. The trip was funded by private donations, including support from the Gates Foundation, the Cleveland Foundation and the George Gund Foundation.

The students spent their week conducting hands-on research with B2 scientists on three projects: volatile gases, soil evolution, and evapo transpiration. They worked in small groups and managed their time to allow daily research activities as well as data tabulation and evaluation. At the end of the week the students presented their research findings in a university-style poster session.

“This experience underscores B2’s commitment to improving K-12 STEM education,” said Matt Adamson, B2 Program Coordinator for Education and Outreach. “While most of our activity in this area until now has been focused on supporting teachers through the B2-based Arizona Center for STEM Teachers, we hope to host more and more groups like the MC2STEM high school group in the future.”

In addition to taking part in cutting-edge research, the students were amazed by the desert Southwest, Adamson added. “Many of these students had never been out of Cleveland or traveled by airplane, so for some of them just being in the Sonoran Desert was an eye-opening experience. They saw quite a few snakes, desert insects and lizards, and even one gila monster, which really excited them!”

Interestingly, Phoenix and B2 have much in common. While Phoenix sought to discover more about the existence and fate of water on Mars, much of the UA-led research at B2 is, and will be, focused on the fate of water on our own planet. Also, both projects are large-scale and in the public eye, providing numerous opportunities to educate the community about “big science”. Thus it is fitting that B2, UA’s world-class environmental research facility should host an exhibit based on equally world-class UA planetary science endeavors.

The Phoenix Lander mock-up is situated just inside the doors of the B2 visitor center, providing an exciting visual welcome to guests as they arrive and setting the stage for the science discussed on the tour of the facility.

The mock-up of the Phoenix Lander will be on display at B2 until the early summer in 2010 when it is slated to journey to its next destination—Washington D.C.’s Smithsonian Institution.
Investigating the Interactions between Climate, Air Quality and Ecosystem Function

In the face of continued environmental change, unified progress in research, education, and outreach is critical in making informed decisions about our planet. At the Biosphere 2 (B2) trace gas lab, a new instrument has been developed to help integrate these components. A new thermal desorption-gas chromatograph-mass spectrometer (TD-GC-MS) has been configured to enable researchers, students, and tourists to investigate organic gases from within and outside B2. For example, this instrument was used by a group of Ohio high school students to study the organic chemistry of soils, plants, and oceans at B2. Two interesting discoveries are highlighted. 1) The B2 ocean is a significant source of the monoterpene Limonene to the atmosphere. While the ocean is generally not considered to be a strong source of organic compounds to the atmosphere, these results suggest that monoterpenes, possibly originating from phytoplankton, may be released in large amounts during spring blooms in the world’s oceans. In addition, as eutrophication of marine environments due to human activities continues to stimulate the growth of phytoplankton blooms, emissions of reactive organics such as monoterpenes from these blooms may increase. 2) Plants produce and release a large number of hydrocarbon compounds often found in fossil fuel. For example, emissions of butane, octane, and many other straight- and branched-chain hydrocarbons were discovered from desert and rainforest plants. As energy demands increase globally, increased attention should be paid to vegetation as natural sources of biofuels.

The main research goal of the trace gas laboratory at B2 is to advance our understanding of ecosystem gas-exchange processes in a changing environment through observations and experiments. Towards this broad goal, Dr. Kolby Jardine, B2 Assistant Research Professor, is developing analytical techniques to measure volatile organic compounds (VOCs) in the gas phase. The ecological importance of VOCs are immense and range from plant growth and maintenance, carbon and energy metabolism, defense against herbivores and pathogens, plant-plant and plant-insect communication, and protection against abiotic stress (desiccation, UV radiation, etc.). Many compounds are highly volatile and remain a gas once they enter the atmosphere. However, some have lower volatility and can condense in the atmosphere to form small particles known as aerosols. Aerosols can have a dramatic influence on climate and air quality. Organic aerosols provide a cooling effect by scattering incoming solar radiation, and they can influence precipitation dynamics by allowing for the formation of cloud droplets. These effects may lead to enhanced precipitation and cooler air temperatures. However, many of the organic gases and the aerosols they form are harmful for humans to breathe and reduce atmospheric visibility.

While many forests have been studied for VOC emissions, deserts have practically been ignored. To better understand the importance of deserts, a summer-long field experiment aimed at investigating VOC emissions from a creosote bush-dominated ecosystem south of Tucson, AZ in the Santa Rita Experimental Range (SRER) was carried out. This site was chosen because creosote bush occupies an area of more than 400 million acres in North America alone. Preliminary results suggest that during the wet seasons, creosote bush manufactures a rich suite of VOCs, many of which have never previously been observed from any ecosystem. While they produce many of the same compounds found in pine and broadleaf forests like terpenoids and oxygenated VOCs, a diverse set of other compounds are also produced and released. However, understanding the ecological and atmospheric impacts of these “new” compounds remains a major research challenge.
Green Roofs in Arid Ecosystems

One of the most profound transformations that accompany urbanization is an alteration of energy and water budgets by constructed surfaces in the built environment. Urban heat islands emerge in cities as constructed surfaces absorb heat during the day and radiate it back out at night, increasing energy demands for cooling, and also increasing the likelihood that people will have adverse health effects from higher temperatures. Impervious surfaces cause urban hydrology to be extremely flashy. Green roofs, the incorporation of growing plants in a soil medium on building roofs, are becoming increasingly popular throughout the world. Green roofs may result in reduced energy use and storm water management, and may also provide new wildlife habitats in cities.

Green roofs are classified as extensive (covering relatively large areas and requiring minimal soil and maintenance) or intensive (requiring more soil to grow larger plants, and more maintenance). Because of their larger areas, the environmental benefits tend to be more significant with extensive green roofs. Most extensive green roofs have been built in temperate environments, where climatic conditions allow rooftop vegetation to be maintained in shallow soil, sometimes without irrigation. Little is known about extensive green-roof performance in arid regions, primarily because of our lack of understanding of the amount of water required to maintain healthy green-roof vegetation and the consequences of this water’s weight on the structure supporting the roof.

Dr. Mitchell Pavao-Zuckerman is collaborating with Ron Stoltz, Director of the UA School of Landscape Architecture, Dr. Margaret Livingston, faculty in Landscape Architecture, and Dr. Steven Smith, faculty in the UA School of Natural Resources and the Environment, to investigate various soil types, irrigation regimes and plant species for use with extensive green roofs in Tucson. A series of small free-standing model green-roof plots are being constructed on the Biosphere 2 (B2) lawn that will address several questions, including, (1) Can plants be sustained under conditions with limited or no supplemental irrigation? (2) Will the proposed design meet appropriate weight/structural requirements for most roof constructions in this climate? (3) Using this design, what is the potential to mitigate the urban heat island, i.e., what are microclimatic effects? Researchers will monitor plot weights, temperature, energy fluxes, and plant survival, growth, and evapotranspiration rates to calculate energy and water budgets for the model green roofs.

To further B2’s outreach mission as the place where science lives, the visiting public at B2 will be encouraged to help collect data as well as measure and monitor the research plots by the research team. Hands-on data collection and interaction with scientists is thought to be a strong tool to help non-specialists understand the nature of uncertainty and variability in scientific data, as well as provide a more immediate context for broader concepts related to climate change and Earth system sciences. This project will continue B2’s use of model systems to understand the natural world, extending this mission into the ecology of the built environment.

Climate Change and Vegetation Shifts

Climate-change models predict that many arid regions around the world—including the North American deserts—will be affected more frequently by recurrent droughts, further reducing the capacity of these landscapes to slow down anthropogenic increase in atmospheric CO₂ and the associated global warming. On the other hand, these regions are experiencing rapid vegetation transformations resulting from the complex interaction among several factors including climate change, increase in CO₂ concentration and anthropogenic disturbances. Thus, understanding the ecohydrological processes driving large-scale vegetation shifts (such as invasion by exotic grasses), in the context of rising temperatures and recurrent droughts are fundamental to global change research.

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Bringing the World’s Oceans to Tucson

Imagine this: the oxygen in every other breath you take comes from organisms living in the ocean. How might that be affected by climate change in the years and decades ahead? Tara Oceans, a global scientific research expedition on the oceanographic schooner Tara, will spend three years cruising and studying the world’s oceans trying to answer this and many other ocean-specific questions. Among many other tasks, researchers on the vessel will be measuring the ocean temperature at different depths and studying everything from viruses to coral reefs.

Dr. Matthew Sullivan, Assistant Professor in the UA Department of Ecology and Evolutionary Biology and Biosphere 2 (B2) research scientist, is the scientific coordinator for viruses on the Tara expedition. Additionally, Sullivan is one of only three scientists in the United States involved with this far-reaching research voyage.

Dr. Sullivan’s Tucson Marine Phage Lab conducts research in B2’s ocean biome. This involves sampling and collecting data on viruses in the B2 ocean. There are several goals of the Tara Oceans/B2 partnership. A permanent exhibit at B2 about Tara is under development, and high school and middle school curricula about Tara’s voyage and the ocean in particular are also being prepared.

Tara Oceans launched its voyage on September 4 from the coast of France and on Saturday, September 5, a launch party was held at B2. Hands-on activities were available for visitors along with opportunities to watch and ask questions of scientists collecting samples in the ocean biome.

At Biosphere 2 (B2), postdoctoral researcher Sujith Ravi’s research is case in point. In collaboration with B2 scientists Travis E Huxman, Javier F. Espeleta, Katernia Dontsova and graduate students Juan Villegas and Henry Adams, Ravi is investigating how the altered ecohydrological feedbacks resulting from exotic grass invasion may drive shrub-native grass systems to an irreversible desertified state. The desertification mechanism they recently proposed suggests that two major drivers of global environmental change, biological invasions and climate change, may act in concert and amplify each other’s effect on land cover and soil resources. Many invasive grasses have the ability to alter their morphology and physiological processes in response to environmental changes even in low-resource environments, allowing them to survive in unfavorable environmental conditions and to invade these landscapes in years of high-resource availability. However, the long-term persistence of invasive grass cover may be restricted as a result of low-frequency recurrent droughts, which displace plant species that have not evolved in this regional climatic context. This could lead to desertification following extensive invasion.

To validate this desertification mechanism, the researchers are designing manipulative experiments in B2 to investigate the impact of droughts, rising temperatures on native and invasive grass communities and how these communities partition resources (soil moisture, nutrients) in these changing environmental conditions. B2 provides researchers an adaptive tool to conduct experiments under controlled conditions to investigate the physiological processes that facilitate the invasion of native grasslands and shrublands. Under ambient and simulated environmental conditions (future warming scenario) in B2, the group plans to compare the physiological (photosynthesis, respiration, water-use) responses of both above- and below-ground tissues of native and invasive grass communities, using leaf gas-exchange analyzers and root observation cameras (‘minirhizotrons’). Further, they will investigate, using isotopic tracers, how the plant communities partition resources like nitrogen and how resource-use patterns change with rising temperature. The group also plans to monitor the physiological responses, resource use patterns and mortality of these plant communities under moisture stress conditions to simulate a global-change-type drought. B2 will greatly enhance the ability of researchers to better understand these processes by eliminating many of the confounding factors, that make these types of experiments challenging under field conditions. Through cross-disciplinary collaborations enabled by B2, this project will relate earth surface science to the dynamics of biological systems to better understand and model the complexity of ecohydrological processes in dryland systems. The findings of these experiments will provide valuable inputs to ongoing modeling studies and the design of large-scale field experiments in future.
Mt. Lemmon SkyCenter

Mt. Lemmon SkyCenter, Biosphere 2’s (B2) partner at the summit, is ramping up its programs this autumn. Building on the success of SkyNights and DiscoveryDays, SkyCenter will offer Saturday programs through October and continue the SkyNights night-time observing year-round. Installation of a new 32-inch telescope is scheduled for later this fall. The Schulman 32-inch telescope will be one of the largest instruments available for public programs in the nation. SkyCenter will continue its connection to B2 with the new telescope, which will be available to B2 visitors for remote night-time viewing.

The DiscoveryDays program, held on alternate Saturdays during the summer, will hold two more programs in October at the summit: How hazardous asteroids can ruin your day, and How the Catalina Mountains rose above from far below. The season’s final DiscoveryDays will move to Sabino Canyon, where participants will build Galileoscopes and launch a monthly evening observing program with Steward Observatory’s Astronomy Club.

For more information about programs, visit the website, skycenter.arizona.edu or call 520.626.8122.

Hold Your Next Conference at Biosphere 2!

Located in the beautiful Catalina Mountains foothills, the Biosphere 2 (B2) campus provides a non-traditional venue that facilitates interaction. The setting is ideal for workshops, conferences, retreats, extended programs, and outreach activities.

The facilities of the B2 Conference Center comprise a Campus Village of 28 rustic Santa Fe-style houses holding 106 double-capacity sleeping rooms and a number of double-occupancy offices. Most facilities offer fast Internet access. All meeting rooms are equipped with white boards, LCD projectors and Wi-Fi. Traditional viewgraph projectors are also available upon request. Eight meeting rooms are available in various sizes to accommodate both large and small groups; the smaller meeting rooms can serve as breakout rooms. In the near future we plan to offer the use of a fitness center to overnight guests. Only group reservations are taken at this time.

To learn more about the conference facilities, room and meeting rates, meals, or to make a reservation, please contact Val Kelly at 520.838.6154 or via email at vkelly@email.arizona.edu. You may also visit our website at b2science.org.

Participants cored trees to learn about their history on Mt. Lemman at DiscoveryDays’ Dendrochronology Program in September.

A dim galaxy in the constellation Cepheus. Photo: Adam Block/Mt Lemmon SkyCenter/ University of Arizona.

Hold Your Next Conference at Biosphere 2!
Biosphere 2 Announces the Creative Science Writing Internship

In May 2009, B2 initiated the Biosphere 2 (B2) Creative Science Writing Internship for UA Creative Writing MFA students in poetry, fiction, and creative nonfiction. The goals of the program are to: (1) increase the intern’s knowledge of the scientific process and research conducted at B2; (2) improve the student’s research skills, as well as her/his skills in constructing engaging forms and narratives for the presentation of scientific research; and (3) disseminate understanding of science and B2 to a wider audience. Run as an eight-week program in summer 2009, the program was administered by faculty from B2 (Dr. Mitchell Pavao-Zuckerman) and the UA Creative Writing Program (Fenton Johnson and Alison Demming). Esme Schwall, MFA student in fiction writing, served as the 2009 intern and uses B2 as a setting for observation and investigation related to her own interests in writing and science. You can follow Esme’s observations and interpretation of B2 science on her blog: http://wheresciencewritinglives.wordpress.com.

How You Can Help

Biosphere 2’s cutting-edge work depends on people who care about our environment and the science that helps us make informed choices. We hope you will consider becoming involved in any of the following ways.

1. Learn more about the many research projects taking place under the dome. You can see some of our ongoing research through our live webcam.

2. Take a tour of Biosphere 2. We are open every day from 9:00 to 4:00 except Thanksgiving and Christmas. Tours last approximately one hour and take you through the human habitat area where Biospherians lived and through each of the biomes. You will also have a chance to meet and talk with research scientists working onsite.

3. Become a member. There are many different levels of membership that provide benefits for you and support our work.

4. Attend a Science Saturday for a hands-on experience in science! Learn about bird species in the Southwest through an on-site birding experience, gain a new appreciation for insects and handle live ones, or participate in physics activities and demonstrations that show how water moves through urban environments.

5. Make a donation. Any gift is appreciated and can be designated to the Biosphere 2 activity or research project that matters most to you.

For more information on any of the above, visit our website: www.B2science.org.