CAP LTER V 2025 ANNUAL REPORT TO THE NATIONAL SCIENCE FOUNDATION

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Report to the National Science Foundation

Contents

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REPORT TO THE NATIONAL SCIENCE FOUNDATION

GOALS OF CAP LTER V

- Use field ecological and social observations and experiments requiring long-term perspectives to understand how human-environment interactions are mediated by urban ecological infrastructure (UEI) to shape the social-ecological urban ecosystem.
- Develop and use models and scenarios through participatory, community-based strategies.
- Advance urban ecological theory while contributing new theory derived from our transdisciplinary research.
- Promote and strengthen a transition to secure environmental future for all Phoenicians using broad approaches.
- Build and use transdisciplinary partnerships to foster resilience and enhance sustainability in urban ecosystems while contributing to the education and well-being of urban dwellers of all types, ages, and experiences.
- Adaptively manage our research and how we frame our work with communities of practice.
- CAP V research will be organized around five interdisciplinary questions that will use and build on 19 long-term datasets and experiments in a fully integrated and synthetic research platform.

KEY RESEARCH ACTIVITIES

Long-term Observations and Experimentations

Ecosystem Response to Urban Atmospheric Deposition (DesFert experiment)

- 15 sites: Five west of urban area in desert parks, five east of urban area in desert parks, and five in urban core in desert remnant parks.
- Treatment plots fertilized with nitrogen (as ammonium nitrate) and/or phosphorus (as triple super phosphate)—winter and spring, all fifteen sites since 2006.
- Atmospheric deposition measurement—collected and analyzed quarterly at six sites.
- PRS™ probes (Western Ag Innovations Inc., Saskatoon, Canada) deployed in rainy season and analyzed for NO_3^- and NH_4^+—winter and summer (monsoon) seasons at nine sites.
- *Larrea tridentata* (creosote) growth measured during spring and fall at nine sites.
- *Larrea tridentata* (creosote) leaves collected for CHN analysis—spring and fall at nine sites.
- Percent composition of annuals recorded in subplots; aboveground material harvested from different subplots, and dry mass determined for harvested material—spring at nine sites.

Arthropods

- Twelve sites, including long-term desert sites (open desert and desert remnant) and residential sites (mesic and xeric yards) that coincide with birding locations.
- Eight additional sites at McDowell Sonoran Preserve, a citizen science partner.
- Ten pitfall traps per site.
- Traps are set quarterly and collected 72 hours after setting. McDowell Sonoran Preserve sites are collected during the summer.
- Arthropods stored in 70% ethanol (one jar for each trap) and identified in the lab.

Bird Monitoring

- 70 points monitored in winter and spring at residential, desert, desert park, and riparian (Salt River) locations.
- 36 of these points located in Phoenix Area Social Survey (PASS) neighborhoods (three per neighborhood).

- Point count surveys by professional bird surveyors—all birds recorded that are seen and heard within a 15-minute window.
- Each point visited independently by three different surveyors during each season.

Bird Monitoring—Salt River Biodiversity Project

- 7 sites monitored quarterly, with each site monitored at six points.
- Point count surveys by professional bird surveyor—all birds recorded that are seen and heard within a 15-minute window.

Herpetofauna Monitoring—Salt River Biodiversity Project

- 7 sites monitored three times a year—spring, summer, and fall.
- Nine 10 m x 20 m plots per site.
- Two surveyors concurrently survey each plot for presence of herpetofauna.

Stormwater

- Water collected from ISCO stormwater samplers at three locations along Indian Bend Wash (IBW): one long-term site at the southern outflow of IBW and at two sites further upstream in the IBW watershed.
- Discrete, time weighted sampling of runoff producing storms.
- Water analyzed for organic matter, total nitrogen, total phosphorus, dissolved organic carbon, total dissolved nitrogen, cations, and anions.
- Fluxes calculated by combining concentration and water flow data.

Regional Drinking Water Quality Analysis

- Water collected monthly at 5 locations in major influent reservoir systems.
- Water analyzed in lab for nutrients, major cations and anions, pH, temperature, specific conductance, DOC, taste and odor compounds, and particulate matter.

Eddy Covariance Tower

- Two towers, one located the Maryvale Neighborhood, the other at the Desert Botanical Garden.
- The Botanical Garden Tower houses sonic anemometer, infra-red gas analyzer, and temperature/humidity sensor to measure high-frequency (10 Hz) 3-D wind, CO_2 (flux), temperature (flux), and moisture (flux).
- New sensors for the Maryvale tower were purchased by the Southwest Urban Corridor Integrated Field Laboratory.

- 10 Hz data is downloaded monthly in person, with a wireless data transfer system currently in production.
- Data is currently being retrieved and processed by the Vivoni Lab.

Microclimate Towers

- Two 10-m towers, one located in desert remnant park within urban area, the other located in outlying desert park.
- Towers house sensors to measure temperature/relative humidity, horizontal wind speed and direction, incoming solar radiation, and precipitation. Data downloaded quarterly.

Earth Networks Weather Station and Greenhouse Gas Analyzer

- CAP LTER hosts this system on eighth-floor roof of ISTB4 building at Arizona State University.
- Weather station provides real-time weather observations for 27 parameters, including temperature, relative humidity (dew point calculated), barometric pressure, wind speed and direction, and precipitation.
- 360-degree weather camera provides weather-related photos to Earth Networks website and local news station.
- Previously, a Picarro greenhouse gas analyzer provided real-time measurements of carbon dioxide and methane (removed in April 2023).

Tres Rios Constructed Wetlands

- Bi-monthly field visits.
- Measurements and samples are taken along two gradients representing the two hydraulic pathways of the treatment cell: whole-system, from inflow to outflow, and within the vegetated marsh proper, from the open water-marsh interface to the shoreline, along 10 permanent transects.
- Measure aboveground primary productivity (biomass) of marsh vegetation, foliar and soil nutrient content, and water quality to produce whole system nutrient budgets, and transpiration and evaporation to produce whole system water budgets.

Tempe Town Lake Biogeochemistry

- Water samples collected every two weeks and after rain events and analyzed for temperature, conductivity, dissolved oxygen, pH, chlorophyll a, inorganic nutrient and DOC concentrations, and DOC fluorescence.
- Eureka Manta+35 multiprobe datasonde deployed in Tempe Town Lake in June 2018. Sensors measure temperature, conductivity, turbidity, pH, dissolved oxygen, chlorophyll a, DOC concentration, and CDOM/*f*DOM at 30-minute

intervals. Datasonde is removed monthly form TTL and brought back to lab for cleaning, data download, and sensor calibration.

Significant Results

- **DesFert Data**
  - A master's student is analyzing the DesFert deposition and PRS probe data to investigate temporal patterns in deposition and soil nutrients. An overall goal is to investigate potential impacts of the "anthropause" during the COVID shutdown.
  - N deposition exhibits high annual variability, influenced by precipitation but not directly related to number of cars on the road. The "anthropause" in NO_3^- deposition during the COVID shutdown (2020-2021) interacts with annual variability in precipitation to extend the period of reduced soil NO_3^- following a wet year.

- **Black widows and the urban heat island (Clark & Johnson, 2024)**
  - This study investigates how the urban heat island (UHI) effect influences the thermal microclimate of Western black widow spider webs (Latrodectus hesperus) over a year. They compared web temperatures between urban and desert habitats, finding that urban webs were 2-5°C warmer than desert webs at night, particularly during spring. This nighttime UHI effect was less pronounced in winter. Additionally, a spider's boldness correlated positively with web temperature, but no significant relationship was found with voracity, web size, or body condition. Understanding these microclimatic variations is crucial for predicting how urbanization and climate change impact urban biodiversity and ecosystem functioning.

- **Dynamic avian habitat use and implications for future coexistence**
  - CAP researchers analyzed long-term drivers of bird communities by combining newly produced long-term seasonal datasets of environmental conditions (urbanization, vegetation, climate) with avian point-survey data collected across the rapidly developing metropolitan region of Phoenix, AZ during the same periods (spring; 2001-2016)
  - Results show that, on average, bird species presence was negatively associated with impervious surface area, with seasonally variable temperature and vegetation influencing site use across the gradient of urbanization.

- **Effect of Urbanization on Bats (Dwyer et al, 2024)**

- This research examines how bats respond to urbanization across seasons and various levels of urban development. Lewis et al. studied fourteen bat species in the Phoenix metropolitan area, Arizona, using acoustic monitors over four seasons. They found that bat species responded differently to urbanization, with some avoiding urban areas and others thriving in them. Contrary to predictions, most species did not change their urbanization response across seasons. However, resource availability, such as food and water, played a significant role in their behavior, especially in summer. The findings suggest that bat conservation strategies should focus on maintaining resources in urbanized areas for tolerant species and preserving high-quality, low-disturbance habitats for sensitive species.

- **Urbanization and climate drive long-term bird community trends across a desert city ecosystem.**
  - We analyzed long-term drivers of bird communities by combining a two-decade, multi-season spatial dataset of environmental conditions (urbanization, vegetation, temperature, etc.) with biotic data (species richness and abundance) collected seasonally during the same time periods (winter and spring; 2001-2016)
  - Results show that impervious surface area and land surface temperature have generally increased across the study period and were negatively associated with overall bird abundance and species richness, especially during winter.

- **Carbon Sink & Learning Forest**
  - Monitoring the carbon sequestration in plant and soil pools in the University Sustainability Program's Carbon Sink & Learning Forest that was planted at ASU's West Valley Campus. Measurements will continue (for decades, hypothetically) by an ENV 410 Soil Science class.
  - No significant increase in C storage has been measured yet. While not all mesquite saplings have survived (expected mortality), those that are surviving are not yet growing much aboveground biomass. Measurements will continue!

- **Urban Nature Interactions and Human-Wellbeing (Mitchell et al. 2023)**
  - Starting in 2021, Larson and MA student Abby Mitchell began analyzing data from 2021 Phoenix Area Social Survey (PASS) to understand how nature interactions changed during COVID, and how those and other nature interactions--along with local environmental and social factors--affect different dimensions of human wellbeing.

- This research (Mitchell 2023) demonstrates that distinct aspects of wellbeing have different drivers, and multiple local environmental and social features should be considered when designing healthy communities for urban sustainability. Specifically, while perceived social and environmental attributes of neighborhoods and proximity to desert preserves had a more significant impact on subjective wellbeing than nature recreation, age and park visitation largely influenced physical health and socio-demographic factors impact mental health. Changes in nature recreation during the COVID-19 pandemic did not significantly impact any dimensions of wellbeing among the survey sample.

- **Human-Snake Interactions (Larson et al., 2024a and Larson et al. 2024b)**
  - Larson et al. (2024a) identified three distinct motivations for snake removals: perceived threats associated with venomous snakes, generalized fear of snakes based largely on negative attitudes, and conservation intentions grounded in the view that snakes are ecologically valuable. Larson et al. (2024b) found that residents who paid to have snakes removed from their property have significantly more positive attitudes towards snakes and believe it is morally wrong to kill snakes. Further, while attitudes affected norms, experiences with snakes in nature and otherwise were the primary driver of attitudes.

- **Park Equity (Larson et al., In Review)**
  - Through analysis of PASS data, we found that park visitation varies in complex ways depending on the type of parks visited (e.g., neighborhood parks vs. desert preserves). However, residents' perceptions of local recreational opportunities were more important than proximity to parks and other objective measures. Latino and Black residents also visit parks less frequently than White residents, depending on the type of park involved.

- **Models for planning multifunctional and equitable green infrastructure to mitigate rising stormwater and heat risks in cities**
  - This project unpacks current green infrastructure planning knowledge systems in US cities, including key actors, information, and processes and aims to develop decision support tools for spatial planning of green infrastructure to maximize stormwater and heat mitigation. This includes interviews with local officials and spatial modeling for 3 case study cities, one of which is Phoenix, and a national survey of US cities.

- **Residential Landscape Change (Zhu and Larson, 2024)**

  - Starting in 2021, Larson and PhD student Qinnan Zhu began analyzing data from the Wheeler et al. survey, in addition to 2012-2021 PASS data to better understand vegetation changes, associated drivers, and their implications for urban/landscape sustainability.
  - We found a sustainable trajectory of residential vegetation changes in Phoenix since mid-2010s, with a static change declining additions of grass and potential increases of in trees and desert plants across residential neighborhoods (Zu and Larson, in review). Aesthetics was an influential driver of both tree planting and native gardening. Additionally, tree planting was associated with low-maintenance needs, while desert plant additions reflected the appreciation of nature and wildlife.

- **Determining introduction pathways of an introduced lizard in Phoenix (Bateman et al. In preparation)**
  - Performed visual encounter surveys of introduced lizard populations, sequenced mitochondrial genes from sampled lizards, and performed population genetic/phylogenetic analyses of genetic data to identify source of introduced populations.
  - We found that populations of introduced ocellated skinks in Mesa and Phoenix were likely introduced independently from the pet trade and are distinct from other introduced populations of these lizards in California. Overall, introduced populations appear to be derived from genetically distinct source populations from the Mediterranean.

TRAINING AND PROFESSIONAL DEVELOPMENT

- CAP's activities in the area of training and professional development are three-fold: 1) We actively promote and encourage training and professional development for faculty, staff, and students; 2) we work with the Julie Ann Wrigley Global Institute of Sustainability and Innovation, the LTER Network Communication Office, and others to design and deliver training and professional development activities to the CAP community; and 3) we design and deliver training and professional development for various stakeholder groups, including teachers, citizen scientists, and practitioner partners.

- During summer 2024, CAP continued our Integrated Summer Research Experience for Undergraduates (REU). This year, we brought seven REU students together in bi-monthly seminars to share their research and engage in discussions about interdisciplinary research, career and graduate school planning, and science communication. We involved graduate students in these

sessions, when possible, to promote near-peer mentoring, learning, and engagement.

- In 2023, Luke Ramsey-Wiegmann, a PhD student in the School of Sustainability, took over as leader of the CAP Student Group, which he has continued to build and develop. They have also organized events to increase networking opportunities for ASU students interested in CAP LTER-related work, including a monthly CAP community coffee hour.

- ASU's Wetland Ecosystem Ecology Lab (WEEL) is highly integrated into CAP. The WEEL spearheads our research at the Tres Rios Constructed Treatment Wetlands and in other urban wetland systems. The City of Phoenix built these wetlands as an alternative to traditional wastewater treatment, and Tres Rios has become a living laboratory for high school, undergraduate, and graduate students who want to experience urban field and lab research for the first time. All field work at Tres Rios in the eight and a half years of the WEEL lab has been done by student volunteers.

- CAP encourages students, staff, and faculty to participate in research conferences and symposia as part of their professional development. Each year, CAP funds students and faculty to present their research findings at the Ecological Society of America's conference, the American Geophysical Union's annual meeting, as well as other conferences and events. Other conferences and events where CAP researchers presented their findings in 2025 included the International Long-Term Ecological Research Open Science Meeting, the Annual Conference of the German Ecological Society, and the International Society of Exposure annual meeting.

- CAP's annual All Scientist Meeting in January 2025 attracted over 100 participants, including more than 30 poster presenters, including 22 students and we anticipate similar attendance and participation in January 2026.

DISSEMINATION

- In 2024-25, CAP students and scientists published a total of 14 peer-reviewed journal articles with an additional fourteen in review. Our journal publications span the biological, physical, engineering, health, and social sciences as well as landscape architecture and urban planning and include journals such as: Urban Ecosystems, Sustainability, Human Dimensions of Wildlife, Landscape and Urban Planning, The Journal of Ornithology, Frontiers in Ecology and Evolution, and PLOS One.

- As noted earlier under Opportunities for Training and Professional Development, CAP actively supports students, staff, and faculty to attend professional meetings and research symposia to present CAP research. In addition to the 30+ poster presentations at the January 2025 CAP All Scientists Meeting, CAP scientists and students have made 39 other presentations at national and international conferences with the scientific community during this reporting period.

- As part of our NSF virtual site visit in May 2021, we created a series of virtual site visits that allowed our reviewers to experience and learn about the work we do at different sites across the CAP area. These videos can be found on our recently revamped website, which houses publicly digestible information such as these videos. Link: https://www.youtube.com/playlist?list=PLmV7x-JlhKmqbrOVCly_cGZpaa8HC34-h

- Every year, we hold our annual All Scientists Meeting and Poster Symposium (ASM) off-campus at ASU's Skysong facility in Scottsdale, which is located north of the ASU Tempe campus. We will continue this tradition for our 28th ASM on January 16, 2026. Our ASM's agenda includes a "State of the Program" update from Dr. Becky Ball. She also gives out CAP Service Awards to individuals who have made great contributions to CAP LTER. At our last event in January 2025, we honored:

    - Dr. Dan Childers, for his leadership of CAP LTER from 2016 – 2024.
    - Ms. Monique Franco, for her outstanding engagement activities with the CAP community.

- Our staff has offices in The Wrigley Center for Planetary Health and the Goldwater Center on ASU's Tempe campus. Both include facilities for large and small meetings, most of which have large screens that allow us to connect with our collaborators remotely.

PLANS FOR 2025-26

- We will continue our work based on the goals of CAP V. To expand our urban air quality and environmental conditions work and our work with the communities of greater Maricopa county.
- Additionally, two long term monitoring projects are approaching in the coming annual cycle:

    - The PASS, is conducted once per funding cycle, scheduled for 2026. The sampling design is a random sample of residents in neighborhoods within the CAP LTER study area. Co-PI Larson leads this effort and is already preparing for the work.
    - The Ecological Survey of Central Arizona (ESCA), in which we document environmental heterogeneity in both space and time at 204 re-visited sampling sites, will next be conducted in 2027, Preparations for this large field effort will begin during the next annual cycle.
- The 28th annual CAP LTER All Scientists Meeting and Poster Symposium will be held at ASU Skysong on January 16, 2026.
- We will be conducting a self-study of the first three years of our grant.

IMPACTS

Impact on Main Discipline

Early on in CAP, we along with our colleagues at the BES LTER Program were initiators of a conceptual expansion of urban ecology from a discipline examining ecology ***in*** the city to a more holistic approach of understanding the ecology ***of*** the city (Pickett et al. 1997; Grimm et al. 2000). CAP continues to contribute significantly to the theory and practice of urban ecology as evidenced by our publication record. The CAP program has published 681 journal articles, 13 books, and 117 book chapters since 1998. CAP research is copiously cited in numerous edited volumes on urban ecology that have been published over the past ten years (e.g., Douglas et al. 2011; Elmqvist et al. 2013; Gaston 2010; Lepczyk and Warren 2012; Marzluff et al. 2008; McDonnell et al. 2009; Niemela et al. 2012; Pickett and Cadenasso 2013), and many have CAP scientists as chapter authors. Recent textbooks on urban ecology also discuss CAP's work in the Phoenix region (Adler and Tanner 2013; Douglas and James 2015; Francis, Millington, and Chadwich 2016; Forman 2014; Parris 2016). CAP scientists have published papers that expand urban ecological theory into the realm of a transdisciplinary and translational ecology for cities (Childers et al. 2014, 2015; Pickett et al. 2016), into linking urban ecosystem services to urban resilience (e.g., Grimm et al. 2016; 2018), and on the concept of urban ecological infrastructure as a social-ecological bridge for translational urban ecology (Childers et al. 2019).

Impact on Other Disciplines

While CAP remains a fundamentally ecological research program, CAP research has always been an inherently interdisciplinary endeavor, and thus have contributed to shaping urban ecology as a collaborative field that includes perspectives, theories, and research from across the natural, physical, social, design, and engineering sciences to investigate the complexity of social-ecological processes in urban areas. During the 2024-2025 reporting period, we had over 50 faculty members, and 60 student researchers actively engaged in CAP research from 12 different academic units/disciplines at ASU and at 12 institutions beyond ASU: University of California-

Berkley, Davis, and Irvine, University of Massachusetts at Amherst, Bowling Green University, Georgia State University, University of Georgia, University of Oklahoma, Barnard College, University of New Mexico, Pace University, and Northern Arizona University.

As such, CAP's contributions outside of urban social-ecological research are often at interfaces among disciplines. In fact, most of CAP's contributions to urban systems science are beyond the disciplines of ecology and urban ecology.

Impact on Development of Human Resources

At the end of Summer 2023, our Lab Manager, Marisa Masles, retired after more than 10 years with CAP. We replaced Marisa with Yi Ren, an ASU graduate who recently completed his MS degree in environmental chemistry. CAP LTER employs nine staff members, bringing and developing expertise across analytical chemistry, field methodology, taxonomy, program management, and data management. CAP Lab Manager Yi Ren has developed a volunteer program that allows new ASU undergraduate students to gain experience in working in a functioning science lab. The program will launch sometime in 2025.

This reporting period also saw a switch at CAP LTER program director. After 8 years as PI, Dr. Dan Childers stepped down in late 2024 and was replaced by Dr. Becky Ball. Dr. Ball has been involved with CAP since she arrived at ASU in 2010 and worked closely with PI Childers over a year of the transition period. Additionally, Dr. Kelli Larson, CAP's Lead Social Scientist, is working with PI Ball as Associate Director, highlighting the role of social sciences in urban ecology through a formal integration into the leadership structure.

CAP LTER Research Experiences for Undergraduates (REU) Program

For our summer REU program, we actively recruit students from across the broad demographics of students represented at ASU. Our 2024 REU students included:

- Arshonne Cazares: "Connecting local river narratives for watershed-scale transformation of the Rio Salado" (Mentors: Clark, Grimm, and Kuhn)
- Lexi Cegielski, Sharika Kapur, and Sophia Ruger: "Expanding residential wildlife gardens in metro Phoenix and Arizona: A partnership between CAP/ASU and the Arizona/National Wildlife Federation" (Mentors: Ashley, Larson, Lerman, and Phillips)
- Raisa Mahmud: "Understand design and decision-making of constructed treatment wetlands in arid cities" (Mentors: Childers and Ramsey-Wiegmann)
- David Nguyen: "Exploring Aquatic Primary Productivity of Tres Rios" (Mentors: Childers and Hernandez)
- Taylor Somyk: "Determining introduction pathways of an introduced lizard in Phoenix" (Mentor: Barley)

- Simone Vega Rabelo: "Trash-removal by Urban Birds" (Mentor: Bateman)

These eight students bring the total number of REU students supported with NSF funding since 1998 to 102. Many of these students have gone onto graduate school in traditional STEM fields and the in newer field of sustainability, and others have moved on to STEM-related careers.

CAP held our Integrated Summer REU program for the eighth straight summer in 2024. This program brings together a critical mass of students— eight in total for 2024 — to share research across traditional academic boundaries. The participating students connected in person or remotely via Zoom for five meetings covering topics such as interdisciplinary research, post-graduate career and education planning, and science communication. The final session involved each student giving a short presentation on their research and experiences. Feedback from students afterward indicated that they appreciated these meetings and that the REU experience had left them with very positive impressions about post-graduation academic degrees and STEM careers. For many students, this was the first time that they had conducted research and the first time that they had engaged in research-related discussions across disciplinary boundaries. Further feedback from students and faculty will assist us in planning for our Integrated Summer 2025 REU program.

CAP LTER Graduate Grants

The long-running CAP Grad Grants Program has been a model structure for supporting graduate student research for many years. Students submit short proposals for funding early in the year, and we convene an NSF-like panel of students who were funded by the program in the previous year and postdocs. The students review the proposals and discuss them in the panel, with the result being recommendations on funding to the Director. This model is one of many ways that CAP trains the next generation of academic and agency scientists on how to write and review proposals effectively. The response to this process by our students has been overwhelmingly positive, and both the CAP Grad Grants Program, and this review process have become models across the LTER Network. In 2024, our CAP Grad Grants Program competitively awarded $34,285 to support the research of four graduate students:

- Ethan Crockford: "Assessing Water Quality of the Salt River - An Analysis of an Urban Aquatic Ecosystem in an Arid Environment" (Mentor: Childers)
- Josh Gilman: "Interactive influences of climate change, water availability, and policy on dryland urbanization: A case study of the Phoenix Metropolitan Area" (Mentor: Jianguo Wu)
- Gisel Guzman Echavarria: "Decoding the Individual Heat Experience: Assessing Personal Heat Exposure, Adaptative Responses, and Non-Life-Threatening Health Outcomes." (Mentors: Middel, Ravanelli, Rosales-Chaves, and Vanos)
- Julia Hernandez: "Wildlife habitat use and activity along a human-modified river corridor" (Mentor: Bateman, Childers, and Lewis)

- Mariah Patton: "Soil Microbial Responses and Thresholds to Nitrogen Fertilization in the Sonoran Desert" (Mentor: Collins)
- Morgan Pierce: "Rodent genetic diversity and gene flow across urban desert remnants in metro Phoenix" (Mentors: Hall and Upham)
- Luke Ramsey-Wiegmann: "Flooding, Flowing, and Frying: How does climate-driven compound disturbance in the Salt River shape urban wetland ecosystems?" (Mentor: Childers)

Impact on Teaching and Educational Experiences

Our Ecology Explorers program is our major vehicle for engaging with K-12 students, teachers, and the public. The Ecology Explorers team has participated in statewide and national meetings and conferences for science and environmental educators to find ways to prioritize pathways for systemically excluded groups.

Impact on Physical Resources that Form Infrastructure

The 6400 km^2 study area of CAP includes all the Phoenix metropolitan area as well as surrounding desert. Because of the vast scale of our research endeavor, CAP's provisioning of field vehicles for research has always been essential for the collection of long-term data, for student research, and for more targeted experiments and investigations in our urban and peri-urban areas. CAP Site Manager Quincy Stewart ensures that the vehicles are maintained and that researchers undergo the appropriate ASU training to use the vehicles, and that vehicles are used properly. In 2023 CAP took delivery of the first electric vehicle (a Nissan Leaf) in our fleet.

Shared instrumentation in the Metals, Environmental and Terrestrial Analytical Laboratory (METAL) allows CAP staff and researchers access to equipment and training to conduct analyses. As well, CAP research helps support the maintenance of these equipment that are then available to the entire ASU research community. The METAL webpages provide a list of equipment.

CAP maintains a diversity of field infrastructure. CAP Research Specialists perform routine maintenance, instrument calibration, and deal with the vandalism inherent in urban areas. Along with the CAP Site Manager, they assist faculty and students in locating short-term investigations at CAP sites.

- A retractable, 22.1m, four-section eddy flux tower, located in a suburban Phoenix neighborhood comprised of single-story housing. The eddy flux tower measures 3-D wind, CO_2, temperature, and moisture, and fluxes are calculated using standing eddy-correlation techniques. The following instrumentation is located on the tower: 3D sonic anemometer, infrared gas analyzer, temperature–relative humidity sensor, and net radiometer.
- At each of the DesFert sites, five permanently marked 20m x 20m plots, two unfertilized controls and three receiving fertilizer additions (N, P, or N+P) twice

per year. Each plot also contains five marked creosote bush shrubs for stem elongation measurements and permanently marked subplots for biomass collection and surveys of community composition of annual plants.
- For measurement of atmospheric deposition, CAP maintains resin-based bulk deposition and throughfall collectors at six of the DesFert sites.
- At one urban DesFert desert remnant site and one outlying DesFert desert park site, micrometeorological stations measure temperature, relative humidity, wind speed and direction, precipitation, and solar radiation.
- At each of seven sites along the Salt River, CAP maintains nine permanent herpetofauna plots and six birding points.
- CAP maintains ISCO automated samplers at three stormwater sampling sites along Indian Bend Wash.
- A Eureka Manta+35 multiprobe datasonde is deployed in Tempe Town Lake with sensors to measure temperature, conductivity, turbidity, pH, optical dissolved oxygen, chlorophyll A, DOC concentration, and DOC fluorescence.

Impact on Information Resources

Data Resources

The CAP LTER added fourteen new or revised datasets to its publicly available data holdings during the reporting period, bringing the total number of CAP LTER data packages archived in the Environmental Data Initiative data repository to 268. Notable additions include updates to many of the CAP LTER's long-term monitoring programs, and new geospatial, time series documenting important geophysical properties, such as Land Surface Temperature (LST), throughout the study area. All CAP LTER dataset metadata are encoded in the XML-based Ecological Metadata Language (EML) schema, with data and metadata available through the CAP LTER data catalog on the project website, the EDI data portal, and DataONE.

Infrastructure

The CAP LTER Information Manager strives always to improve the presentation, utility, and management of CAP LTER information resources. Notable improvements for this reporting period include:

- A refreshed CAP LTER website that provides a more seamless, streamlined experience to locate project information and resources.
- A new data-reporting template and instruction suite to make it easier and more intuitive for investigators to submit data and metadata for publication.
- Continued improvement of a suite of R-based tools that aid the development of EML metadata used to describe research data. In particular, new and updated features that support documenting geospatial (vector, raster) data products were

added. Though developed by and for the CAP LTER, these tools are generalizable and publicly available.

Network Participation

The CAP LTER is committed to making a strong contribution to informatics within the LTER Network and the ecological sciences. CAP LTER Information Manager Stevan Earl participates in all Network information management meetings and activities, participates in numerous informatics and scientific conferences, and contributes to publications spanning both the ecological and informatics sciences. S. Earl is a contributor to numerous working groups, including: (1) a joint effort by the LTER and EDI to improve tools and resources to characterize units of measure, (2) a LTREB and NCEAS synthesis working group exploring the impacts of wildfire on the biogeochemistry of flowing waters in the arid Southwest, and (3) developing ontologies and other resources to improve the discoverability and interoperability of soil chemistry data.

CAP LTER also had a strong presence at the International LTER Open Science Meeting in October 2024, including one of the organizing committee members (co-PI Grimm), an invited keynote speaker (Berbés-Blázquez), and contributed talks (PI Ball and co-PI Grimm).

Impact on Society beyond Science and Technology

- Our Education and Engagement committee has focused on building the relationships between historically underserved communities through arts and place-based educational offerings in the community in the form of event vending, workshops, presentations/demonstrations, and resource co-creation.
- To support a sense of place and encourage nature-based thinking, community offerings were held in local underutilized/underserved nature spaces. Learners joined guided Rio Salado River walks and site explorations using Photovoice and storytelling as tools to co-create visions for the future. Sense of place is further supported through the sharing of the Research Experience for Undergraduates (REU) supported 'Living Lands' game in context to river-focused events such as the Walk for the Wild, Tres Rios Nature Festival, and local educational events.
- Land-based learning was extended to include community gardens and agricultural spaces. Traditional land use, practices, and knowledge proved to be a fruitful space for community building, collaboration, and co-creation. Brassica Pláticas (community circles), nature song learning/playing (Son Jarocho), and mini nature camps to explore music, nature, and food were some of the activities.
- Land-based learning allowed us to support relevant cultural knowledge exchange. Tlaxcalli (tortilla) workshops using non-GMO blue corn were used as a

tool for discussing history, culture, food, and ecology. Further environmental justice and community history and resiliency were supported through our collaboration with various environmental justice-focused collaborators including work with our Research Experience for Teacher (RET). As a lead for culturally relevant teaching courses (Native, Black, Chicanx Histories) and support for student groups (Mecha - Movimiento Estudiantil Chicano de Aztlán, Black Student Union, and Native Youth Council), we were able to support ecological context to a cultural lens. Activities included using traditional Sonoran Desert native plants to create recipes, school presentations on environmental justice, and visits to local historical sites, led by youth participatory action research.

- Participants were supported in their expression throughout these offerings using arts-based approaches that made communication and discussion accessible. Collaborating with local artists and art spaces, we supported art in ecology work through co-created canvasses, design charrettes, storytelling writing, and data visualization.
- As we continue to navigate the complexities of intentional, respectful community collaboration and engagement, we are participating in the NSF-funded APEAL.
- Our goals are: 1) To continue to strengthen and expand existing relationships with Indigenous communities and groups, including incubating cross-community engagement (this is current engagement); and 2) to leverage these existing community relationships to begin to engage additional local Indigenous community organizations and tribes (we have identified five of these); we call this future engagement "pre-engagement". Our framework for how these two goals, their associated activities, and these various communities interact is below.
- A major goal of CAP V is to engage with local Indigenous communities and tribes; this includes graduate and undergraduate students, community members, and knowledge-holders and decision-makers in urban and reservation areas. The engagement effort we propose here will help us begin to build and strengthen these relationships (what we are calling "pre-engagement") in respectful, strategic, coordinated, and trust-building ways."

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