

SciVIEW

Fall 2015 | Science Journalism Project | University of Arizona



PIECING TOGETHER THE PAST

Graduate researcher
digs up truth about
ancient culture,
page 16

Symbiosis

Science journalism is the epitome of a symbiotic relationship. Together, scientists and journalists keep the public up to date on groundbreaking research, helping people live more informed, better lives. In Professor Susan E. Swanberg's science journalism class, we learned to embody this symbiosis, and we reaped the benefits of a heterogeneous classroom. Entomologists, microbiologists, geologists, hydrologists, neuroscientists and journalists gathered together to learn from one another. We asked ourselves, for example, "How should a journalist report on global warming?" In asking such questions, we learned that science ties us together in more ways than one. We wept together as we heard how pseudoscience put a man behind bars; we cheered when scientific evidence released him. We dug up the truth about our history in the Arizona State Museum's osteology lab. We joined forces to investigate endangered species of the Southwest, both avian and botanical. Our curiosity grew as we experienced a collective sense of discovery and began to research our own topics. These stories are the product of our collaboration, of not limiting science and journalism to separate boxes. We enjoyed learning from each other, and I hope you enjoy learning from us, too.

Elizabeth Eaton



FRONT COVER: Homol'ovi Utility Ware
PHOTOGRAPH BY ELIZABETH EATON
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Al Litzow

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PHOTOGRAPHS BY REBECCA NOBLE

Thomas Bohan, past president of the American Academy of Forensic Science, briefs listeners on junk science and its impact in the courtroom. Unvalidated scientific evidence has convicted innocent people, including exoneree Ray Krone.

Justice is blind, experts should be, too.

Improving the use of expert witness testimony in the US justice system



by **GLORIA JIMENEZ**

The American justice system is based on the promise of a fair trial, in which a judge and jury objectively evaluate evidence on both sides of a story. Nowhere are the system’s failures more obvious than in the misuse of expert witness testimony.

The case of Ray Krone serves as a stark example. Krone, who now works with Witness to Innocence, is a former death row inmate whose conviction hinged on an expert witness’s assertion that Krone’s teeth matched a bite mark on a murder victim. Krone was later exonerated by DNA evidence, and his case raised questions about the reliability of bite mark evidence.

Krone’s story is a testament to the need for better policing of expert testimony in the courtroom. But applying scientific evidence in the legal system is a complex process

where even vocabulary can trip the unwary.

In scientific circles, “proof” is used very conservatively, and generally only after repeated and rigorous statistical tests. The courts, though, need an outcome. According to Chris Robertson, Associate Dean for Research and Innovation at the University of Arizona, “We don’t have the luxury of waiting for perfection.”

Robertson notes that proof also has a specific definition in a legal setting. In civil cases, proof simply means that something is more likely true than not, and in criminal cases, that it is true beyond a reasonable doubt.

Expert testimony is intended to help a judge or jury determine proof. But the process by which expert testimony enters the courtroom is labyrinthine and varies from state to state.

Judges generally serve as gatekeepers who must evaluate whether an expert’s testimony is reliable and thus admissible as evidence. In most states, they accomplish this task with the Daubert test, which asks whether a theory has been tested and published,

whether there are established standards for applying it and whether the theory is accepted by the scientific community.

This process has obvious shortcomings. For one thing, many judges have little scientific training, making it difficult and time-consuming for them to evaluate whether a scientific theory is valid, or even whether a given expert is credible. This is further complicated by the necessity to decide between the very different expert testimony offered by prosecution and defense witnesses.

Then there is the problem that in a jury trial, testimony can devolve into a battle between opposing experts, and the jury is tasked with deciding whether to believe defense or prosecution expert testimony.

Within our existing legal framework, how can we ensure that judges and juries are presented with accurate, unbiased scientific evidence; and as a corollary, how can we ensure that the experts who give evidence in a case are properly credentialed? Robertson suggests that the process must systematically account for the inevitable imperfections of



Experts discuss the state of forensic science in the United States. The speakers participated in the *With Conviction* workshop, held Sept. 26, 2015, at the James E. Rogers College of Law in Tucson.

human judgment.

First, “blinding” experts — asking a scientist to evaluate evidence without knowing the details of a case — is one of the best strategies for limiting bias. For example, an expert being asked to evaluate whether a defendant’s teeth matched a bite mark might be sent several sets of tooth mark impressions from different people, and the defendant’s would not be identified. Better still, these impressions could be sent to multiple experts.

Robertson’s research shows that blinding confers a significant advantage, doubling the odds that jurors would believe a given expert. “When science can be made clear and credible... they rely on the science,” he said.

Thus, blinding also tends to add to an expert’s perceived credibility. Robertson notes that juries generally mistrust experts who they perceive to be “hired guns,” or scientists paid to give whatever testimony an attorney asks. More prestigious credentials can actually lessen a jury’s trust in an expert less because they assume the expert is being paid more.

The practice of blinding, though a seemingly obvious strategy to ensure accuracy, is uncommon. Robertson suggests that blinding could become more common if judges insisted on the use of blinded evidence. Alternatively, attorneys could question whether the opposing side used blinded methods during cross-examination. Experts themselves could insist on being blinded as well, using strategies such as asking to be contacted by an intermediary rather than an attorney.

Another stumbling block for the fair and appropriate use of expert witness testimony hinges on the vastly different resources that are generally available to the prosecution and the defense. Robertson points out that defending a routine criminal case costs ten times the median income in the United States. This raises serious questions of equity that can only be solved by institution of a workable publically funded system.

This discrepancy in resources can affect the perceived credibility of the defense’s expert witnesses, according to Thomas Bohan,

former president of the American Academy of Forensic Sciences and director of MTC Forensics, a consulting firm in Portland, Maine. Bohan notes that expert witnesses for the prosecution are often state scientists for whom giving testimony amounts to doing their job. In contrast, the defense must pay to bring in an expert, who prosecutors then accuse of being a hired gun.

These problems come down to a lack of objectivity. The consequences of misusing expert testimony can be severe, leading people to lose their freedom and sometimes their lives for crimes they did not commit.

Krone is commonly asked whether he is afraid to return to Arizona, the state that wrongfully charged and imprisoned him. But he demurs. “I’ve proved my innocence,” he said, a smile flashing across his face.

If meaningful reforms can be made to the American justice system, perhaps other innocent men and women will be able to say the same. ^(SV)

RAY KRONE

A PROFILE



by **EMILY HUDDLESTON**

The warm spring sun hit Ray Krone's face as he emerged from a Yuma prison, a free man. For 10 years Krone had been known as the Snaggletooth Killer, but on April 8, 2002, he became the 100th death row exoneree.

Dressed in a tan suit jacket and jeans, long hair pulled back into a ponytail, Krone's passion filled the large room at the James E. Rogers College of Law. He told his life changing story during a workshop, *With Conviction: Reporting on Science in the Courtroom*.

Krone grew up in a small agricultural town in Pennsylvania, where he sang in the church choir. In his early 20's, he was honorably discharged from the U.S. Air Force and later became an employee of the U.S. Postal Service in Phoenix, Arizona. He had no criminal history.

But on December 31, 1991, Krone was arrested for the kidnapping, sexual assault and murder of a woman named Kim Ancona. Ancona was found sexually assaulted and stabbed to death in the men's bathroom of the bar where she worked.

The bar sponsored sports teams on which Krone played, and he quickly became a regular. A coworker of Ancona's told police a man named Krone was dating Ancona and police immediately focused on Krone as a suspect.

"I was not dating Kim and I didn't kill Kim; I don't know why anyone would kill Kim," Krone said he told police. "I was home all night with my roommate."

The centerpiece of the State's case against Krone was a bite mark the attacker left on Ancona's left breast.

The prosecution's star witness was Dr. Raymond Rawson, a forensic odontologist. Rawson was a Nevada state senator



PHOTOGRAPHS BY REBECCA NOBLE

(ABOVE) Ray Krone, an innocent man convicted of murder in 1992, and students at the University of Arizona watch attorneys and forensic experts discuss the intersection of law and science. (BELOW) A death row exoneree, Krone told the story of his imprisonment and eventual release during the *With Conviction* workshop at the UA. Krone was sentenced to death because of bite-mark evidence.



and college professor. He appeared to be an impressive, reliable man.

During Krone's trial, Rawson presented a video that compared Krone's dental mold to the bite mark. He argued that because Krone had been in a car accident that broke his jaw when he was a teenager, Krone's teeth were unique. Therefore, this was, beyond a reasonable doubt, the "perfect match."

But it wasn't a perfect match; it wasn't Krone's bite mark.

A bite mark doesn't leave a perfect outline of your teeth like biting into a sandwich does.

"In my bite mark, there were only three teeth they identified," Krone said. "Can you believe that?"

The trial lasted only two and a half days, and the jury found Krone guilty of kidnapping and murder. Because the judge thought the bite mark inflicted excruciating pain, Krone was sentenced to death.

"This is another example where junk science landed someone on death row," said Andy Silverman, a professor at the James E. Rogers College of Law and the director of the Civil Rights Restoration Clinic.

Bite mark evidence is problematic. Human skin is elastic, making it subject to swelling,

which can deform the mark. Also, bite mark analysis can be subjective. Different experts can reach very different results based on the same mark.

Today because of DNA testing, bite mark evidence is rarely used. During the workshop, Assistant to the Pima County Attorney and Chief Legislative Liaison Kathleen Mayer advised other prosecutors not to bother with bite mark evidence because of its unreliability.

In 1996 Krone was granted a second trial, and even though the defense had six independent bite mark experts testify that this bite mark did not match Krone, he was convicted again.

"They wanted me to show remorse," Krone said. "But how do you show remorse for something you didn't do?"

Krone is a hopeful man, and even as his life was being ripped away from him, hope is one thing he didn't let go of.

"Sometimes I would think I was going to die in there for something I didn't do and other times I get a letter from my seventh grade English teacher saying, 'I believe in you,'" Krone said.

"Days when I was feeling the most down something would happen that would pick me back up and keep me going."

In 2002, after Krone had served more than 10 years in prison, DNA testing proved he was innocent. The saliva and blood found on Ancona was tested and matched to a man named Kenneth Phillips. At the time of the DNA test, Phillips was in prison for another sex crime. He'd lived a few blocks from the bar where Ancona worked and was out on parole at the time of the murder.

On April 8, 2002, Krone traded his orange prison jumpsuit for blue jeans and a T-shirt and enjoyed a beef burrito for the first time in 10 years, three months and eight days.

After he was exonerated, Krone was back in the media again, although this time he was free of the title Snaggletooth Killer.

Asked how he had reconciled his faith with his wrongful sentencing, Krone said he told the reporter, "Maybe it isn't about those 10 years; maybe it is about what I have to do for the next 10 years."

Krone tells his story to thousands of people every year. He is the director of membership and training for Witness to Innocence, an organization that empowers exonerated death row survivors to be the voice that helps end the death penalty in the United States.

Krone is doing just that.

"I speak to a lot of law students and criminal justice classes where many of those students are probably going to be a part of the legal system," Krone said. "Anything I can tell them that will help them make a more balanced judgment or a fairer decision down the road is worth it."

Even though advocating for the abolishment of the death penalty has become a part of Krone's life, he doesn't want it to consume him. He still rides motorcycles, goes fishing and drinks beer.

"Today when I get off, I will probably find a neighborhood bar, have a beer, talk about sports and no one will know who I am," Krone said.

"I want to be known as Ray Krone, not Ray Krone death row survivor.

"To the end of my days, I will probably be speaking out against the death penalty," he said.

Krone has no doubt in his mind that the death penalty will be abolished someday. He points out the significant steps that have already been taken. In the 13 years since he has been a free man, six states have abolished the death penalty.

"One day, we will look back on the death penalty the same way we looked back on segregation, same as we looked back on women's right to vote, same as we looked back on slavery," Krone said. "And we'll say, 'What the hell were we thinking?'" SV



PHOTOGRAPH BY REBECCA NOBLE

DNA and Beyond

Kathleen Mayer describes how prosecutors can help ensure the integrity of the criminal justice system.

Kathleen Mayer and the intersection of science and law



by **STEPHAN DONG**

Kathleen Mayer, Assistant to the Pima County Attorney and Chief Legislative Liason, doesn't accept the easy answers in court. She believes that each case must be thoroughly investigated with all resources and tools available.

Among the most powerful of these tools is scientific evidence. Using science, biases can be reduced or eliminated.

Mayer was the first to successfully introduce DNA evidence into an Arizona courtroom to prosecute a defendant. While this case went smoothly, her second introduction of DNA was, in her words, "an incredible hurdle."

"It was a two and half year admissibility hearing...I had to call in experts from around the world in population genetics, the forensic use of DNA, and every person in the FBI laboratory who had ever touched the

evidence," Mayer said.

The defense had even claimed that the use of DNA evidence was "junk science."

A commonly used buzzword, "junk science" is a term used to dismiss evidence because of invalidity. Unfortunately, even appropriately used science can be misunderstood.

Compared to other pieces of biological evidence, DNA is a cut above. "You're much more likely to find these days, DNA that we can analyze," Mayer said.

Although fingerprints can be tracked to an individual, they may not always be the most reliable way to associate an individual with a scene. The quality of a fingerprint can vary based on the surface it's on, the clothing the individual is wearing, or how the print was pressed.

"DNA touch evidence is not quite so limited in that way," Mayer said. DNA evidence can be acquired from a multitude of sources ranging from a stick of chewed gum to a single piece of dandruff.

Despite DNA being a powerful tool in prosecution

and defense cases, Mayer does not believe that it is the final word. Answering a question by way of scientific process means being open to all possibilities.

"There's an inherent danger in being enamored with DNA," Mayer said.

Never satisfied with just a single exciting clue, Mayer always works her hardest to untangle a mystery, and at the same time, prevent wrongful accusations and ensure that those who commit a crime are unmasked.

"We would be doing a disservice to the victim, the defendant, and the public if we didn't rely on our scientific partners to tell us what is going on in the world," Mayer said.

Mayer thinks science is crucial in eliminating uncertainty, but embraces uncertainty at the same time. "It [science] makes me less afraid of what I don't know and as a result of being less afraid of what I don't know I'm more likely to go out and find what I don't know," Mayer said.

As long as there are new breakthroughs in science, Mayer's work will never be

done. Mayer strives to keep up to date with the most recent scientific literature.

"I'm still learning about science today, with every new technological breakthrough, particularly as it relates to DNA," Mayer said.

Mayer also believes that it is the duty of all prosecutors and attorneys alike to learn about science that is relevant to the justice system.

"We have to reteach ourselves," Mayer said. "The fundamental building blocks of biology don't change, but the scientific processes and technological processes that are advancements...require us to keep up with whatever's new in the field."

To those who try to skirt the scientific process, "There's no way of avoiding it, really," Mayer said.

Due to Mayer's open-minded viewpoint and willingness to learn new things, innocent lives have been spared a prison sentence and the right criminals have paid their societal debts. With every new case, Mayer takes Arizona one step closer to justice. ^(SV)

CHOCOLATE LAB OR CRIME LAB?

Q & A with Wendy Halloran



COURTESY OF WENDY HALLORAN

Wendy Halloran is the chief investigative reporter for 12 News in Phoenix.



by ALEX WOLFE

When Wendy Halloran first heard about the Phoenix Fire Department's secret weapon, she couldn't help but be skeptical. The department claimed to have the highest arson clearance rates in the country, thanks to their four-legged comrade. Sadie, a chocolate labrador retriever, was the fire department's arson accelerant detection dog, trained to sniff out accelerants used in arson fires. Her handler, former Phoenix Fire Captain Fred Andes, claimed that Sadie was right 100 percent of the time. All was well until a video surfaced showing Andes telling Sadie to "put her nose down and at least fake it" for him during a crime scene investigation. Here Halloran discusses what was so special about this dog.

SciView: What was it about the story of this dog that interested you?

Wendy Halloran: It was the bragging of the lead investigator that this dog was the secret weapon, and I know enough to know that there are issues with dogs and law enforcement. It seemed to me like the dog was everything. I'm always suspicious, and I always question authority and it was just my gut instinct that was telling me that there was something here.

SV: Did you do further research on the dog and the dog's training?

WH: Oh yes I did a tremendous amount of research. After I did my initial story, I received an email from the boyfriend of the defendant and it really laid it out there. I just kept thinking to myself "gosh this

could be too good to be true, but if I could prove this, oh my goodness." I already had my suspicions about the dog, and they were already boasting that they had the highest arson clearance rates in the country so I was wondering how they arrived at that. I started looking into it myself, and I had to study a great deal of information. I sought out science experts, forensic science experts, and I found the [arson dog] program, which is operated through State Farm Insurance. The State Farm Arson Dog Training Program sponsors the dog and the handler, and they send both to [a program in] Maine for certification. So I had to study the process of all of that.

SV: Are records kept on the dog and its training?

WH: Once a handler is certified, and the dog becomes active, the handler is required to keep a log of the training and when the dog is used in any fire investigations -- whether the dog hits, whether the dog doesn't hit, statistics to show the dog's reliability. So there is a method to all of this. What is critical in fire investigation is following the National Fire Protection Association guide book. It specifically states that the dog is supposed to be used as an accessory, a helpful tool.

SV: Do you know how the dogs are selected?

WH: They select them through the State Farm Arson Dog Training Program and Maine Specialty Dogs. You'll find a lot of chocolate labs! I wanted to title my presentation "Which is better? The chocolate lab or the crime lab?" They're wonderful creatures, but they're food reward dogs. They work to eat and that's another issue.

SV: In this case it seems that the dog was more likely responding to the handler instead of the crime scene. Is that correct?

WH: Sure... and when [the handler] was

running the dog through the burnt out home, he became frustrated because she wasn't detecting anything. He was inappropriately running his dog through the crime scene.

SV: If they had been keeping better records, do you think they might have retired the dog earlier when they found she wasn't as effective as they thought?

WH: I don't think she would have been retired because my evidence and my investigation proved that these fire investigators didn't have the supervision that they should have had.

SV: So the dog wasn't at fault, but the handlers who weren't properly coaching the dog were?

WH: When Andes, the canine handler, was questioned about his record keeping, he finally admitted, because he's under investigation, that he didn't keep records. If he had kept records it would have proved that his dog was only right 50-60 percent of the time and here you have Captain Andes testifying in criminal and civil cases, under oath, that his dog is 100 percent right. You've got a problem right there.

SV: Have any other fire departments come under fire for their use of arson dogs?

WH: No, not that I know of. This seems to be an anomaly.

SV: Is the fire department using any new dogs now?

WH: No, no dogs now.

SV: What happened to the dog after all of this?

WH: The dog was retired and Captain Andes was able to adopt her. He loves that dog! I'm happy with that, because we know that the dog is well taken care of. (SV)

MODEL MARTYRS



PHOTOGRAPH BY ELIZABETH EATON

Stephan Dong peers at *Drosophila* flies through his microscope, collecting the virgins and disposing of the rest. Using virgin specimens is important when breeding flies for scientific purposes.



by **STEPHAN DONG**

Model organisms are responsible for an outstanding number of scientific discoveries, especially medical findings. In the past 100 years, all Nobel Prize winners in medicine (with the exception of one) used animals to model their work. However, when a treatment or cure for a disease is found, the emphasis is placed on the humans who can benefit from the treatment. It is important not to forget the animals that aided the work.

Mice are the poster children for scientific research due to their accessible genes and easily studied behaviors. People relate to monkeys due to their humanlike cognitive functions and behaviors. I will admit a personal bias towards fruit flies because I work in a *Drosophila* genetics lab, but I believe they are fascinating creatures and magnificent tools for genetic research. (sv)



PHOTOGRAPH BY STEPHAN DONG

Drosophila melanogaster, a fruit fly species and classic model organism, is used as a research tool in developmental biology, genetics and neuroscience. Graduate student Stephan Dong uses the fruit fly in his research at the UA.

Flight to Light Response

in Nocturnal Insects



by **JOHN D. PALTING**

Manpower was prominently featured at the 1893 Chicago World's Fair. People marveled at mechanical devices of all sorts: giant railroad engines, a cannon that fired 300-pound shells 16 miles, color photography and synthetic chemical fabric dyes.

It was the electric lights, however, that illuminated the fair like "one huge flaming orb at the edge of the lake" and left the greatest impression on the attendees, according to historian William Leach, author of the 2013 book "Butterfly People." The fair had three times the electricity of the city of Chicago itself, with tens of thousands of lights illuminating the buildings and searchlights piercing far into the night.

To these lights were attracted insects by the millions, mostly moths, previously unseen denizens of the dark. The multitude of flying insects was so impressive that it was mentioned in the newspapers.

In the early 1800s limelight, an intense light made by focusing a jet of gas on a lump of calcium chloride, was used by naturalists to collect moths for study, as were the gas streetlamps in larger cities.

In the 1880s, the electric light was perfected, and the surface of nocturnal earth was forever changed. Even the casual observer can see that electric lights have a profound impact on many nocturnal insects. So why are insects attracted to these lights?

The reaction to light seen in diurnal (daytime) insects, such as butterflies, is well-studied. Butterflies as a group are overwhelmingly diurnal and positively phototactic (light-seeking), as can be seen when a butterfly is released in an enclosed glass conservatory and flies toward the ceiling.

Nocturnal (nighttime) insects' reactions to light are more complicated. Nocturnal species are arguably negatively phototactic (light avoiding) during the day. Bright light induces



PHOTOGRAPH BY SUSAN E. SWANBERG

Moths are negatively phototactic (light avoiding) during the day and positively phototactic (light seeking) at night. These insects probably use celestial light sources for navigation.

them to hide and rest in the shadows, but at night many appear to be positively phototactic in response to human-made lights.

Moths and other nocturnal insects might have evolved to use celestial light sources as fixed points for navigation in the dark. Since these celestial objects are so distant, the insect can fly in a direction relative to the light and have it remain in the same place. Fewer nocturnal insects are attracted to artificial lights when the moon is at its zenith because a full moon can override the attractiveness of human-made lights.

There is good news, however, for both moths and for people who enjoy nightlife. Over the last 10 years commercial urban lighting has moved from highly attractive mercury vapor lights to high pressure sodium

lights or low pressure sodium lights and even LEDs with a corresponding drop in the degree of attractiveness to nocturnal organisms.

This switch has been driven largely by electricity costs as well as a call from astronomers to minimize light pollution, not by a desire to protect insects.

Understanding what is behind the response of nocturnal insects to light, will help us know how to remediate the effects of light pollution. Modern human societies need light to function, but they generally do not want clouds of pesky moths flying around them as was seen when the first artificial lights interrupted nighttime at the Chicago World's Fair some 100 years ago. Now we can choose lighting designs that minimize this attraction. (SV)

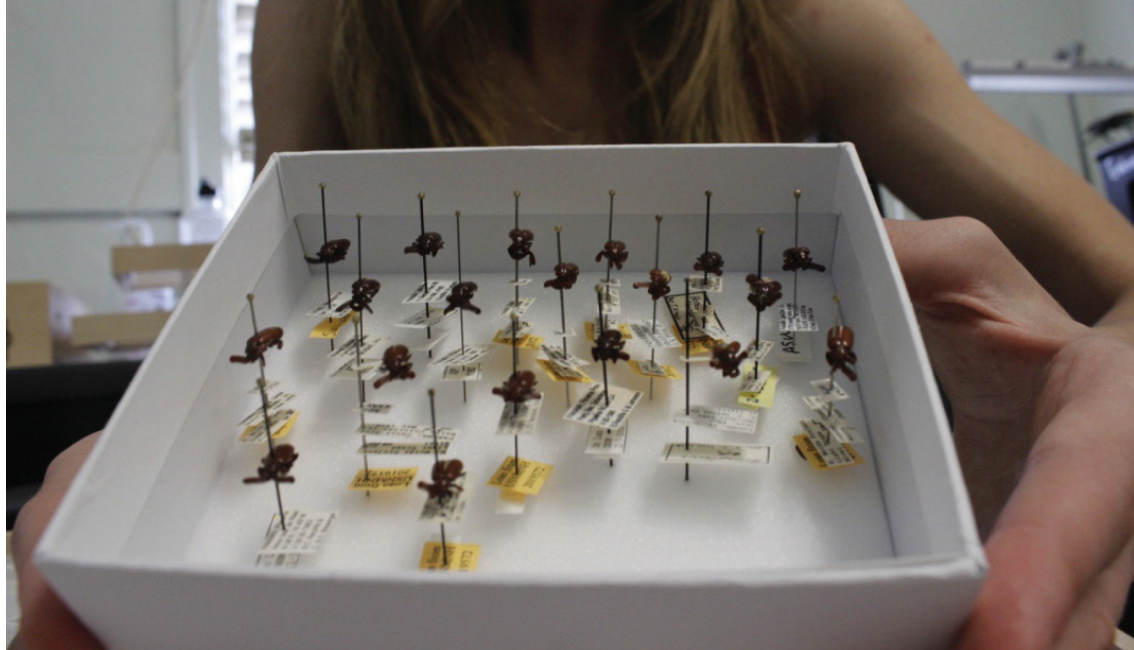


**STRANGE BEASTS:
HOMOPTERUS
AND THEIR ODD
ANTENNAE**

**PHOTOGRAPHS BY
ELIZABETH EATON**

Angela Hoover, an entomology graduate student, displays her collection of beetles.

Hoover researches *Homopterus*, an elusive beetle found in Central and South America; no live specimens have ever been collected.



by ANGELA HOOVER

There are three drawers on my desk – shallow boxes with glass tops. Inside are smaller boxes lined with foam which contain all the pinned beetle specimens of the genus *Homopterus* known to science.

These auburn beetles, some as large as a grain of rice and others significantly chunkier, look like bean seeds with legs. They were collected in Mexico, Central and South America and have traveled a great many miles to rest comfortably in my office.

It took me weeks before I would look at their fragile little bodies with a mixture of awe and apprehension. Any clumsy mistake could result in my destroying a third of all the known *Homopterus* beetles (and consequently a third of my research).

I was first drawn to these beetles by their morphology – their elaborate, fern-shaped antennae and foldable, collapsing joints. Beetles can be shaped in strange ways, but I had never before seen antennae like these. I wanted to know more. I found out, however, that not very much is known about *Homopterus*.

I'm a master's student, and right now my job is to set the record straight on this group of beetles. There are twelve species that have been described, but we don't actually

know if these species are valid scientifically. We also don't know how the species within the group *Homopterus* are related to one another. There's a new species that needs to be scientifically described. It might sound rather straight-forward, but it isn't.

Describing a New Species

Over the years, several scientists have looked at specimens of *Homopterus* and made their own judgments about what gives each species within the genus its identity. One species might be characterized by the way its legs are a little more flared than the legs of other species, another might be identified by notches in its antennal segments. It's up to the individual researcher to choose informative traits to describe each group. The previous scientists were at a disadvantage because they could not look at specimens collected in more recent years.

One of the most difficult things about working with this tiny group of beetles is that they are so rarely collected. Back when certain species were first described, there were fewer specimens to compare.

Describing a species is simple, yet also complicated. Every feature needs to be put into words in painstaking detail. How big are the legs in comparison to the body? What do the antennae look like? Where are the hairs, bristles, hooks or spines? The goal is to be able to read the species description and identify a specimen without any pictures. Figures are always an essential component of a species description. I need to both write descriptions and create figures for my new species. By the time I've finished, my

Homopterus will have a sleek new species name, a verbose, yet dry species description and some beautiful figures of its anatomy for everyone to see.

While morphological work is important in the classification of species, a new layer of technological advances has revolutionized the field. It is now possible to sequence genes from the tissues of preserved specimens using molecular DNA techniques.

I was not lucky enough to get DNA out of my new species. Having only one specimen, it was risky to try and get DNA from the body because if the specimen is damaged, I won't be able to accurately describe it. Worse yet, there will only be a damaged specimen to take the title of the "voucher". A voucher specimen is the representative that embodies the characteristics of a given particular species. Having vouchers is incredibly important in the business of describing and ordering species.

Future plans

After completing my studies at the University of Arizona Department of Entomology, I'll have put together just how many species of *Homopterus* there really are, as well as how they are related to one another. That won't be the end of the line for me, however. Someday, I'd like to conduct research on these beetles in Gamboa, Panama, at the Smithsonian Tropical Research Institute where I hope to uncover more about these elusive beetles, what ants they live with and how they survive in the jungles of South America. ^(SV)



A science journalism tradition

REPTILE DAY

PHOTOGRAPHS BY ELIZABETH EATON



Cecil Schwalbe, Ph.D., Ecologist Emeritus, visits the fall 2015 science journalism class with his reptile friends.

Tracking down a mysterious people, one pot at a time



by **ELIZABETH EATON**

The Homol’ovi Project isn’t like Atlantis; there’s no mystery as to where this civilization disappeared. Instead, what anthropologists like Claire Barker are trying to figure out is where the people came from.

Think of Barker as an anthropological detective; she has to put together clues from the past in order to track down the origins of the Homol’ovi settlement.

But she goes about this a little differently than Indiana Jones might – instead of hat and a whip, Barker pieces together corrugated pottery to learn more about the people that settled in the Homol’ovi area back in the 14th century.

Unlike the decorative, “pretty” pottery that most tourists see in Native American museums, corrugated pottery is “ugly,” and was generally used for cooking. However, Barker believes that the uglier the pottery, the better insight it can give to the identity of these peoples.

Barker described the difference between the two types of pottery as being like the difference between your mother’s fine china and her Tupperware. When you serve a fancy meal to guests, you use the nice plates because “you’re trying to say something about who you are, the kind of person you are, and what kind of society you live in.”

When you clean up the meal, however, and put it away in Tupperware, you’re not worried about presenting that image. “It’s just this very passive social identity,” Barker said.

Growing up and using the same kind of Tupperware as your mother, Barker said, is another example of passive social identity; you do so because “this is the way it’s done.” Following familial traditions is a part of our identity that occurs without us ever actively thinking about it.

Different for the sake of being different

Although studying corrugated pottery isn't "sexy" archaeology, Barker has always been someone who doesn't want to follow the norm or do what's expected of her.

The dull black pots seem uninspiring and might be overlooked by archaeologists who prefer to research more stereotypically exciting topics, but Barker's enthusiasm and ability to understand some of the intricacies of an almost forgotten people turn ancient cookware into a treasure map.

"I like studying things that are not studied, that maybe have something different to say," Barker said. "I like looking at things that are not what everybody is looking at, because they're not the things that everybody else is looking at."

Her desire to take the archaeological path less traveled began while Barker was in high school. During a field trip her freshman year, Barker visited the Crow Canyon Archaeological Center in Colorado, which is when she first became interested in ceramics.

Although decorative pottery is visually appealing and on the surface seems more interesting, Barker found herself drawn to the corrugated cooking pottery.

Ever on a quest to be different, Barker spent two field seasons before earning her bachelor's degree, studying Romano British archaeology in the United Kingdom. She then applied for graduate school to study classical archaeology, mostly because her advisors expected her to study American Southwest pottery.

"I think I applied to be ornery," Barker admitted, unable to hold back laughter.

Despite her reluctance to become a Southwest archaeologist because "everybody does that," Barker has found that working on the Homolovi Project has satisfied her curiosity and offered her a huge forum of knowledge to which she can contribute.

Amid unity, diversity

When the settlement was originally excavated for artifacts, researchers found several pieces of decorative pottery that were all made in the same style as the pottery unearthed in the Hopi Mesa area.

Previous research indicates that a relationship between the Hopi and Homol'ovi people existed, involving emigration between the two sites, so the similarities between the two decorative pottery lineages weren't really surprising to Barker, though they did make her start asking questions.

"If you have a group of diverse people coming together and living together, there could easily be some kind of investment in projecting this unity that you see," Barker said. "So is that unity because they're all from the same place? Or is that unity because they're all trying to look like one community that gets along as a way of social control?"

Barker began looking at cooking pots to address this idea of unity

“

I think that's why all of us do archaeology, just to learn about people who were like us a couple thousand years ago.

Claire Barker



PHOTOGRAPH BY ELIZABETH EATON

Claire Barker, a Ph.D. student, researches corrugated utility pottery found in the Homolovi area. Here, she holds an "ugly" pot in front of a map detailing all the sites associated with these early pueblos.

and identity within the Homol'ovi settlement cluster, which is an aggregation of seven pueblos. As she investigated the pottery in the different areas, stark contrasts and diversity began to appear – sometimes different materials were used to make the pots, or the way the indentations in the pots were made varied.

Though she hasn't finished analyzing all of the pottery in each of the pueblos yet, she has found evidence suggesting multiple groups of people lived at Homol'ovi I, Homol'ovi II and the Chevelon Pueblo, an offshoot of Homol'ovi.

"We have this dichotomy between this pottery that's more associated with the active parts of social identity and the kinds that are more associated with the passive parts of social identity," Barker said. "And we really do see that there is this investment in constructing a unified identity, but at the same time there's diversity on the level where nobody is really looking."

Archaeology of the everyday folk

Though Barker can't say for sure, the implications of her research could help reveal the dynamics of migration, community, and power structures in the Homol'ovi settlement 700 years ago.

That's another reason why Barker loves her field of archaeology – she is able to learn about how ordinary people lived in the past, as opposed to historians, who often focus on important and famous people like Charlemagne.

"Charlemagne is cool, but I don't really care about Charlemagne," Barker said, acknowledging that she was probably insulting historians around the world. "He's not a representative sample of the people who were living in France at that time... and for all that what he was doing was cool, he was completely irrelevant to Joe the pig farmer."

Ever one to give a voice to something that has been thrown by the wayside, it's clear why Barker chose to study corrugated pottery in the Southwest, and why her research has the potential to uncover the complex dynamics of the people living in the Homol'ovi area hundreds of years ago.

"I think that's why all of us do archaeology, just to learn about people who were like us a couple thousand years ago," Barker said. (sv)

BEEZ IN THE TRAP



by **ANISSA MCKENNA**

A disorder known simply as Colony Collapse Disorder (CCD) has taken the spotlight as the foremost detriment to bee populations.

The disorder first made its appearance in Pennsylvania in 2006 when 70 to 80 percent of bee hives were lost. Scientists are uncertain whether this disorder causes death of bees or merely their disappearance, but whether the bees are absent and alive, or dead somewhere, what is certain is that hives are losing virtually all of their bees when this disorder is present.

The prevalence of CCD is not entirely understood, but certain factors might be related to the disorder. Climate change, pesticides, mites, even bacterial and viral infections could be involved. Research is underway to determine which single factor or combination of factors causes CCD, but scientists are at odds regarding which factor or factors are most responsible.

Beekeepers' dilemma

One of the specific areas of concern is the honeybee's critical role as a common vector for agricultural pollination. In the past decade great emphasis was placed on the health of all bee species, most importantly on the honeybee because of its importance to the world agricultural system.

In the U.S., beekeepers manage between 2 and 3 million honeybee colonies. Somewhere between 1 and 1.5 million of those colonies are transported to California every February and March to pollinate crops because beekeepers

are not making the revenue they need to sustain themselves by only selling honey.

To increase their earnings, beekeepers are signing pollination contracts, particularly for almond crop pollinations, as there are 900,000 acres of almonds in California needing pollination each year. Almonds represent one of the largest cash crops in need of honeybee services.

What is causing colony collapse?

According to Stephan Buchmann, Ph.D., a scientist in the zoology branch of the Department of Entomology at the University of Arizona, CCD is most clearly associated with a category of systematic pesticides called neonics. This pesticide is a neuro-active and systematic toxin that permeates the plant, including the pollen, which is collected by the bees. Neonics can cause health problems in bees, such as confusion and general poor health.

"I still think it is a lot of factors, not just pesticides, but I am leaning more and more towards the neonics. I believe they are making up the lion's share of problems," Buchmann said.

Aside from neonics, other causes of CCD might include environmental factors. Bee lifestyle factors can cause fluctuations in hive populations. For example, in certain areas there are fewer types of flowers from which the bees can collect food, decreasing the variety in their diet.

Peter Warren, Urban Horticulture Extension Agent for Pima County, believes neonics are not the most important factor causing CCD. According to Warren, a combination of factors might lead to the perfect storm causing CCD.

"It [CCD] is a combination of things, including diseases from viruses and fungi. However, beekeepers have figured out ways to manage some of these associated symptoms, including those



PHOTOGRAPH BY ELIZABETH EATON

Anissa McKenna shows off her tattoo of a bee. McKenna, concerned about the disappearance of bees, decided to learn more about Colony Collapse Disorder, which is what many scientists attribute loss of bee populations to.

from predatory mites," said Warren. "Pesticides are certainly an issue, but they are much less of a concern than thought. Neonics are still under investigation to determine if there are any long term health effects, but it is not the main issue anymore."

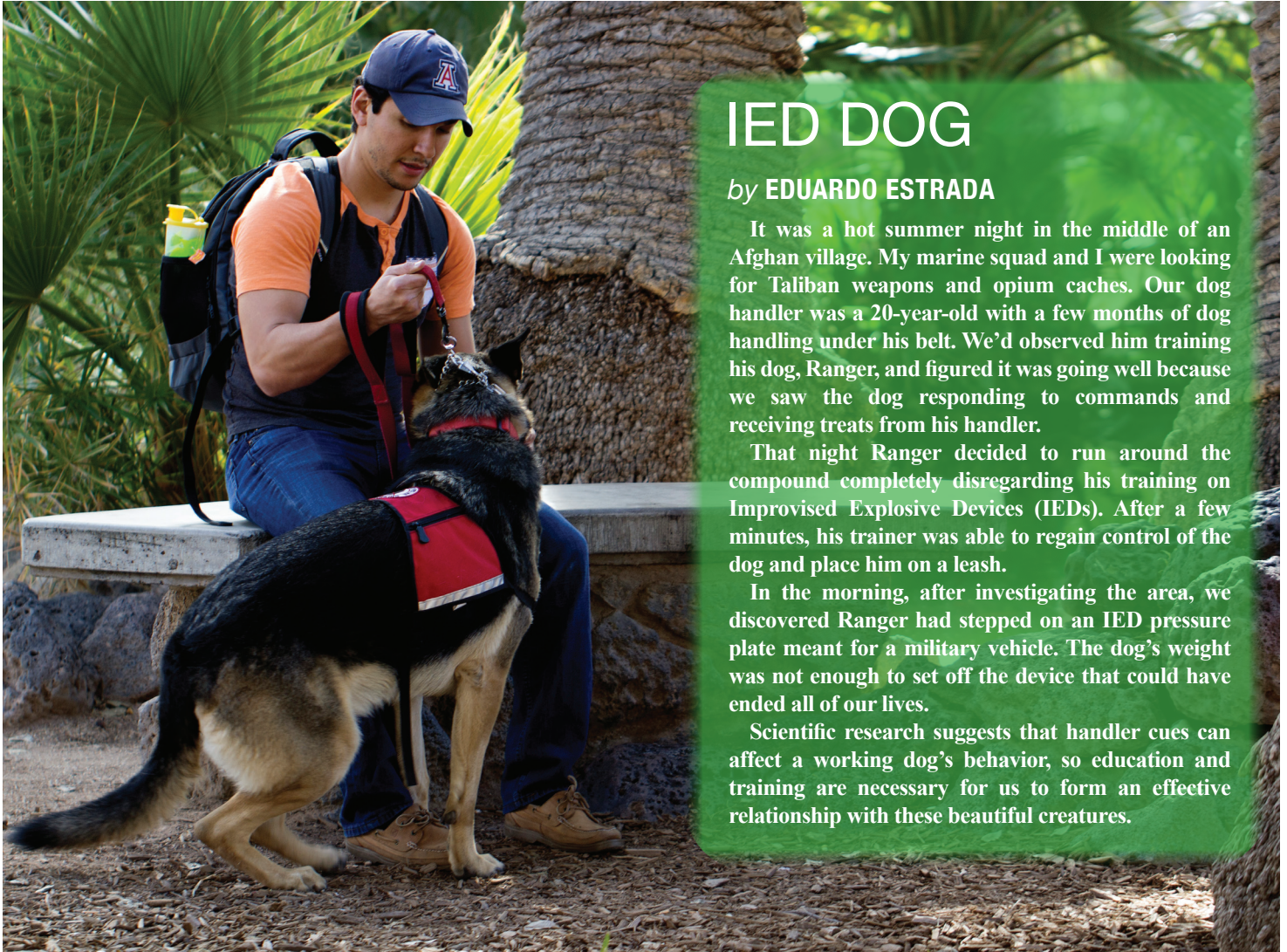
Saving Bees

In 2015, President Obama issued a memorandum describing his administration's new strategy to promote the health of honey bees and other pollinators.

Under this new policy, a large tract of land planted with diverse food sources, will be set aside to help conserve pollinator bees.

This could be the beginning of real change in bee conservation. ^(SV)

Eduardo Estrada: A VETERAN AND HIS DOG



IED DOG

by EDUARDO ESTRADA

It was a hot summer night in the middle of an Afghan village. My marine squad and I were looking for Taliban weapons and opium caches. Our dog handler was a 20-year-old with a few months of dog handling under his belt. We'd observed him training his dog, Ranger, and figured it was going well because we saw the dog responding to commands and receiving treats from his handler.

That night Ranger decided to run around the compound completely disregarding his training on Improvised Explosive Devices (IEDs). After a few minutes, his trainer was able to regain control of the dog and place him on a leash.

In the morning, after investigating the area, we discovered Ranger had stepped on an IED pressure plate meant for a military vehicle. The dog's weight was not enough to set off the device that could have ended all of our lives.

Scientific research suggests that handler cues can affect a working dog's behavior, so education and training are necessary for us to form an effective relationship with these beautiful creatures.

PHOTOGRAPH BY SUSAN E. SWANBERG

Eduardo Estrada interacts with his service dog, Manny, in Tucson in December 2015. Manny was living a feral existence until Estrada took him home to train him.

by ELIZABETH EATON

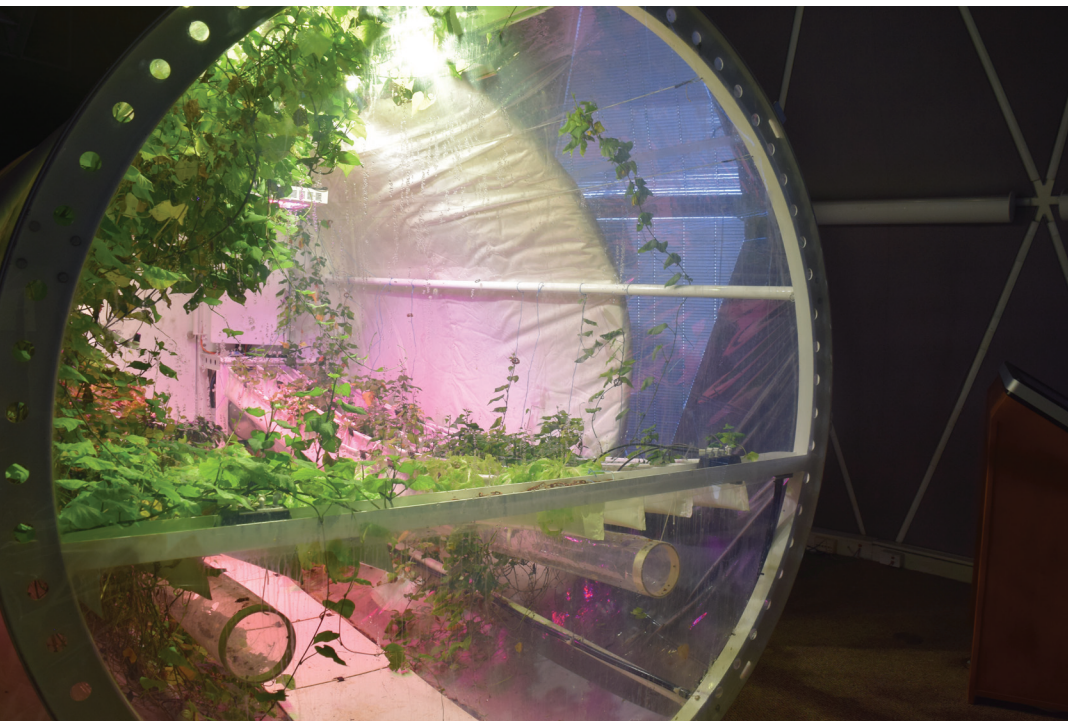
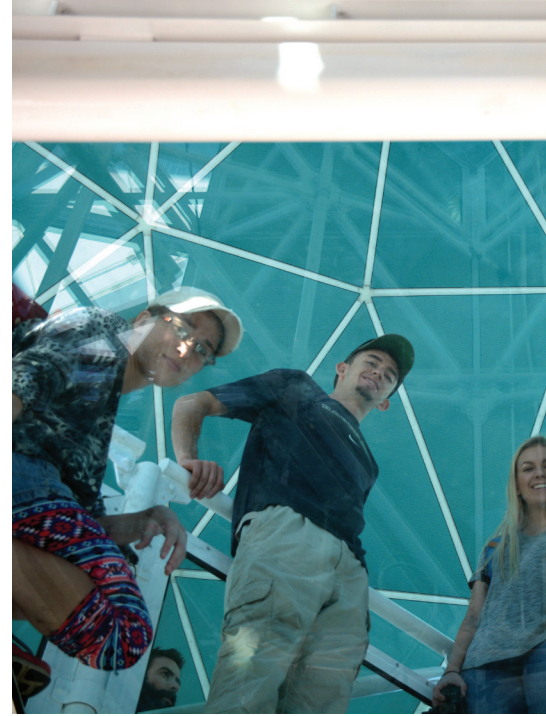
SV: Tell me about Manny, your German shepherd service dog.

ES: He was my grandfather's. When my grandfather passed away, my grandma wasn't taking care of Manny. He was eating people's crops and beating up dogs and tripping people, causing havoc in the neighborhood, so they wanted to put him down. When I heard about him, I was looking for a dog just like him and was going to pay a breeder. I heard he had been a handful, was a good-looking dog, but other than that he was pretty much feral. But I took him. I thought, "I can do this." I had heard of a veteran's program where they put you with a trainer and help you train a service dog if you qualify. I got Manny neutered, and four months after, he started to mellow out and we got accepted into the program.

SV: How has Manny changed your life?

ES: When Manny came into my life, I was having marital problems and just being irritable in general with everyone around me. I was having difficulty adjusting [to civilian life] and stuff. But then I got this dog that immediately loved me, and it was pretty awesome. We connected and started doing a lot of hikes. That was a big help for me. And Manny, I thought I was helping him by rescuing him, but in reality he was helping me, helping me adjust to life again, life in Tucson. I thought it was the humanitarian thing to save this crazy dog, but he was saving me.

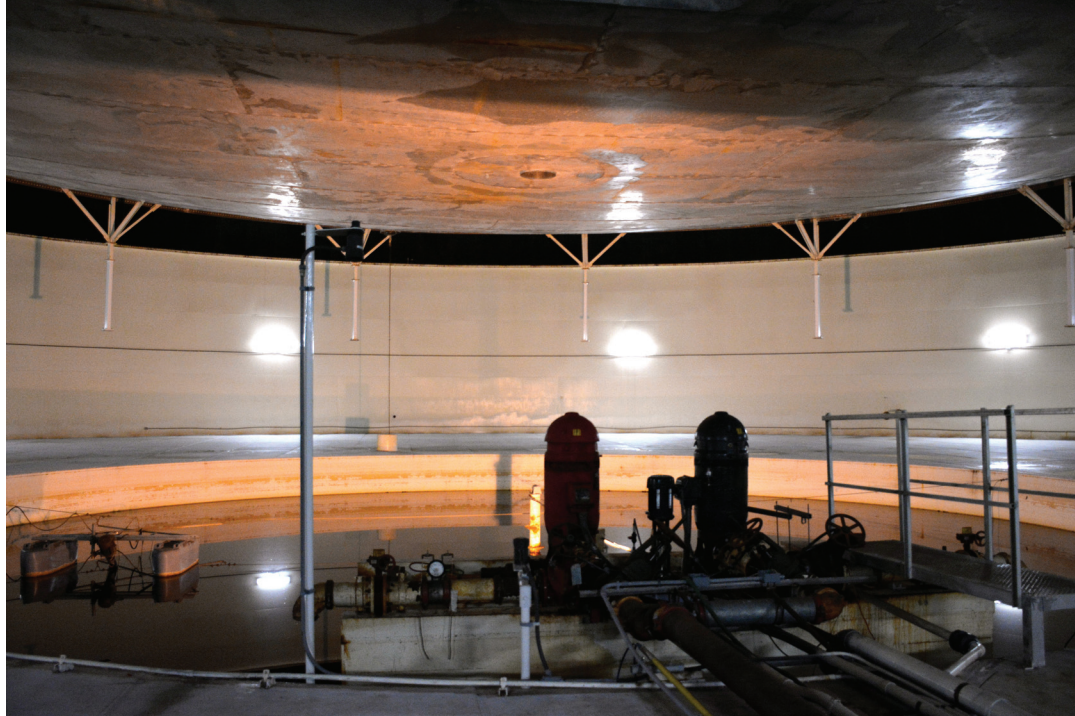
SV



Journalism meets science

A DAY AT BIOSPHERE 2

PHOTOGRAPHS BY JORGE ENCINAS AND ELIZABETH EATON



Science journalism students explored Biosphere 2 for an end of the semester field trip in December 2015.



(LEFT) © 2006 ANGELLA PARKER / ASDM SONORAN DESERT DIGITAL LIBRARY (RIGHT) © ROGER HIRSCHMAN / ASDM SONORAN DESERT DIGITAL LIBRARY

Loss of riparian habitat might lead to gray hawk decline



by **KALYNN MILLER**

Flying high through the Sonoran desert, the hawk reads its victim's next move, calculates the quickest angle, and swoops up the prey. Cooper's hawks and Red-tail hawks are the raptors one usually sees, but the gray hawk is moving in.

The gray hawk (*Buteo plagiatus*) is a relatively new bird to North America, as its range is moving rapidly north into parts of Arizona, New Mexico and Texas. These hawks live in riparian areas (near rivers) and feed on small rodents or reptiles. Because gray hawks are relatively unknown, William Mannan, a professor at the University of Arizona studies them.

"They [gray hawks] are dependent on riparian zones, which are in decline in the southwest. They are great to study from a management perspective," said Mannan.

Along with Brent Bibles, an assistant professor in Wildlife Ecology at Unity University, Mannan conducted a study about productivity and nest sites in

Southern Arizona. The results of the study showed a positive increase in population and range of gray hawks in southern Arizona, particularly in the San Pedro riparian area.

After these results, Mannan conducted another study, this time focusing on productivity and the food web. Ariana La Porte, a graduate student at the University of Arizona, hopped on board, and took the study on as her research project.

La Porte wanted to study gray hawks after spending time with the Students Conservation of America (SCA) in the Grand Tetons. She recognized the gray hawk as a top predator in the food web and thought the bird would be an ideal subject for studying food webs in riparian areas.

"Riparian ecosystems are endangered habitats in the desert Southwest because of rapid decline of water from pumping and drying," La Porte said. "They are an integral part of the food web in some areas, and, as a top predator, they change the dynamic of what is going on around them."

Before a project could be started, a model for hawk distribution had to be created. Mannan and La Porte decided to replicate the Fretwell Lucas model,

which was developed in the 1980s and used an ideal free-distribution model. This means animals will distribute themselves equally where resources are most readily available.

From his past experiences, Mannan thought riparian areas surrounded by mesquite provided the most resources for the gray hawk. Mesquite and grassland-surrounded riparian areas were the areas that provided the gray hawk with a better chance for successful breeding and higher nesting survival rates.

Another focus of the project studied whether different water levels in the San Pedro River affected the way gray hawks feed and how their feeding affected the food web. Nests were observed in areas with high or low water levels and productivity was compared.

The study began in spring of 2014. Nest sites were found in both riparian areas surrounded by either mesquite or grassland. Data from more than 50 nests was recorded within the study areas, but because there was no previous data to compare, another year was required for a comparison to be possible. Spring of 2015 rolled around, and a new year's worth of data could be collected and compared.

Studying these areas was no easy task.

Miles upon miles had to be searched and walked while carrying 50 pounds of gear. La Porte recruited the help of Doris Duke Scholars to help her during the summer of 2015. Heatherlee Leary, who was part of the Doris Duke team, enjoyed the project and realized why studying gray hawks should be important to conservation.

“Gray hawks can be used to determine the health of a riparian area,” Leary said. “Riparian areas are unique parts of the landscape and make up only about two percent of the Southwest, making them extremely valuable for conservation.”

Leary also appreciated the way gray hawks can adapt to areas with different water levels. Humans are expanding at an unprecedented rate, and riparian areas have been heavily impacted.

“Gray hawks function as an apex predator and can serve as a way of observing how changes in groundwater influence the food web in riparian areas,” Leary said. “Ultimately, studies...on gray hawks are crucial for understanding the consequences of human population growth on riparian zones.”

While the study is not done, La Porte does have some preliminary conclusions.

She has found that the grasslands the gray hawks have expanded their home range into are indeed used for hunting. She bases these conclusions on pictures captured of baby gray hawks in grasslands eating small rodents, like cotton rats, that would exist mainly in grasslands.

She also has found that nest sites have a higher success rate in mesquite areas, but found that grassland nests, if successful, produced more chicks.

“I have never found, in the mesquite areas, more than three chicks,” La Porte said. “In the grassland areas, of the 10 nests that were sampled, two nests had 4 chicks each, and so whether it is a different strategy that is allowing them to be productive or individuals that are able to lay more eggs, there are a lot of different reasons that could explain this.”

La Porte also found that nests that were previously occupied by gray hawks were later settled by red-tails and grey-horned owls. This raises the question of how interspecies connections work.

Because not enough data has been taken to make conclusive statements, these results could have occurred by chance alone.

La Porte’s preliminary results suggest several questions. Why do gray hawk chicks like to feed on adult lizards? She also has more questions on gray hawk expansion. La Porte wants to look at how the gray hawk interacts with other bird species like the red-tail hawk, and gray-horned owl, for example.

La Porte hopes that studies like this reach the public as the results are important to more than just animals. Numerous animals like the gray hawk need the endangered riparian ecosystem to survive.

“This is something we are trying to protect in Arizona,” La Porte said. “The gray hawks are a good indicator on whether or not we are doing a good job protecting it.”

There is only one peer-reviewed study on grey hawk food webs currently published by Bible and La Porte. If reported findings show anything captivating, or enticing, then other scientists might want to study gray hawks in riparian ecosystems.

“The gray hawks need this endangered ecosystem,” La Porte said. “Not very much is known about them, even though Raptors are atop the food chain.” ^(SV)



**PHOTOGRAPH BY
ARIANA LA PORTE**

Three-week-old chicks posture as an observer approaches the nest. Note the unhatched egg underneath the chick on the right.

No, the ‘hiatus’ doesn’t disprove global warming



by **EMMA REED**

Scientists at the National Oceanic and Atmospheric Administration (NOAA) say that the “hiatus” — a pause in global warming since 1998 — might never have happened at all.

A paper, spearheaded by Thomas Karl and eight other NOAA researchers, was published in *Science* in late June of 2015. The authors found the hiatus in global warming might not be a real trend, but might represent differences in ship and buoy measurements. Their findings have garnered the attention of other scientists, the media, and the U.S. Congress.

The authors of the paper, and NOAA itself, were recently issued a subpoena by Lamar Smith, Chairman of the House Committee on Science, Space and Technology. The subpoena seeks “all documents and communications referring or relating to corrections to sea temperature data from ships and buoys,” particularly emails between Karl and his collaborators.

“This subpoena appears to be furthering a fishing expedition,” Committee Ranking Member Eddie Bernice Johnson wrote in response to Smith. “Unfortunately, this is reflective of much of the Committee on Science, Space and Technology’s ‘oversight’ work this Congress, and it is a disturbing trend for the legitimacy of this Committee.”

A “faux pause”?

Global average surface temperature since 1951 has increased by 0.11 degrees Celsius per decade, but the warming trend since 1998 is less than half that — 0.04 degrees per decade.

This slowdown in global warming, dubbed the “hiatus,” has become a favorite argument for climate change skeptics.

“One-third of Man’s entire influence on climate since the Industrial Revolution has occurred since January 1997. Yet for 224 months since then there has been no global warming at all,” writes a popular climate skeptic blog, Watts Up With That. “On the evidence to date, therefore, there is no scientific basis for taking any action at all to mitigate CO2 emissions.”

These arguments ignore two key facts: 1) Although warming has slowed in the past decade, it is still occurring; 2) natural climate variability can act as brakes — or accelerators — on larger warming trends.

What is natural climate variability? For years, scientists have acknowledged the effects of variations in ocean temperature on the rate of global warming. In particular, the Pacific Decadal Oscillation, a pattern of sea surface temperatures in the North Pacific, has helped the ocean absorb much of the heat that would otherwise accumulate in the atmosphere. In fact, the ocean absorbs a whopping 93 percent of heat trapped by greenhouse gases. The hiatus in warming refers to the tiny 2 percent of heat that remains in the atmosphere.

These numbers are changing. In the past year, scientists have observed a change in the Pacific Decadal Oscillation that could throttle down the ocean’s heat uptake. Some of that excess heat will stay in the atmosphere, which could lead to accelerated warming in coming years.

So, a hiatus doesn’t disprove global warming — it’s evidence that climate sensitivity can change the rate of warming caused by greenhouse gases, but that warming is continuing nonetheless.

Big bad biases

Although climate variability has been used to explain the hiatus, “observational biases in global surface temperature data have not received similar attention,” wrote Karl and colleagues in their 2015 *Science* paper. “In particular, residual data biases in the modern era could well have muted recent warming.”

Data biases occur because measuring global temperature is more complicated than averaging every thermometer reading

worldwide. For example, we have more temperature measurements in more populated and developed areas, which are warmed by heat exhaust and create temperatures that are hotter than their rural counterparts. Scientists identify these biases, compare them to nearby, unaffected temperature readings and apply mathematical corrections to compensate for these biases.

Karl and his fellow NOAA researchers have discovered new biases in the temperature record. For example, ocean temperatures rely on measurements from commercial ships and surface buoys. In recent years, the amount of data collected from buoys has outstripped ship data — and the ship data is often warmer. Complicating matters even more, old ship data was collected with a bucket seawater method, and is now done with engine intake thermometers. Each method has certain biases.

To make useful comparisons between these different data sources, NOAA scientists had to correct these biases. They used overlapping buoy and ship measurements to determine the average difference between the two, and used this difference to correct the ship temperature data.

These new corrections may look similar to the old ones, but they raise recent temperatures by a fraction of a degree. That’s enough to eliminate the tenuous “pause” in global warming.

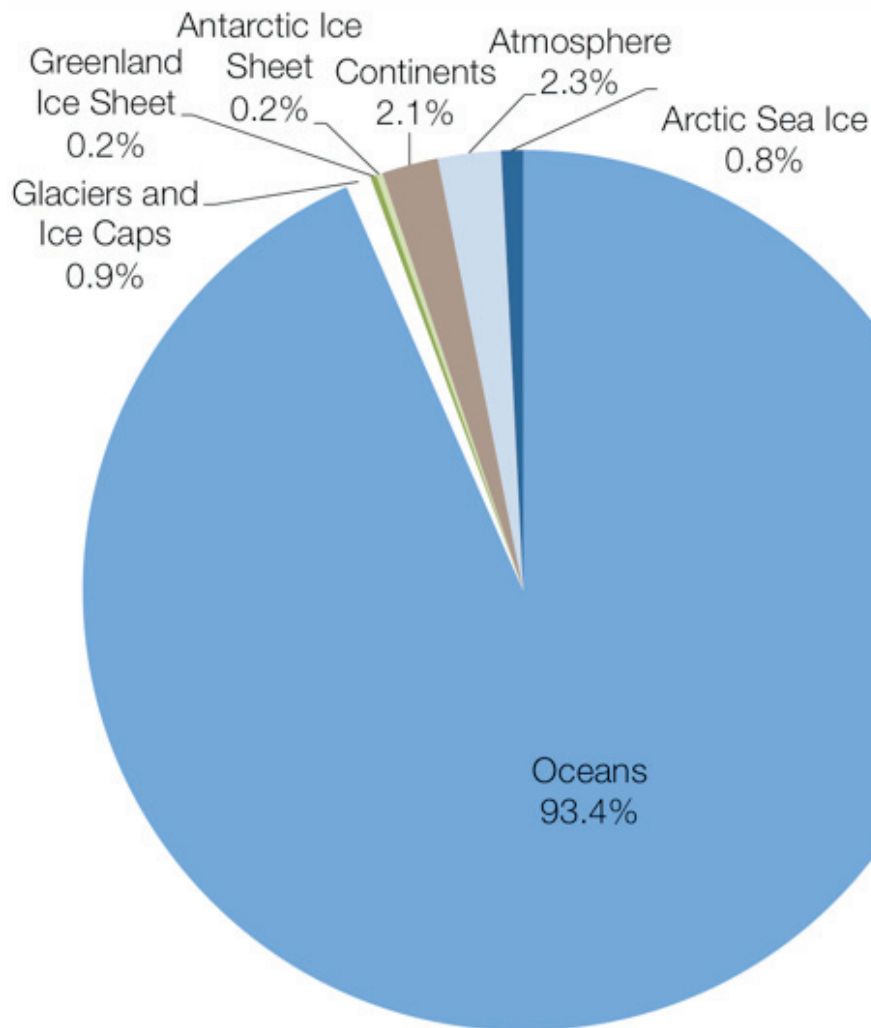
“Newly corrected and updated global surface temperature data...do not support the notion of a global warming hiatus,” the NOAA scientists concluded.

The rate of warming during the hiatus is still slower than in previous decades, but not as slow as previously thought, and certainly not the pause that skeptics claim it to be.

The backlash

Rep. Lamar Smith (R-Texas), Chair of the House Committee on Science, Space and Technology, hasn’t taken these findings well.

After the study was published, Smith ordered NOAA to provide “all data



GRAPHIC BY EMMA REED. BASED ON DATA COLLECTED BY INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

related to this study and the updated global datasets” — data that was already published and available — along with “all documents and communications referring or relating to corrections to sea temperature data from ships and buoys” and relating to “other global temperature datasets” and “satellite bulk atmospheric temperatures.”

NOAA has briefed the Committee repeatedly and provided staffers with all data, but Smith nevertheless issued a subpoena to NOAA in October.

Committee member Eddie Bernice Johnson (D-Texas) wrote a scathing response. “This subpoena appears to be furthering a fishing expedition,” she wrote to Smith. She noted that this investigation “appears to be adopting the discredited tactics of fossil fuel industry

funded climate denier groups” and “seems more designed to harass climate scientists than to further any legitimate legislative purpose.”

Emails, unlike papers, statements, or other official documents, have not been vetted or proofed, which makes them easy to misconstrue. That possibility is well known to climate scientists. In 2009, the emails of many climate scientists were hacked and leaked. This incident, dubbed “Climategate” by skeptics, lifted quotes from their original context to create the appearance of a conspiracy. Investigations cleared all scientists of any misconduct, but the defamation, frivolous lawsuits and even death threats continue today.

If the subpoena of NOAA is another quote-mining expedition, its sheer scale

dwarfs Climategate. The documents and communications ordered by the subpoena refer to more than data and emails: they include letters, diaries, presentations, meeting notes, texts, phone calls — any form of communication — for each of NOAA’s 12,000 employees.

“NOAA, rightfully, has been reluctant to waste their time and resources, not to mention break confidence with their superb research scientists, by responding to this demand,” wrote Rep. Johnson.

At worst, NOAA’s research has become more ammunition in Congress’ battle between climate change skeptics and believers, a battle that scientists settled long ago. At best, the ongoing hiatus debate shows that the gap between scientists and policymakers needs a stronger bridge. (SV)

A Sonoran Symbol in Danger



by **EMILY HUDDLESTON**

Hues of pale magenta, blue and orange envelope the Sonoran Desert sky as the faint chirps of birds drift throughout the landscape. Lizards dart across dirt paths, water rushes through Rincon Creek and a group of backpackers is awakened by the bright light of morning. Looking out across the valley and admiring the day's first movements is the majestic saguaro cactus, standing tall. This is Saguaro National Park.

Saguaro National Park is a unique area where cactuses dominate the landscape, mountain islands rise into the sky and animals find refuge. But Saguaro stands out among America's national parks for another reason: it is split in two by the growing metropolis of Tucson. The park is composed of two districts, The Rincon Mountain District to the east of Tucson and the Tucson Mountain District to the west.

Saguaro became a National Monument in 1933 and a National Park in 1994. Since its creation, Tucson has grown from a small city of about 50,000 to a continuously expanding urban center of one million. With this population boom came urban encroachment.

Standing atop the Rincon Mountains 60 years ago, one would have seen city lights twinkling in the distance, but today cars pull into driveways directly across the street from park boundaries. This increase in human activity is disturbing natural functions within the park.

Saguaros threatened

Through increased urban encroachment, the park and its Saguaros are being isolated from other natural resources. The park is losing its character. Invasive species are being introduced, and there is an increase in noise and atmospheric pollution.

PHOTOGRAPH BY JORDAN FOWLER

A saguaro cactus blooms in April in Saguaro National Park in Tucson. Saguaros are threatened by loss of land and invasive species.



A buffer zone is in place to prevent high density and commercial development in the immediate area around the park with the hope of preventing Tucson from expanding into the park boundaries. However, this is not enough. Even the development in this area is endangering the welfare of Saguaro.

To save this natural desert oasis, we need to limit roads, homes and businesses around and in Saguaro National Park.

Roads present one of the greatest challenges to the park. Their presence increases pollution and harmful interactions between wildlife and humans, at times resulting in the death of park species as they cross these roads. Critically, however, roads create barriers for wildlife by dividing and fragmenting habitats. Species become isolated within the park, which might affect the health of these populations.

Picture Rocks Road is an example of this developing problem -- a high commuter road that runs through the northern portion of Saguaro's Tucson Mountain District. This road illustrates how human developments and stressors can influence park resources. Studies by park staff have shown that 51,000 vertebrates die every year on the park's 50 miles of road and most of those deaths occur on Picture Rocks Road. In 2002, the park tried to close the road but the public pushed for it to remain open because of its convenience. The road also brings light, noise and litter deep into the park.

Threatened by Urban Sprawl

Housing sprawl is another culprit.

The Saguaro National Park website predicted that by 2090 the park will become a protected island surrounded by suburban development. A protected island occurs when a protected area becomes disconnected from other natural areas. Imagine that you could no longer leave Tucson because travel was impossible. That is the reality of most species within the park. The housing sprawl also increases pollution and light, which degrades the park's natural appearance and functionality.

Saguaro National Park is also not safe from the development of business. According to an article in the Arizona Daily Star, in 2014 a bike ranch to be located near the entrance of the park was proposed to the Pima County Board of Supervisors. The facility was to have 49 units, training facilities, retail space and a restaurant. While the park welcomes cyclists in and around the park, for the protection of natural resources it opposed this proposal. Fortunately, the supervisors decided against the ranch.

But it may not be long before another business attempts to build near park boundaries, and then

the park might not be so lucky. Once commercial use is allowed adjacent to the park, a precedent will be set and expansion will be hard to contain.

Development is also causing another massive problem in the form of invasive species. Invasive plants are not part of the natural ecosystem. They are brought to the park, usually by humans, and interfere with the native ecosystem so quickly that it can't adapt or respond.

The Desert's Archenemy – Buffelgrass

An example of this is the Sonoran Desert's archenemy: buffelgrass. Buffelgrass was brought to the U.S. from central Asia and Africa. It is extremely resilient and can thrive almost anywhere. Buffelgrass was imported by farmers who wanted to turn their barren land into grasslands for cattle grazing. But now this grass grows in the desert better than any other native grass, and this is not a good thing.

Buffelgrass spreads very quickly, often through developing roads. Construction disturbs areas around the road and creates ideal conditions for buffelgrass to gain a foothold and spread. The grass then takes space and sunlight from native plants and alters the fire regime of an area.

Under normal conditions, wildfire is uncommon in the desert because there is not enough fuel to keep the fire going. Because buffelgrass is rampant, it fills in the sparse vegetation. This allows wildfire to start more easily and spread more quickly through areas invaded by buffelgrass, killing everything in its path.

The Benefits of Healthy Ecosystems

Keeping species healthy and their habitats intact is important for the park, but healthy ecosystems also offer us many benefits. Saguaro National Park offers solace. The park is a place people can visit to escape the stress of the city and enjoy the peaceful wilderness. Visitors come to the park for this experience, to watch beautiful sunsets on quiet, dark nights and to enjoy the natural scenery the park has to offer. These natural luxuries are already diminishing, and if Tucson continues to expand, this peaceful escape will be nothing more than an extension of the city.

Every citizen of Tucson should understand the importance of Saguaro National Park to the entire metropolitan area. Our water flows from its peaks, our air is cleaned by its forests. Our city is known around the world for the cactuses it protects. Development in and around Saguaro National Park is a massive threat to this pristine swath of desert. For this reason, development in and around the park needs to be limited before we lose an integral component of the American Southwest. (sv)



**PHOTOGRAPH BY
ELIZABETH EATON**

The ocean biome at Biosphere 2 is a microcosm of a Caribbean reef, complete with wave generation. Fish, algae and coral call the biome home, and live in a self-sustaining cycle with little human assistance.

ARIZONA'S

Our dwindling water bank account



by **JESSICA AHLSTROM**

The Colorado River moves 2.8 million acre-feet of water into Arizona each year, leaving water managers with critical decisions for the state's future.

The Salt, Gila, Verde and Agua Fria rivers contribute another 1.2 million acre-feet to water users in Arizona, according to the Arizona Water Resources Research Center.

All of these rivers are considered renewable water resources – meaning that the natural water cycle will replenish the water that is used year after year.

According to Joaquim Delgado, public information specialist with Tucson Water, one acre-foot of water provides four families of four with water for one year in Arizona.

Groundwater, a vital water resource for residents of Arizona, has been accumulating slowly over hundreds of years and is considered a nonrenewable water supply.

Like any bank account, too many withdrawals and too few deposits will lead to a depletion of savings – leaving the spenders, Arizona's water users, broke.

Over the last 15 to 20 years, the West has seen more high temperature droughts, reduced snowpack at high elevations and less snowmelt

free to flow through our rivers and renew our water supply.

It should not come as a surprise that residents of Arizona are facing a gap between water supply and demand.

The Arizona Department of Water Resources predicts that by 2060, Arizona will need to develop an additional 0.9 to 3.2 million acre-feet to meet the demand of water users.

With water shortage looming on the horizon, water resource professionals are looking to use new technologies to make every drop go a little farther.

Water reuse

“Currently only about five to six percent [of wastewater] is reused beneficially,” said Shane Snyder, professor of environmental and chemical engineering at the University of Arizona and co-director of the Arizona Laboratory for Emerging Contaminants (ALEC) and the Water & Energy Sustainable Technology (WEST) Center.

Tucson Water augments the city's water supply by using reclaimed wastewater to irrigate parks and golf courses around the city, in turn saving potable (drinking) water.

In Tucson, reclaimed or recycled water is wastewater treated to remove solids and impurities before it is recharged into the groundwater system.

This recharged water is pumped from the groundwater system and sent to a water reclamation facility for further cleaning before it is dispersed through Tucson's recycled water distribution system.

Tucson Water has moved forward with a plan to develop an indirect potable reuse program to augment the city's potable water supply.

Indirect potable reuse blends advanced treated recycled water into a natural water source – in Tucson's case, groundwater.

This takes advantage of natural microbial processes in the soil, which clean contaminants from the water as it infiltrates into the groundwater.

“The soil is incredibly effective at cleaning these contaminants because the microbes like to eat them,” said Jean E. McLain, associate director of the Water Resources Research Center and associate research scientist in the department of Soil, Water and Environmental Science at the University of Arizona.

McLain studies the biology of recycled wastewater – specifically trace contaminants and microbial antibiotic resistance.

McLain found that when adding wastewater to a basin to recharge the groundwater system, the numbers of multi-antibiotic resistant bacteria actually went down significantly compared to an agricultural irrigation pond, for example.

These results were very surprising.

“What if recycled water is actually making the environment so much healthier for human beings?” McLain said.

Unfortunately, there is a stigma associated with potable water reuse, and the phrase “toilet to tap” doesn't help.

“When people think about trying to drink something that went down the toilet . . . It's not easy to grasp until you really get to the science behind it,” Snyder said. SV



WATER FUTURE

Preventing wastewater from being wasted water



by **JORGE ENCINAS**

With a potential shortage on the Colorado River projected later in the century, Tucson Water is looking ahead to a new source of drinking water that until now has just been flushed down the toilet.

Tucson, like much of the Southwest, needs to plan for the future to meet demands for water. While the city has projected no shortages until around 2050, the city needs to find new sources of water and increase conservation to prevent a water crisis later.

To visualize just how much water is used in Arizona, Kelly Mott Lacroix, a senior research analyst at the Water Resources Research Center at the University of Arizona, describes the amount of land that could be filled with the annual statewide usage in acre-feet. One acre-foot is the amount of water that covers one acre in one foot deep of water.

"In Arizona we use approximately 7 million acre-feet a year," Mott Lacroix said. "Which is the equivalent of about 2.3 trillion gallons. but if you were to put that across, assuming the landscape is flat, it is the equivalent of completely covering Maricopa

county to a foot deep of water...It's a lot of water, right?"

Mott Lacroix points out that the majority of the water usage in Arizona, 70 percent, goes to agriculture.

A potential candidate that can provide for sustained water usage in the future and prevent Tucson from drying up is reclaimed water, also known as wastewater.

Wastewater is considered a renewable source because every time it is flushed down a toilet or poured down a drain, it goes to a reclamation center where it is processed, cleaned, treated and reclaimed.

Groundwater does not have the same resiliency and is, for practical purposes, generally considered a non-renewable source of water. This is because of the time it takes for groundwater to build back up naturally through rain and snowmelt.

One artificial process used to recharge groundwater supplies is the infusion of Central Arizona Project (CAP) water placed in large fields that replenish the aquifer while simultaneously having the excess banked underground for later use.

This banking of CAP water is why Tucson is not projected to see any shortages until about 2050. Once a shortage is declared, the first to notice the affects will be the agricultural industry.

Fernando Molina, a public information officer with Tucson Water, estimates it would take about 15 to 20 years for those living in cities to notice the affects of a shortage.

If Tucson loses the allocation of CAP water it is currently using to replenish groundwater supplies, then it will need to find a new source to replace that void. A potential solution is recycling wastewater to provide a source of drinking water later.

According to Molina, El Paso, Texas, is building a recycled water plant and has been recycling water for some time by taking wastewater and recharging the aquifer with it. The new plant will provide El Paso with the means to have a more controlled program that can monitor the quality going in.

"That's how most communities right now are looking at recycling water for drinking water," Molina said. "They're usually going to put it into a lake or into an aquifer and there's benefits for doing that."

A big benefit is the natural processes in the soil remove many of the bacterial, viral and pharmaceutical contaminates people worry about as the previously treated water seeps down to the aquifer, Molina said.

"The natural treatment process goes a long way ... I've been to some conferences where they've said 90 percent of those chemicals or constituents that people are concerned about are eliminated just through the recharge process," Molina said.

Mott Lacroix highlights the need to take a serious look at exploring the use of recycled water to meet the future needs of Arizonans.

"As a prudent water manager you have

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PHOTOGRAPH BY ELIZABETH EATON

Homes in the Sam Hughes neighborhood, located near the University of Arizona, are irrigated with reclaimed water. Irrigating with toilet to tap water helps conserve healthy, clean water for drinking.

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to consider all of your options,” she said. “And potable reuse, which is kind of the terminology that everybody uses for it, is something that should be considered.

“Because if we come up to the point where our back’s up against the wall, you would have hoped somebody has done a whole heck of a lot of work in the science to understand the safety of it,” Mott Lacroix said.

Two researchers at the UA who are working on that science are Robert Arnold, who holds a doctorate in environmental engineering, and Eduardo Saez, with his doctorate in chemical engineering.

“When they say 90 percent, they are talking about all the suite of compounds that are present in the water but that doesn’t refer to specific compounds. For example, what’s going to happen to a specific pharmaceutical when you filter it through the ground,” Saez said. “People really don’t know, for some compounds, what their fate is going to be so that’s actually part of my research.”

The advance filtration used to make wastewater into drinking water is not simply filtering out contaminants but also chemically

treating the water and thereby changing the harmful organics into harmless compounds.

“Because these compounds are organic they can be oxidized all the way to carbon dioxide which is harmless and so that’s what our technology is doing,” Saez said. “So that technology is called advanced oxidation.

“You can remove some of the organics by filtration and you can destroy some of the organics by this type of treatment and then the water that you get at the end is going to be perfectly safe,” he said.

While the process of purifying the water as well as the ground filtration leaves the water perfectly safe, and possibly even more pure than before, the psychological factor of people drinking what had once been wastewater is a drawback, Saez said.

“That’s a big problem with water reuse because people find it hard to take, they usually say ‘toilet to tap,’ and that sort of thing and that’s not really representative of what’s going on,” Saez said.

In Tucson’s case the natural aquifer that holds the supply of water underground is the best tool to put reclaimed water to use for drinking purposes. The ability of the natural process to remove many of the compounds

without expensive direct reuse methods makes it more cost effective, Arnold said.

“I would totally recommend against that, direct potable reuse, and the reason is because we don’t need to do it,” Arnold said.

“That is, in the past we’ve relied on indirect potable reuse to some extent ... but we have this great aquifer that can store, almost indefinitely, the amount of water that we would like to put back into reuse,” he said.

A benefit of the aquifer is its ability to provide free treatment for the water as well as protection against contamination and that should be taken advantage of, Arnold said.

The potential for using reclaimed water to prevent Tucson from experiencing the shortages that are affecting California will rely on the research and preparation being made by both scientists and water providers.

It will also take public understanding to support use of reclaimed water for drinking purposes.

“You wouldn’t want people to say, ‘Oh no, that’s gross, I don’t even want to do that,’ and then all of a sudden we need to do it and we don’t have the science to do it safely, right?” Mott Lacroix asked. (sv)

Putting curiosity back into STEM



by **MORGAN BROWN**

It's high time we put curiosity back in the classroom.

Curiosity. It's the name of a Mars rover, the driving force behind every scientific discovery and the reason I chose to pursue a degree in STEM. The STEM fields, science, technology, engineering and mathematics are cutting edge; they are fast paced, competitive and exciting.

These fields require curious and passionate students willing to ask questions and explore new frontiers, but these are not the students our educational system is turning out. If our students are to succeed in STEM, it is imperative we change our approach to education.

I always knew I would have a career in science. When I reflect, however, on my earliest exposure to the STEM fields in my elementary high school courses, I don't ever remember feeling passionate about science or research.

Had I been exposed to the more interesting parts of STEM earlier I certainly would have been more prepared for the challenge of college-level science and math, and I would also have been more excited about pursuing a science-based career.

Unfortunately, students have few opportunities to be excited about science until far too late in their education. In an article published in *USA Today*, high school students across the U.S. reported that at school they felt: tired, stressed and bored. These are not trivial findings either. The sample size was 22,000 students from across the nation. Feeling "excited" was only reported 4.7 percent of the time.

These findings are disturbing. We cannot expect students to consider careers in STEM when every ounce of curiosity has been stifled by the time they get to college.

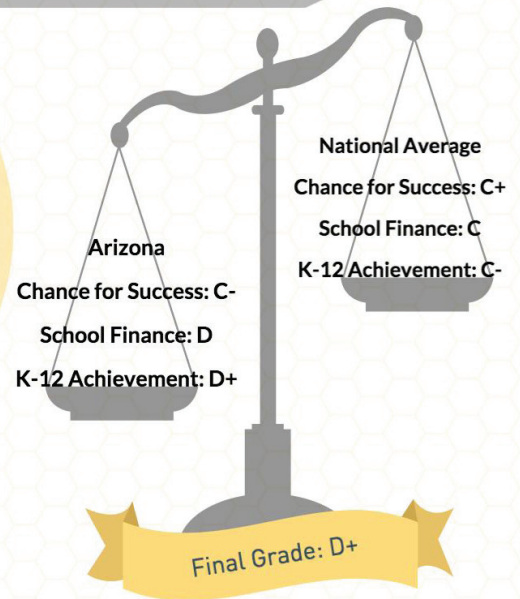


The Chance-For-Success Index:

- Preschool enrollment
- Kindergarten enrollment
- Elementary reading
- Middle school mathematics
- High school graduation
- Postsecondary participation



Arizona ranked 47 out of 50 states in Education Week's 2015 Report Card



GRAPHIC BY MORGAN BROWN

If critical subjects like chemistry, biology and physics are boiled down to textbook examples and standardized questions, we have inevitably stripped students of their most vital resource: their questions.

My most exciting high school science moments were never in the classroom. As a sophomore I worked with a friend in a materials engineering laboratory at Arizona State University to gather data for our state science fair project. Working in that lab was my first taste of a very exciting and very accessible world with endless possibilities.

My experience in the materials lab left me with a very important lesson: science is exciting. If more high school students could have hands-on, no-textbook experiences we would be fostering a much more engaged and aware group of individuals ready to tackle any challenge presented to them.

In an article on Edudemic, Kristen Hicks cites five ways to make STEM more exciting for students: incorporate

pop culture, make it relevant, debate, let guests lecture and let student passions drive assignments.

Students are already connected via smart phone and computer to pop culture phenomena, so let this drive a discussion about the mechanics of hover-boards or the water crisis in California. Guest lecturers, such as scientists or engineers, are masters of their fields, and from personal experience I can assure you that scientists love to talk about their research. These are just some of the ways we bring curiosity back to the classroom.

It is imperative that we teach our students how to ask questions, especially because the need for scientists, engineers, mathematicians and computer scientists has not and will not be met. Albert Einstein said, "I have no special talent. I am only passionately curious." It's time our students were reminded that our world is a beautiful place to explore with passionate curiosity. ⁽⁵⁾

