

- A. Project Title
 - Slithery Situations: Biodiversity Threats to Local Herps (Amphibians and Reptiles)
- B. Authors and Date
 - Michael Weiss and Seth Wisniewski Smith
 - 22nd Nov. 2009

- C. Summary of Activities

Our workshop will educate the public about threats to biodiversity using interactive, local amphibian/reptile examples.

Our presentation will contain two mini-presentations, one for each species-threat pair. Each will include a lecture portion in which we verbally introduce the threat and the species, detailing what physiological or behavioral characteristic makes the species susceptible; each will also include a more interactive portion, which will be tailored to the particular audience. Our model organisms will be the desert tortoise and the lowland leopard frog, through which we will explain the threats of habitat fragmentation, habitat degradation, and invasive viruses and species. The interactive portions of each presentation will include musical performances, live data collection with a desert tortoise, and visual displays that present the changes in each species' habitat as our cities grow. For adults we will detail current UA research and community projects so they can become involved. This partitioned format will suit a 'browsing' audience.

We also want to encourage people to creatively consider ways to raise awareness about threats to biodiversity, set up in the form of a raffle. People will submit their suggestion for a prompt we give them and leave their contact information, and (if possible) the winner could get a discount coupon to return to B2 or a t-shirt.

Elevator speech: “Sonoran Desert Discovery is a new outreach course at the University of Arizona in which groups of students develop lesson plans about current topics in ecology that relate to the Sonoran Desert. By collaborating with faculty mentors at the UA, we ensure that our topics exhibit the latest research and information in our region, information that might otherwise take years to reach public awareness. Our presentations every Saturday at Biosphere 2 are the culmination of our work this semester, but we also provide our lesson plans online so that teachers can share this knowledge in their classrooms.

The Sonoran Desert contains some of the highest levels of biodiversity in North America, meaning that we have a very substantial variety of plant and animal species in our region. Unfortunately, there are many threats to biodiversity in our area, some you wouldn't expect. Our presentation tells the stories of two local species whose numbers are in decline, the Sonoran Desert Tortoise and the Lowland Leopard Frog. Using songs, games and some visual aids, we will explain what endangers these species, what we are learning about them through research, and how the methods of helping these particular species could benefit the entire ecosystem. If anyone is interested, we will also provide resources for becoming informed and involved in conservation, and we welcome everyone to enter our raffle for a chance to win a prize from Biosphere 2.”

- D. Targeted Audience:

This workshop is designed to appeal to a broad age range. The visual aids utilize a balance of pictures and tiered informative text to engage individuals with various levels of education. The interactive activities are aimed toward a younger crowd, but adults should find them amusing and informative nonetheless. The “dialogue-lecture” format allows presenters to modify the information depth from group to group depending on their interest and background.

- E. Introduction/Background Information

There are numerous threats to biodiversity, and unfortunately many of these threats exist in our own Sonoran Desert. Ecosystems located near sprawling cities like Tucson or Phoenix can suffer from degraded and fragmented habitats—often due to roads or other developments through areas important for maintaining interactions between populations. Fragmentation of habitats with roads and rail networks increases the amount of “edge” around the habitat it bisects, making it easier for invasive species (or humans transporting invasive species, as with Bullfrogs in Arizona) to enter the habitat while preventing naturally occurring species from safely traveling throughout historic ranges. Male Gila Monsters described in Kwiatkowski et al. (2008) are an example of the latter point. The males’ retain their naturally larger home ranges and movement patterns despite inhabiting high-traffic urban regions, leading to higher mortality and female-biased sex ratios. Invasive species can threaten native species in many ways, including spreading new pathogens that can infect native populations (Bradley et al. 2002).

Although these threats affect the entire ecosystem, certain species might be more susceptible than others due to their behavior or physiology. This lesson focuses on reptiles and amphibians that especially exemplify this susceptibility: the desert tortoise (*Gopherus agassizii*) and the lowland leopard frog (*Rana yavapaiensis*). Discussing how to counteract threats to these local species can raise awareness about globally important issues in the fight to preserve and conserve earth’s biodiversity.

The Sonoran Desert

QuickTime™ and a
decompressor
are needed to see this picture.

The Sonoran Desert is located in California, Arizona, Baja California and the state of Sonora. It is located in close proximity to the Sierra Madre Occidental and Rocky Mountain ranges, as well as the Mohave, Chihuahuan, and Great Basin deserts. The Sonoran Desert contains a great amount of geographic diversity, which includes part of the Madrean Sky Island complex (www.skyislandalliance.org). The geographic diversity leads to multiple biomes in a small area (areas of different temperature and precipitation patterns typically categorized by local plant species), which allows an extremely high level of plant, animal, and insect diversity in the Sonoran Desert. According to the Sonoran Desert Conservation Plan, the Sonoran Desert has been designated as a top eco-region worldwide by the Nature Conservancy (SDCP online at <http://www.pima.gov/CMO/SDCP/index.html>; TNC online at www.nature.org).

The Desert Tortoise (*Gopherus agassizii*)



The historical habitat of the desert tortoise ranges from the northern reaches of Sinaloa in Mexico, north through the Sonoran Desert, into southeastern California and east into New Mexico. Within the Sonoran Desert of Arizona, desert tortoises typically live on steep, rocky hillsides among the paloverde and saguaro, and at least eight genetically similar but distinguishable populations have been studied, separated by vast expanses of desert floor (Edwards et al. 2004). These long-lived creatures range from around two inches in length at birth to around 14 inches in length as adults. The legs of the desert tortoise are elephantine and the front legs are somewhat flattened (for protection when in the animal retreats into its shell) and powerfully muscled for digging. The domed shell is brownish-gray on top and yellowish underneath the body. Males have a concave section towards the rear of the under shell to make room for the shape of the female's shell during copulation (ASDM 1999).

Desert tortoises are most active in the spring and the monsoon months of summer. In spring, desert tortoises feed on annual plants and retain most of their water by storing the moisture from these plants, although they also seek out rain puddles as water sources. The water garnered from these sources can account for up to 40 percent of its body weight (ASDM 1999). Unlike humans, desert tortoises can survive long periods without consuming water because their excretory systems efficiently remove water from urea, storing it as solid waste. When a source of fresh water is available the urea can be expelled; this doubles as a defense mechanism in desert tortoises if attacked or harassed. Thus the desert tortoise must be able to locate water, if only occasionally, in order to use these functions.

The behaviors of desert tortoises can be summarized, if somewhat oversimplified: If two males meet, they will fight; if a male meets a female, he will try to mate. Often a male will tip an opponent on his back to assert dominance, and a fight is usually won when the submissive male retreats from the dominant male. Some individuals are capable of traveling great distances across the desert to mate with other populations. Edwards et al. (2004) observed one individual traveling over 30km, and through subsequent genetic testing determined that the populations needed at least one migrant per generation to maintain their observed genetic similarity. This aspect of behavior in desert tortoises places their population structure, and therefore their genetic identity, at risk.

Although habitat loss is the primary threat against desert tortoises (thousands of acres of their habitat are developed as Phoenix and Tucson expand each year), habitat fragmentation also threatens them because it seriously impedes any journeys between populations. Roads, railways and canals are dangerous obstacles for a desert tortoise to overcome, and Arizona's infrastructure has grown substantially in the past three decades. As more of the range they inhabit becomes fragmented by passageways, the voyages they embark upon will become more dangerous and less successful. Since desert tortoises take 13 to 15 years to reach sexual maturity, their populations could have a harder time rebounding than shorter-lived species and the effects of

habitat degradation and fragmentation might not be apparent until it is too late to act effectively (ASDM 1999, Edwards et. al. 2004).

Taylor Edwards and others within the University of Arizona are currently conducting research on habitat fragmentation and the genetic impact it has on populations of desert tortoises. The utilization of population genetics is shedding light on the significance of the migrations to the maintenance of genetic variation within the Sonoran desert tortoises. By studying the meta-population dynamics of the desert tortoises, which could involve certain populations emigrating or immigrating more than others, we can assess the importance of unimpeded movement to their conservation and propose legal action to protect them. Since *many* other organisms are affected by the dangers of crossing roads to access their natural habitat (such as mountain lions, jaguars, and rattlesnakes to name a few), a solution for desert tortoises could help a variety of desert animals in that regard.

Lowland Leopard Frog (*Rana yavapaiensis*)



Lowland leopard frogs were historically distributed throughout the Sonoran Desert, but now occupy less than half of that area and their numbers continue to decline (Clarkson and Rorabaugh 1989). Similar to the desert tortoise, urban sprawl and development has rendered a sizable segment of their range uninhabitable, and their dependence on water regimes has further reduced their numbers due to our current drought and historical water consumption and diversion.

Aside from habitat degradation threats to their existence, human introduction of bullfrogs (*Rana catesbeiana*) in Arizona has helped decimate leopard frogs in their natural range. Besides being indiscriminant predators (bullfrogs will eat just about anything, including other frogs), the bullfrog is a known vector for the fungus *Batrachochytrium dendrobatidis*, or “Bd” for short. Bd is a potential precursor to the much-feared chytridiomycosis, a disease implicated in amphibian population declines around the world. Studies have shown that up to three-quarters of bullfrog populations in the Sonoran Desert are infected with Bd, and although these populations showed a lower rate of infection than Lowland Leopard Frog populations, the difference was not significant (Schlaepfer et al. 2007).

Chytridiomycosis confirms that an organism’s physiology can make it more susceptible to a threat, and the lowland leopard frog’s amphibian skin is what puts it at risk for this deadly infection. The infection spreads easily across many amphibian species, often killing its host. It does this by feeding on keratin, a component of adult amphibian skin; since most amphibians rely on their skin for oxygen and water absorption, as well as a first line of immune defense, this pathogen may disrupt necessary processes for metabolism (Berger et al. 1998). Frogs infected by chytridiomycosis exhibit extra growth of skin cells (epidermal hyperplasia) and varying levels of

skin discontinuity (cutaneous ulcerations). Of course, this threat applies to many different frogs in Arizona, including other leopard frogs and canyon tree frogs (Bradley et al. 2002).

Habitat loss, habitat degradation, invasive predators, and the spread of chytridiomycosis together present a dangerous situation for lowland leopard frogs. In areas around Saguaro National Park, this species is becoming genetically isolated and the current drought is limiting their habitable areas further. The neighborhood surrounding the park, along with UA researchers, is participating in a project to provide ponds for lowland leopard frogs. These ponds act as genetic “reservoirs” where frogs can survive in dry years, preserving the diversity of their gene pool even if their numbers decline in the wild. The hope is then to reintroduce frogs into their wild habitat when conditions are more favorable. For more information on the Lowland Leopard Frog Habitat Restoration project, visit www.friendsofsaguaro.org.

Threats to biodiversity often occur simultaneously and their additive effects can devastate species that cannot adapt to their presence. Understanding the effects and interactions of multiple threats on species is an emerging and complex science, and strong scientific evidence that the species or area is endangered is required before legislative action to protect a species or area can occur. To truly protect a species requires looking beyond its geographic location, beyond its behaviors or physiology, and beyond the species itself to the interactions of the entire ecosystem and the threats affecting all levels and phenologies within it. Although desert tortoises and lowland leopard frogs demonstrate the need to understand animal behavior and physiology in regard to specific threats, they should also serve as reminders that if one part of the system changes, the effects ripple throughout.

- F. Credit for the Activity:

The workshop was developed as a form of public outreach in the Sonoran Desert Discovery class at University of Arizona, formatted based upon a modified Marine Discovery template. Michael Weiss and Seth Wisniewski Smith developed the games and activities. Song and lyrics by Michael Weiss.

- G. Estimated time to do the activity

The workshop requires between 30 and 45 minutes. It is modifiable based on the interests of the audience.

- H. Outreach Goals

- Broad Goals:

- To engage the public’s interest in the area of conservation and ecology
- To teach children and adults about threats to biodiversity and the role of research in conservation
- To promote support and participation in local conservation projects.

- Specific Goals:

- To understand that the Desert Tortoise and Lowland Leopard Frog are examples of animals with behaviors or physiologies that put them at greater risk to certain ecological threats.
- To understand how certain threats to the environment (habitat fragmentation, invasive species/disease) affect animals.
- To understand that one environmental threat can exacerbate another.

- J. Materials Needed
 - Basic needs:
 - Two tables
 - Chairs or seating for visitors to rest
 - Visual aids:
 - Posters for the Desert Tortoise/Habitat Fragmentation and Lowland Leopard Frog/Invasive Species and Pathogen sections (available as .pdf below).
 - Props from Edwards et al. (2004): including radio-telemetry equipment, microchip identification equipment, and DNA storing/testing equipment. Papers to label the props.
 - Raffle setup:
 - Glass jar with a slot in the top for entries.
 - Raffle tickets with name/phone number information.
 - Large paper/poster for public to write upon (also need tape to put it on wall or board backing to prop it up).
 - Crayons or markers.
 - Tortoise Movement Activity [Child Presentation]:
 - Desert Tortoise (Sonoran population preferably)
 - Holding tank
 - Lettuce or other enticing tortoise food
 - Stopwatch
 - Measuring tape
 - Sidewalk chalk
 - Whiteboard
 - Calculator
 - Leopard Frog Game [Younger Child Presentation]:
 - Six numbered poster-board “ponds”
 - Six numbered cards with harmful events, one card labeled “conservation effort”
 - Paper to keep track of turns
 - Musical source (boom box or guitar)
 - Leopard Frog Game [Older Child Presentation]:
 - Rule sheet and cards listed in APPENDIX
 - Need to build board game with eleven ponds, each separated by 1-5 marked “spaces” from each other.
 - Dice
 - Sing-along [Child Presentation]:
 - Stool
 - Guitar(s)
 - Printed copy of lyrics for each person and/or large board with lyrics. Printed copy of lyrics will include take-home facts from the presentation and basic definitions.
 - Giveaways:
 - Pamphlets from Tucson Herpetological Society
 - Information from Sky Island Alliance
 - Coloring Sheets from Tucson Herpetological Society

- K. Preparation and Tips for Presenters
 - Before presentation/setup: Find a location with plenty of room for people to gather in a crowd while still allowing other people to walk past. Find a location on the tour route that most people will have to walk past.
 - Prop up the posters on the table or tape them to the wall, depending on wind. Place the props on the table in front of the appropriate poster, next to labeled sheets of paper that identify each prop.
 - Set up the raffle beforehand, with the large sheet of paper and crayons/markers in an easy place for kids or adults to write their thoughts. Place the raffle box near the paper.
 - For the tortoise activity, set aside the measuring equipment and white board. Until it is time for the activity, keep the tortoise and tank up on the table near the tortoise poster to attract attention.
 - For the Leopard Frog/Bullfrog game, set up the game board and pieces beforehand.

- L. Step-by-step procedure for the activity
 - Introduce yourself (name, major, interests, the course)
 - Gather the audience around the poster in a group and explain that after you teach them a few things about animals and threats to animals there will be a game and a song performance. Encourage the audience to ask questions and inform them about the raffle. Tell the children that they will get coloring sheets, whether or not they participate.

 - Interactive Lecture #1 (Desert Tortoise/Habitat Fragmentation, 4-5 minutes):
 - Define biodiversity. Explain that there are many different threats to biodiversity, and the purpose of this presentation is to show that sometimes how an animal naturally acts can make it more endangered.
 - Begin with some basic facts about Desert Tortoises, and encourage questions. Make sure to explain their range, how long they take to mature, the dangers of being young, and the safety of being an adult with a full shell. Tell everyone that the number of D.T. have declined since humans have started developing Arizona. Ask what could cause this.
 - Explain that researchers at the UA want to help D.T., but first we need to know more about the tortoises. Ask why it's important to gather information before taking action.
 - Describe the methods used by Edwards et al. (2004) to track the tortoises using radio-telemetry technology, and show the equipment they used. Explain the results of the radio-telemetry data. Next, describe their genetic investigation while passing around equipment for DNA testing (test tube holders and tubes). Explain that this study found that tortoise populations exchange individuals at least once every generation.
 - Explain the concept of habitat fragmentation, using pictures on the poster to show the growth of Tucson and Phoenix. Remind the audience that tortoises can travel far and that they historically traveling across regions of the desert where we've built roads and other infrastructure. Ask age-appropriate questions that integrate the material: (1) why it's dangerous for the tortoises to cross their natural habitat now that humans have arrived, (2) how things will change as humans continue to develop on the tortoise's habitat.

- Activity #1 (Tortoise Data Collection Game, 4-5 minutes): Explain that measuring an animal's behavior is important to understanding how to protect them, and that this activity will show everyone how to gather behavioral data.
 - Ask for two volunteers. Hand out the measuring tape to them and pass out scrap paper and pencils for everyone to collect data.
 - Begin the activity by placing the tortoise on the ground at the starting point. When the instructor starts the stopwatch, let the tortoise follow a piece of lettuce that the instructor is holding until it walks several feet.
 - For larger groups/no tortoise: Volunteers can pretend to be tortoises as well. Line up the volunteers side-by-side and ask them to walk forward by placing one foot directly in front of the other so that their feet still are touching. For every three steps forward, the volunteer must take two steps backward (to keep them from going too far). The instructor should demonstrate this for the kids before starting.
 - The instructor should start the stopwatch and let the tortoise walk for fifteen seconds before marking the distance traveled. Ask the children with the measuring tape to find the distance. Mark the start and end points on the ground. Ask everyone to record the distance(s), and write them on the white board for all to see.
 - Have the audience gather around and show them how to perform calculations that measure the speed the tortoise was traveling on average:
 - Average the distances traveled in 15 seconds, explain the importance of replication.
 - Convert the average distance to distance in miles.
 - Multiply by 4 to see how far they go in a minute; then multiply by 60 to see how far they travel in m.p.h.
 - Compare to different speeds in everyday life (walking speed about 3 mph, an oncoming car on the highway about 60mph)
 - Compare the data to what is known about how far tortoises can travel (over 18 miles in one year; 6 miles in one week in one recording) and their inability to move out of the way of oncoming traffic. Ask the audience what other kinds of things might be dangerous to a tortoise on their long journeys and why.
- Time for questions/remind people about raffle/let everyone know about second part.
- Interactive Lecture #2 (Lowland Leopard Frog/Invasive Species and Pathogens, 4-5 minutes):
 - Explain that it is not only how an animal acts that makes it susceptible to dangers, but that just being a particular animal in a certain spot can put it in danger.
 - Start with basic facts about LLFs. Use prompting statements and questions to keep this from being a monologue and keep the audience actively involved. Make sure to cover the range, natural habitats, and skin, making sure to define the concept of physiology. Talk about how water usage and drought are shrinking habitats. Use visual aides to display the appearance of the frog, and typical habitats. Ask if anyone has a pond in his/her yard; explain that ponds can be beneficial or harmful.
 - Explain what invasive species are and ask why they could be harmful to native species. Talk about the bullfrogs and the problems associated with them. Explain the bullfrogs' voracious appetite and ability to travel distances between water sources. Lead into Disease and the carrying of Chytrid by bullfrogs.

- Talk about Chytrid and Bd and the link between the two. Now relate the bullfrogs carrying Bd to their being an invasive species in the habitats of Lowland Leopard Frogs. Make sure to explain that Bd-infected bullfrogs represent one of many threats to Lowland Leopard Frogs, and that it can travel without bullfrogs.
- Activity #2: Leopard Frog Game (GAME BOARD VERSION, older children)
 - This game involves players choosing a game piece (Lowland Leopard Frog) that is placed on one of the “ponds” on the game board. Any number of participants can play. The board contains many ponds, each connected to the nearest pond by a line with varying distance markers. [RULE SHEET AND POND CARDS IN APPENDIX]
 - Participants begin by rolling the dice. For whatever number they roll, they are allowed to move up to that number of distance markers, but they must end up in a pond. Participants can remain in the same pond and pass their turn if they choose.
 - After everyone has rolled the dice and moved, an “event” card is drawn. These say things like “Oh no, all the frogs in pond six have caught Chytrid Fungus from an invasive bullfrog and they’re out of the game,” or, “Uh oh, the drought has dried up pond four and all the frogs in that pond are out of the game.” At this stage, all the cards relate to harmful events in certain ponds. When one of these events occurs, that pond is removed from the game because it is uninhabitable. Keep track of the order that each pond is removed from the game, and how many people get out on each turn. This round ends when all the participants are out of the game or only one pond remains. Make a note of how many turns it took for everyone to get out of the game, or how many “leopard frogs” remained in the last pond. The game continues until only one pond remains, or until all players are out of the game.
 - Ask the players if they thought that multiple threats (like habitat loss or invasive species) make it easier or harder for the leopard frogs to survive in the wild, and why they think so. Propose hypothetical situations (e.g., what if all the frogs in the last pond are female?) and ask how this could affect the population.
 - Explain to them that they get to play again, but this time one of the old cards in the deck gets taken out and a new card replaces it. This new card is called “conservation effort,” and if it gets pulled the last pond that was removed from play gets cleaned and restocked with any players who got out in the last turn. Play the game again, noting the order of the ponds getting removed from play and the number of participants out on each turn, and stop after all the cards have been pulled.
 - Ask the audience if they thought the conservation effort helped the frogs or not, and why they think so; use the outcome from both of the games to illustrate the point. If the data end up similar, ask what effect more conservation efforts would have and why. Depending on how individuals get out of the game (perhaps they get stranded on a far away pond), ask how those threats affect the species and what actions could be taken to counter these threats.
 - Inform the audience about captive breeding programs like the Lowland Leopard Frog Habitat restoration Project and explain their importance.

- Activity #2: Leopard Frog Game (POND HOPPING VERSION, younger children)
 - This game involves children circling a set of six numbered poster-board “ponds” on the ground. Any number of children can play, but the ponds should be spaced further apart for more participants. All the children are meant to be “leopard frogs.”
 - Children begin by standing near a pond (more than one person per pond is OK). When the music begins, everyone hops (like a frog) clockwise around the ponds. When the music stops, each person should go stand by the nearest pond to his or her location (facing forward).
 - At each stop, the instructor will pull a card out of the deck. These say things like “Oh no, all the frogs in pond six have caught Chytrid Fungus from an invasive bullfrog and they’re out of the game,” or, “Uh oh, the drought has dried up pond four and all the frogs in that pond are out of the game.” At this stage, all the cards relate to harmful events in certain ponds. When one of these events occurs, that pond is removed from the game because it is uninhabitable. Keep track of the order that each pond is removed from the game, and how many people get out on each turn. This round ends when all the participants are out of the game or only one pond remains. Make a note of how many turns it took for everyone to get out of the game, or how many “leopard frogs” remained in the last pond.
 - Ask the children if they thought that multiple threats (like habitat loss or invasive species) make it easier or harder for the leopard frogs to survive in the wild, and why they think so.
 - Explain to them that they get to play again, but this time one of the old cards in the deck gets taken out and a new card replaces it. This new card is called “conservation effort,” and if it gets pulled the last pond that was removed from play gets cleaned and restocked with any leopard frogs who got out in the last turn. Play the game again, noting the order of the ponds getting removed from play and the number of participants out on each turn, and stop after all the cards have been pulled.
 - Ask the children if they thought the conservation effort helped the frogs or not, and why they think so; use the outcome from both of the games to illustrate the point. If the data end up similar, ask the children if they think more ponds being cleaned and restocked through conservation efforts would help, and why.
 - Sing-along (3 minutes): Gather everyone and pass around copies of the lyrics for everyone who is interested. Explain that everyone will listen to the song, and can clap along and can sing the bolded lyrics. [LYRICS SHEET IN APPENDIX]
 - Time for questions/remind people about the raffle/let everyone know about the other Saturday projects.
- M. Images, work sheets, web links
 - File names of posters: “SDD RAYA Poster”, “SDD GOAG Poster”
 - Screenshots of posters (Appendix B); file names “SDD RAYA poster screenshot”, “SDD GOAG poster screenshot”
 - www.tucsonherpsociety.org
 - www.skyislandalliance.org
 - www.nature.org
 - <http://www.pima.gov/CMO/SDCP/index.html> (Sonoran Desert Conservation Plan)

- N. Items for discussion (or conclusion); Questions to participants
 - How can we help animals cross roads that divide their habitat?
 - We could build underpasses for animal road crossing, make sure our barriers don't completely block passage, or physically move animals from one location to the next.
 - How can we slow fragmentation?
 - Slowing human development would slow habitat fragmentation, as would constructing roads with safe passages for animals to cross.
 - How can we help prevent the spread of Chytrid to local amphibians?
 - The first step is to learn more about how the disease spreads and what effects temperature and species type have on transfer. Once we understand the disease we can better prevent its movement. Preventing the spread of carriers, such as bullfrogs, is one short-term solution.
 - How can average citizens protect animals and preserve biodiversity?
 - By becoming informed and involved in conservation projects or politics.
 - What can we learn from gathering information from one or two species? How can this information help save other species?
 - Studying one species at a time allows a full understanding of the problem. Many environmental problems affect the entire ecosystem (for example, habitat fragmentation affects any species that normally travels from one point to another but cannot safely cross man-made structures). In such cases, helping save one species could help many others directly, but other species that depend on those species would be helped indirectly.
 - Why is it important to preserve biodiversity?
 - There are many ethical and functional reasons to preserve biodiversity. Each person should reflect on his or her own connection to the ecosystem, and the negative impact of the loss of biodiversity on that system.
 - Why these two species in particular?
 - The Desert Tortoise and Lowland Leopard Frog were chosen as example species because they are local and their numbers are in decline. Each tells a story about multiple threats to the environment that deserve more attention, threats that apply to many other species besides these two. Additionally, both species are researched at the UA.

- O. Assessment

Our workshop's educational goals included engaging the public (i.e., making them interested in learning about threats to biodiversity), teaching the public about two local species whose numbers are declining due to specific threats, and asking the public to extract the lessons from these two species in order to think (and act) proactively about issues of conservation and ecology on a larger scale. In the process, we tried to extol the value of ecological research by describing local studies and projects without using scientific jargon.

Overall, we believe that our workshop was successful in these areas. For most of the day, our workshop relied on discussions with individuals, and while we successfully conveyed our information to these small groups, who were mostly older patrons, they were far less interested in our activities, music, or raffle, and most were not interested in filling out evaluations. Near the

end of the day, we were fortunate that a large group of children from a private tour sat through most of our planned presentation (we omitted the tortoise data collection activity). This large group readily participated in the game, the song, and the raffle question, and several of the chaperoning adults asked us interesting questions afterwards (e.g., one gentleman asked about the potential of invasive species interbreeding with local species).

Assessing our experience might be easiest if we broke it down between the browsing audience we had for most of the morning and the large private group in the afternoon because our approaches to each audience varied considerably. It was more difficult to attract the attention of passersby who were browsing the area. Our location, it should be noted, could not be walked through; the browsers we did attract were typically escorted in while we pitched our workshop. These groups were more difficult to engage, displaying caution when entering our hard-to-escape workshop. Most stayed for only 3-5 minutes each, so our approach was to quickly hit our main points for each species, and expand on what individual browsers seemed interested in. Our posters and visual aids were very helpful during these short presentations because they made our narrative more tangible and provided a tactile aspect. We could gauge the success of our goals to convey information and stimulate a 'big picture' understanding of the material by the quality of questions that the browsers asked. Many seemed very interested in the research and conservation projects we discussed (e.g., one woman asked us about the specific microsatellites used to measure genetic distance in GOYA populations; another asked for us to email more information on the RAYA pond projects). Although the browsers were initially hard to engage and disinterested in our activities (with the most common excuse being that they did not have enough time to participate), we still reached our goals with groups that stayed for at least a few minutes.

The large private group, as mentioned, sat through most of our "planned" presentation, which was similar to our practice presentation to the SDD class in content and length (about 35 minutes). The children were very engaged by the visual aids, and were especially interested in the preserved specimens. We spent the first few minutes showing them the materials, then we began our presentation proper and asked everyone to take seats. We began with an interactive lecture, followed by the pond-hopping game, followed by the song, followed by the raffle. These sections allowed us to achieve our goals in a logical flow: the lecture allowed us to introduce the GOYA and RAYA species, threats and research; the game allowed us to state these threats more explicitly, and to question the audience about how threats exacerbate each other; the song allowed us to recap everything and provide resources to get involved (each child took a sheet of lyrics with links on the back for more information); and the raffle question allowed us to encourage everyone to think about the best ways to raise awareness about these issues.

Since we had been catering to a browsing audience most of the morning, our presentation to the big group was not executed flawlessly. For instance, our interactive lecture began slowly while trying to seat everyone and gather attention, and our information (as Geoff pointed out) was not always correct. Likewise, our presentations to the browsing audience would have been improved with more practice engaging passersby (near the end of the day we were getting much better at this). But given that we accomplished our main goals using an adaptive presentation style, these flaws seem overshadowed by the overall success of the workshop.

Refinement:

After our assessment and feedback, we made several changes to our project's template that strengthen its use as an outreach program or classroom lesson plan.

We reversed one of our previous changes, which was changing the RAYA pond game from an interactive musical-chairs type of activity to a table-top board game activity. In our template we now include the instructions for both versions of the activity. We originally made the switch because we predicted that a browsing audience would show little interest in hopping around in a circle. However, they showed little interest in the table-top game as well. We choose to include both types in the current lesson plan because either could be used in the classroom to convey the lesson, providing individual teachers with options: perhaps the hopping version would be more effective with a younger class, and the game board version more effective with an older class who can follow the rules. We also included the pond game cards in the file, as well as the rule sheet for the game board version.

In our template we also included a more robust introduction to the Sonoran Desert Discovery course by adding our elevator speech. Many of the visitors to B2 were unaware of the Sonoran Desert and its diversity, so we included a definition of the desert itself as well. We found it necessary to begin our discussions with browsers by assessing their level of knowledge about our area and ecology, and we often had to begin at a more basic level than we addressed in our lesson plan. Including this information in the lesson plan should make it easier for teachers from other areas to approach the material.

We tweaked the order of our lesson plan slightly, changing the two smaller songs into one long song at the end of the presentation. In our workshop experience it flowed better as one long song, and using it at the end of the presentation picked up everyone's interest and recapped everything they had learned. Additionally, we plan to record the song for distribution on the website. Since it will be recorded as one file, it will be easier for others to incorporate it in a lesson plan if it is played in its entirety (rather than pausing it halfway through). We have also updated the lesson plan to include both sides of the lyric sheet: the front lists the lyrics and the back lists resources for further information about conservation and ecology.

We have amended our resources section because we felt that it was too focused on local conservation efforts. Many of the visitors to B2 were not local to Tucson, and we failed to provide resources for the national or international crowd. This was a hurdle in the original design—it was difficult getting people interested in projects or societies they could never attend.

Summary Evaluations and Recommendations:

After our experience presenting the workshop to the public and reading the evaluations from our presentation, we have a better understanding of which aspects worked best and which aspects could be improved.

Our posters and visual aids (preserved frogs/tortoise, radiotelemetry and DNA analysis props) were very helpful in achieving our workshop goals. Being able to reference the pictures and maps on each poster allowed us to more clearly convey our concepts during the interactive lecture section of the presentation, but it also allowed the browsing audience to understand our main points with or without active explanation. The props were helpful in engaging the browsing audience and maintaining their attention. Working the props into discussions about threats to GOYA and RAYA prompted many questions from the browsing audience, which prevented the workshop from becoming dry and lecture-focused. In general, adults seemed more comfortable asking questions about the visual aids than the posters, while children seemed comfortable

asking questions about anything. In the future, the visual aids could be arranged in a way that helps tell a narrative, rather than simply being placed in front of the posters. For a browsing audience without our guidance, increasing the number of posters per animal and including direct references to the visual aids in the posters would help facilitate learning.

For the children, the coloring sheets, raffle, song, and game worked very well in keeping their attention and conveying our concepts. Some children took the coloring sheets home with them afterward, and most in the large group took the lyric sheets home. When we performed our song, everyone was very engaged and some kids even tried to sing along to it. We plan to record a version of the song for future presentations (or to post on the website) because many people commented that they enjoyed it. Although the song does not tell the entire story presented in our workshop, it could generate positive interest in conservation and ecology nonetheless. The game and the raffle, which were ignored by the browsing adults, were extremely successful with the large group of children. The activity of jumping around and getting “wiped out” by different threats helped the children understand that threats occur simultaneously and that conservation efforts can counter such threats. The raffle question allowed the children to proactively think about these lessons in a broader context, and many of their suggestions were pretty interesting.

Additionally, the elevator speeches and interactive questions worked very well. The elevator speeches allowed us to engage visitors with a quick, rehearsed overview of the workshop. This added to the professionalism of our approach, and our questions that followed the “pitch” allowed us to tailor the presentation to the individual. For example, if we found out a couple was visiting from across the country, we knew to inform them about the Sonoran Desert before jumping into local species, or if a family had a pet tortoise we were able to discuss behaviors they had observed firsthand. Adapting to each group required flexibility on our part, but ultimately led to better communication.

Certain aspects of our setup could be changed for future presentation. Our location was poorly chosen for a browsing audience since there was no easy way to wander in or out of the area without confronting the SDD team first. This may have discouraged visitors who wanted to sample the content before interacting with our group; in the future the posters should be more accessible. Also, having five SDD students standing around the entrance to our area may have intimidated small browsing groups from entering. Lastly, our location was at the end of the tour route, up a flight of stairs, just past another presentation. Many visitors were simply too tired when they reached our area.

The content of our presentation could also be modified in light of our experience at B2. Surprisingly, the raffle failed to interest any of the adults who visited our workshop. Some seemed to not care about winning prizes from B2, while others appeared suspicious about having to answer questions or fill out a raffle ticket. Since it was successful with the younger crowd, it should be retained in future presentations. The literature for becoming more aware and involved (i.e., free pamphlets and newsletters from Sky Island Alliance) were not taken readily by any age group, although a few individuals seemed interested in becoming more involved in ecology and conservation. Perhaps in the future these sources of information could be actively integrated into discussions with visitors rather than offered to people as they leave. In our arrangement, these resources were laid out next to the evaluation box, an inconspicuous location in retrospect. As mentioned earlier, our resources were too locally-focused (e.g., SIA, THC). Visitors from other cities, states, or countries showed little interest in becoming involved in these local organizations.

Lastly, our table-top version of the frog pond game went unused during the entire workshop (we utilized the hop-in-a-circle version for the large group). We were surprised that no one wanted to play, but there was no incentive for browsers to stay around and learn the game. We should have devised an incentive for winning the game, which would have engaged people in the outcome and promoted our workshop's lessons. As mentioned in our assessment, we did not perform the tortoise behavioral measurement activity. This was partly because we failed to locate a tortoise, but also because of space issues with the only group (about 35 people) who seemed willing to participate in the activities. We decided to retain the activity in our lesson plan because teachers with enough space and a pre-determined number of participants could still find value in it, especially since it emphasizes measurement and math.

- P. Beyond the activities

The audience is encouraged through the raffle to extend what they have learned to create a potential way to address the issues from the presentation. Furthermore, educative pamphlets from the Sky Island Alliance and the Tucson Herpetological Society will be made available for the audience, providing resources for further involvement. The Sky Island Alliance offers volunteer conservation excursions for the public, and the Tucson Herpetological Society offers information about the reptiles and amphibians of the Sonoran Desert. Resources from The Nature Conservancy will be provided for non-local visitors.

- Q. Web Resources

<http://www.tucsonherpsociety.org>

www.skyislandalliance.org

www.nature.org

<http://www.pima.gov/CMO/SDCP/index.html> (Sonoran Desert Conservation Plan)

- R. Additional References:

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- S. Keywords:

- Sonoran Desert: Covering parts of Arizona, California, and Mexico, the Sonoran Desert is one of the most diverse deserts on the planet.
- Biodiversity: The wide variety of life forms found on earth, including plants, animals, bacteria and other groups of species.
- Physiology: The functioning of a living system, especially relating to anatomy.
- Habitat Fragmentation: The fragmentation of an species' range or habitat due to anthropomorphic (man-made) structures like roads, canals, or railroads.
- Herpetology: The branch of zoology concerning the study of amphibians and reptiles (herpetofauna)
- Chytrid Fungus/Chytridiomycosis: Chytrid fungus can infect the skin of amphibians, leading to the disease Chytridiomycosis, which feeds on the keratin of amphibian skin and disrupts necessary metabolic processes.

- Desierto de Sonora: Cubre partes de Arizona, California, y el estado de Sonora en Mexico; el Desierto de Sonora es uno de los mas diversos del planeta.
- Biodiversidad: La variedad de vida encontrada en el mundo, incluyendo plantas, animales, bacteria y otros grupos de especies.
- Fisiologia: La funcion de un sistema viviente, especialmente la anatomia.
- Fragmentacion de Habitat: La fragmentacion de una especie o habitat debido a estructuras antropomorficas (hecho por hombres) por ejemplo calles, canales o villas de tren.
- Herpetología: el ramo de la zoología que trata de los reptiles y los anfibios (herpetofauna)
- Hongo Chytrid/Chytridiomycosis: Hongo Chytrid puede infectar la piel de anfibios, causandoles la enfermedad Chytridiomycosis, lo cual destruye la queratina de la piel anfibia y destruye el proceso necesario metabólico.

- T. Acknowledgements:

Special thanks go to Kevin Bonine, Tiffany Alvarez, and the entire Sonoran Desert Discovery class, Taylor Edwards, Dennis Caldwell, Ed Moll, and Cecil Schwalbe.

Appendix A: Front of lyrics sheet

Part I:

The Desert Tortoise has been here a while
They've been around for millions of years
But their numbers have dropped since we've arrived
Yea their populations just don't thrive
If we want to help them, first we need to know why they're at risk

Well we learned not long ago
That a tortoise can travel real far
But they have to watch out when they're crossing our roads
Yea they have to watch out for all those cars
They're not used to all this traffic, and they don't know how to change

**Oh if the desert tortoise is what we want to save
Then we're gonna have to learn about how they behave**

Sometimes how an animal acts makes it more predisposed to
Being hurt by the threats in life that it's been exposed to
If we want to help save the earth's biodiversity
We have to understand what makes each animal unique
(And how it interacts with everything)

Part II:

The Lowland Leopard Frog
It hops around from pond to pond
But it's been having trouble in the last few years
Because a nasty fungus called "Chytrid" appeared
And all it takes is amphibian skin to catch this pathogen

Well how did it get to here?
And how does it get around?
It can hitch a ride on the invasive bullfrog
And they're getting everywhere the native frogs belong
Humans chose to bring them here, and now they won't disappear

**If you like leopard frogs and you want 'em protected
Then we're gonna have to learn why they're getting infected**

Sometimes an animal's skin makes it more predisposed to
Being hurt by the threats in life that it's been exposed to
If we want to help save the earth's biodiversity
We have to understand what makes each animal unique
(And how it interacts with everything)

Backside of lyrics sheet:

Protecting the Sonoran Desert Tortoise and the Lowland Leopard Frog:

There are many threats to species in the Sonoran Desert, and they can occur simultaneously. They include:

- *Habitat Degradation and Destruction: For example, building a housing development on or near the habitat of a species.*
- *Habitat Fragmentation: For example, building a road that divides a habitat and prevents species from crossing safely.*
- *Invasive Species and Pathogens: For example, an invasive, non-native species like the American Bullfrog could outcompete local frogs for resources.*

How can I learn more about the animals of the Sonoran Desert?

There are many great resources available to the public, including the Arizona Fish and Game Department (online at www.azgfd.gov/w_c/index.shtml), the Arizona-Sonora Desert Museum (online at www.desertmuseum.org), and the Tucson Herpetological Society (online at www.tucsonherpsociety.org).

How can I get involved in conservation?

Besides educating yourself, you could volunteer to take part in conservation projects. The Sky Island Alliance is always looking for volunteers, so visit them online at www.skyislandalliance.org. If you're not from Tucson, check out The Nature Conservancy online at www.nature.org.

Pond Jumpers!

Can *you* survive?

RULES:

1. To begin, each player places a game piece on a pond.
2. Players take turns rolling the dice. Players can move as far as the number on the dice (for example, if a player rolls a 3, they can move three spaces).
 - a. No one can remain in the same pond for more than two consecutive turns, because there's not enough food at one pond to stay there the whole time. If a player cannot roll a high enough number to leave the pond by their second turn, they are out of the game.
 - b. Ponds don't count as spaces themselves. Feel free to move "through" ponds in a single turn.
3. After each roll, a card is drawn from the deck with an "event" that corresponds to a specific pond. Place the card on its pond so that everyone knows whether they can go there anymore.
 - a. Most of these events remove ponds from the game. If the pond you're in gets out of the game, you're out of the game too!
 - b. If the "conservation effort" card is drawn, the last pond to be eliminated gets cleaned and restocked. Anyone who got out on the previous turn is returned to the game!
4. You can go "through" a pond that has been eliminated from the game, but you cannot stop on it anymore.
5. The game is over when only one player or one pond is left.

Cards:

OH NO!

The frogs in POND 3 have been infected with the Chytrid Fungus!

OH NO!

POND 9 has temporarily dried up. Perhaps the monsoons will bring it back next year!

OH NO!

POND 4 has been converted into a neighborhood park area and stocked with non-native species!

OH NO!

POND 10 has become completely isolated from human development! No one can leave or enter pond 10! (put the card on pond 10 to mark it)

OH NO!

POND 5 has been damaged by a flash flood. Sometimes too much water is a bad thing for frogs!

OH NO!

POND 11 has become filled with dirt from a nearby hill! There were no plants to hold the soil in place because of a fire.

OH NO!

POND 6 has been polluted and native species cannot survive!

CONSERVATION EFFORT!

A pond has been cleaned and restocked with native species. Take the most recent pond eliminated from the game and put it back in play. Any frogs who were in that pond get to return!

OH NO!

POND 1 has been invaded by bullfrogs who ate everything in sight!

OH NO!

The frogs in POND 7 have been infected with Chytrid fungus from a fisherman's infected bait!

OH NO!

POND 2 has dried out due to the drought!

OH NO!

POND 8 has been overrun by non-native bullfrogs and the native species cannot compete!

OH NO!

The frogs in POND 3 have been infected with the Chytrid Fungus!

OH NO!

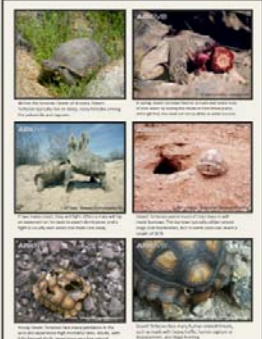



POND 9 has temporarily dried up. Perhaps the monsoons will bring it back next year!

Appendix C: Screenshots of posters

How Habitat Fragmentation Threatens Desert Tortoises

Michael Weiss and Seth Wisniewski Smith, Sonoran Desert Discovery


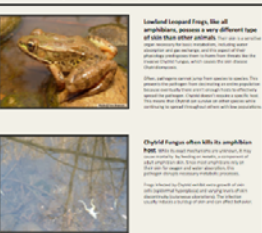


Ecology & Evolutionary Biology

Who is the Desert Tortoise?	Desert Tortoises can travel great distances.	What is habitat fragmentation?
 <p>Desert tortoises are native to the Sonoran Desert. They are large, long-lived reptiles that can live for over 100 years. They are found in a variety of habitats, including grasslands, shrublands, and open woodlands. They are known for their ability to travel long distances in search of food and water.</p>	 <p>Desert tortoises are highly mobile and can travel long distances. They are known to migrate between populations, often crossing roads and other barriers. This ability to travel long distances is crucial for their survival, as it allows them to find new habitats and avoid local extinction.</p>	 <p>Habitat fragmentation occurs when a habitat is split by a road or passageway. Along with habitat destruction and degradation, fragmentation is one of the major worldwide threats to biodiversity. For migratory animals with many disconnected populations like the Desert Tortoise, fragmentation makes long journeys more perilous. This is especially true when an animal needs to cross a major divide such as a freeway or railroad. But fragmentation can also be harmful if it allows humans or invasive species to more easily access and degrade the habitat.</p>
<p>UA Researchers use genetics to measure tortoise movement</p> <p>Researchers from the University of Arizona used blood samples and DNA analysis to measure the genetic distance between populations. By comparing segments of the DNA that mutate relatively quickly, called "microsatellites," the researchers estimated that the "gene flow" between populations would require at least one migrant per generation (about 25 years). The researchers also used radio-telemetry equipment to prove that Desert Tortoises are capable of this movement – one tortoise even made a trek over 300mi!</p>		
<p>Land Development in Arizona Equals Habitat Loss</p>  <p>Land development and urban sprawl throughout the Sonoran Desert has led to a significant loss of habitat for desert tortoises. The maps show the increasing amount of land developed over time, with a significant increase in the number of roads and other infrastructure. This development has led to a significant loss of habitat for desert tortoises, as well as a fragmentation of their remaining habitat.</p>		
<p>Without the ability to migrate between populations, the genetic structure of the Desert Tortoise will most likely be altered. Some describe their structure and distribution as a "meta-population," a collection of small, vulnerable populations that rely on immigration among themselves. While more research is needed in this area, fragmentation poses an obvious threat to any potential meta-population dynamics.</p>		

How Chytrid Fungus is Making Local Frogs Croak

Michael Weiss and Seth Wisniewski Smith, Sonoran Desert Discovery

Ecology & Evolutionary Biology

Who is the Lowland Leopard Frog?	Chytrid causes amphibian death	Invasive Species spread Chytrid
 <p>Lowland leopard frogs are native to the Sonoran Desert. They are large, long-lived amphibians that can live for over 100 years. They are found in a variety of habitats, including grasslands, shrublands, and open woodlands. They are known for their ability to travel long distances in search of food and water.</p>	 <p>Chytrid fungus often kills its amphibian hosts. It is a deadly disease that has caused the decline and extinction of many amphibian species. The fungus attacks the skin of amphibians, leading to a variety of symptoms, including skin lesions, ulcers, and eventually death. The spread of chytrid is greatly aided by humans, who accidentally transport the fungus or infected animals, which opens the pathogen to local amphibians.</p>	 <p>American Bullfrogs are not native to the southwest. They were introduced by the Arizona government as game animals. Since then, Bullfrogs have spread throughout the Sonoran Desert, aided by the lack of natural predators and their ability to travel great distances (see 4th slide).</p> <p>Human development and habitat fragmentation make it easier for Bullfrogs to access Lowland Frog habitats. Multiple studies have shown additive negative effects on a species, and increased noise due to fragmentation adds the greatest of impacts, reducing bullfrog populations in natural habitats.</p>
<p>Community Conservation:</p>  <p>Conservation efforts are being made to protect lowland leopard frogs from chytrid fungus. This includes creating artificial ponds, installing barriers to prevent the spread of the fungus, and monitoring populations. It is important to continue these efforts to ensure the survival of this species.</p>		
<p>Where did the ponds go?</p> <p>Human development and habitat fragmentation have led to a significant loss of habitat for lowland leopard frogs. This includes the destruction of ponds and other aquatic habitats. The loss of these habitats has led to a decline in the population of lowland leopard frogs, as well as a fragmentation of their remaining habitat.</p>		