Arizona Jaguar and Ocelot Conservation Education Project:
K-12 Education Plan, Educational Materials, & Examples of Curricula
Intra-Agency Agreement Number:
G13AC00222

Co-Principal Investigators:
Melanie Culver¹² and H. Randy Gimblett²

Prepared By:
Aletris Marie Neils² and Chris Bugbee²

U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit¹
University of Arizona, School of Natural Resources and the Environment²

Collaborators:
Sandy Anderson, Gray Hawk Nature Center

Submitted to:
U.S. Fish and Wildlife Service
Arizona Ecological Services Office - Tucson

11 May 2015

Cite as:
Project Overview

Jaguar and ocelot conservation education program

The purpose of this program was to provide K-12 students with a general understanding of conservation and the importance of conserving native wildlife, and to develop and implement an education program for jaguars and ocelots in southern Arizona. In order to accomplish this task, we worked closely with Arizona educators to train, teach, and evaluate learning in the classroom and in the field. We aimed to instill not only an appreciation for Arizona jaguars and ocelots, a well-rounded knowledge of their ecology, and how they fit into wildlife communities, but also a sense of responsibility to protect these charismatic species and the habitats in which they live. Educating youth about wild cats will hopefully catalyze their interest in wildlife, and help to spread conservation messages to their parents and throughout southern Arizona communities.

This study builds upon the Jaguar Surveying and Monitoring Project in the United States study awarded in November 2011 (Contract number: F11PX05778) to the University of Arizona (UA). UA embarked on a three-year project to detect and monitor jaguars along the northern side of the U.S.-Mexico border south of Interstate 10, from the Baboquivari Mountains in Arizona to the “boot-heel” region of New Mexico. That project established and implemented a non-invasive survey and monitoring program to gather scientific data on jaguars, ocelots, and other wildlife (Image 1).

Background

Why do we teach science in the first place? This question has always been important, but much of the reform going on in the U.S. today has not addressed the question directly. For example, the National Science Board (NSB), in its September 2010 report on “Preparing the Next Generation of STEM [Science, Technology, Engineering, Mathematics] Innovators,” stated that the development of the nation’s capital through schooling was an essential building block for the future of innovation. The authors outlined recommendations in three areas, including providing opportunities for excellence, casting a wide net to attract individuals to science, and creating an environment that fosters innovation. The foundation for the NSB report is embodied in these two stated rationales:

1. The nation’s economic prosperity, security, and quality of life depend on the identification and development of our next generation of STEM innovators.
2. Every student in America should be given the opportunity to reach his or her full potential.

High quality, inquiry based science programs motivate children and provide them with intellectual skills, positive attitudes, and values that help them to succeed in school and in life. Science learning raises and examines critical questions and promotes understanding about the
natural and physical world, and provides students with inquiry and investigation skills that will encourage a lifetime of learning. These programs increase interest in subjects that are of considerable importance to the development of highly educated citizens who understand critical issues for the future, as well as student preparation for well-paying, science-related careers. Good science programs help students learn to work together and learn methods that help them resolve conflicts peacefully (National Science Board 2010).

Every child should have the opportunity to participate in a strong, coherent science program. It should be a priority for a 21st century world education. Science education can have a powerful impact on children and learning, and it can make a significant difference in the lives of children. Success requires understanding, commitment, dedication, passion, persistence, and hard work over time. Programs should incorporate all major groups of science: natural sciences, which study natural phenomena (including fundamental forces and biological life), formal sciences (such as mathematics and logic, which use an a priori, as opposed to factual, methodology) social sciences which study human behavior and societies, and applied sciences, which apply existing scientific knowledge to develop more practical applications, like technology or inventions. The natural sciences and social sciences are empirical sciences, meaning that the knowledge must be based on observable phenomena and must be capable of being verified by other researchers working under the same conditions. (Popper 1959). Natural science, social science, and formal science make up the fundamental sciences, which form the basis of interdisciplinary and applied sciences such as engineering and medicine (National Science Board 2010). Specialized scientific disciplines that exist in multiple categories may include parts of other scientific disciplines but often possess their own terminologies and expertise.

Wildlife education

Many of today’s residents of urban communities, especially youth, do not have the opportunity to experience wildlands firsthand, which creates a disconnect between humans and nature (Wells 2006). Researchers have recently begun describing this detachment as Nature-Deficit Disorder (Louve 2009; Jacobs 2012). In addition to the negative health and well-being consequences, the disconnect between youth and the natural world negatively affects their attitudes toward the natural environment and constituent organisms (Louve 2009; Solis and Burgess 2010). Urban children are increasingly unfamiliar with most wildlife species; the exceptions are charismatic carnivore species like wild felids, which are often recognizable but misunderstood. These factors can lead to irrational fear of wildlife and/or disregard for ecological requirements of wildlife. In order to appreciate wildlife, children first need to understand and feel connected with it. As said by Senegalese conservationist Baba Dioum: “In the end we will conserve only what we love. We will love only what we understand” (Kimbell et al. 2009). According to the Central Intelligence Agency (2013), 82% of the U.S. population lives in urban areas with an urbanization rate of 1.2% annually. This high urbanization rate is creating a growing need to research social, health, and educational benefits, as well as the environmental benefits, of environmental education programs. According to the Executive Director of the Wildlife Society, “one of the greatest threats to the future of science-based wildlife management and conservation is a growing public ignorance of ecology and nature” (Hutchins 2012). Only
recently have a limited number of schools and teachers actively sought to bridge the gap between children and nature (Davis 2009).

Wildlife education has been defined as “those teaching and learning processes that introduce information about specific wildlife resources, habitats, ecological relationships, conservation, and management strategies into public schools and community educational programs” (Morgan and Gramann 1989). According to Kellert (1994), attitudes toward wildlife are developed through a combination of four factors. These include basic wildlife values, perceptions of particular species, knowledge and understanding of wildlife, and people-animal interactions. This study touched on all of these factors but focused on two in particular: perceptions of particular species, and knowledge and understanding of wildlife. The goal of this study was to increase knowledge and awareness and, in turn, positively affect perceptions of wild cats among the K-12 population. By presenting conservation lessons to students, students will hopefully transfer knowledge to their parents and the Sonoran desert region community and act as catalysts for conservation. Conservation lessons focused on presenting information on the three levels of wildlife knowledge outlined by Kellert (1994): factual understanding, ecological knowledge, and awareness of conservation issues. This study helped facilitate the development of effective conservation education programs and aided in understanding where conservation efforts need to be focused. According to Hansen (2007), an engaged and caring public is crucial to wildlife conservation. Encouraging Tucson students, and subsequently residents of all ages, to take an active role in conserving local wildlife could have significant impacts on local, and potentially global, wildlife conservation.

**Goal and Objectives**

**Project goal**

The goal of this study was to increase knowledge and awareness and, in turn, positively affect perceptions of wild cats among the southern Arizona K-12 population.

**Project objectives**

The general aim of this project was to teach K-12 students about the ecology of borderland jaguars and ocelots and about the conservation of these endangered felids. Specific objectives of this project were to:

1. Develop stimulating education materials about jaguars and ocelots.
2. Develop educational toolkits that can be used independently.
3. Provide Tucson teachers with a solid scientific platform for understanding wild cats.
4. Develop an educational poster that promotes the four cats of Arizona/northern Sonora.
5. Show measurable changes in K-12 student knowledge about jaguars and ocelots.
6. Instill a wildlife conservation ethic in K-12 students exposed to this project.
7. Get K-12 students excited about science.
8. Incorporate systems-based learning into the 8-12 learning curriculum.
9. Be a positive role model for K-12 students, particularly girls.¹

¹This is important because research from The Wildlife Society shows that women are still a minority, accounting for only 34% of wildlife biologists and a significantly lower percentage at advanced and senior level positions (Hutchins 2012).
Methodology and Results

The lesson plans we developed are included in Appendixes II-X. To build an effective and efficient education program, we divided the education protocol into seven distinct phases to build in sophistication and to provide us with a method to expand the program in the future to include more students.

Phase 1- Synthesize felid lesson plans and curricula

There is a copious amount of preexisting resources for teachers, including developed curricula pertaining to carnivores and felids, particularly large cats such as tigers. Examples of implemented felid education programs include Project TIGER in New York and Project CAT (Cougars And Teachers) in Washington State (www.projectcat.net - temporarily offline). We conducted detailed web searches and compiled resources for K-12 teachers on already-developed lesson plans. Search terms used included: big cat lesson plans, wild cat lesson plans, cat lesson plans, cat lesson plan K12, lynx lesson plans, bobcat lesson plans, puma lesson plans, mountain lion lesson plans, cougar lesson plans, catamount lesson plans, jaguar lesson plans, panther lesson plans, jaguarundi lesson plans, ocelot lesson plans, tiger lesson plans, lion lesson plans, cheetah lesson plans, panthera lesson plans, felid lesson plans, felidae lesson plans, wolf lesson plans, and carnivore lesson plans. After thoroughly examining the results we screened lessons for scientific merit, removing plans that were scientifically inaccurate. Table 1 shows examples of some of the germane lesson plans we found.

We further examined the top 75 lesson plans, scoring them 1-5 for both the quality of the content in the lesson plan and the applicability/pertinence to the goals for this project and Arizona wild cats. See Appendix I for the entire list.

Table 1. Examples of existing lesson plans and activities germane to developing curricula pertaining to carnivores and felids.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Grades</th>
<th>Timeframe</th>
<th>Description</th>
<th>Web Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invent an Animal</td>
<td>1-5</td>
<td>30-45 minutes</td>
<td>Learn about and apply camouflage to your own animal. Hide your animals around the room and try to find as many as possible.</td>
<td><a href="http://www.outdoorbiology.com/files/resources/activities/InventAnAnimal.pdf">http://www.outdoorbiology.com/files/resources/activities/InventAnAnimal.pdf</a></td>
</tr>
<tr>
<td>Tigers are Not Rubbish</td>
<td>1-5</td>
<td>30 minutes (plus additional time for the art)</td>
<td>Learn about geography and habitat while exploring why tigers are endangered. This is also a fun “found object” art project.</td>
<td><a href="http://www.savewildtigers.org/sites/default/files/pages/33/files/tigers-lesson-ideas.pdf">http://www.savewildtigers.org/sites/default/files/pages/33/files/tigers-lesson-ideas.pdf</a></td>
</tr>
<tr>
<td>Cheetah Adaptations</td>
<td>3-5</td>
<td>30-45 minutes</td>
<td>Using common items, discuss the adaptations of a cheetah and how it uses those adaptations to survive.</td>
<td><a href="http://www.cheetah.co.za/resource/english/grade_4_lesson_3.pdf">http://www.cheetah.co.za/resource/english/grade_4_lesson_3.pdf</a></td>
</tr>
<tr>
<td>Habitat Hunt</td>
<td>3-6</td>
<td>1-2 hours</td>
<td>Determine if an area makes a good habitat after understanding what animals need to survive.</td>
<td><a href="http://www.nwf.org/pdf/Schoolyard%20Habitats/HabitatHunt.pdf">http://www.nwf.org/pdf/Schoolyard%20Habitats/HabitatHunt.pdf</a></td>
</tr>
<tr>
<td>Activity</td>
<td>Grades</td>
<td>Timeframe</td>
<td>Description</td>
<td>Web Address</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------</td>
<td>-----------------</td>
<td>-------------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>A Home in the Brush</td>
<td>3-6</td>
<td>2-3 hours</td>
<td>Discuss interactions between ocelots and their habitat. This activity focuses on the Texas population but can be modified. It includes math problems as well!</td>
<td><a href="http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_if_w7000_0026.pdf">http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_if_w7000_0026.pdf</a></td>
</tr>
<tr>
<td>Are You as Agile as a Cat?</td>
<td>3-8</td>
<td>30-60 minutes</td>
<td>Compare your abilities to a mountain lion’s! Test jump height/length, field of vision, and sense of hearing.</td>
<td><a href="http://www.azgfd.gov/i_e/ee/focus/lessons_lion.shtml">http://www.azgfd.gov/i_e/ee/focus/lessons_lion.shtml</a></td>
</tr>
<tr>
<td>Wolf Survival</td>
<td>4-6</td>
<td>45-60 minutes</td>
<td>This predator-prey simulation demonstrates limiting factors and how they affect animal populations. Habitat is an influence in this particular simulation.</td>
<td><a href="http://www.wolfquest.org/pdfs/Wolf%20Survival%20Lesson.pdf">http://www.wolfquest.org/pdfs/Wolf%20Survival%20Lesson.pdf</a></td>
</tr>
<tr>
<td>Mexican Wild Cats: Endangered Ecosystem Activity</td>
<td>4-8</td>
<td>2 hours (a few additional weeks for optional project)</td>
<td>Become an explorer! Use case studies to learn and help researchers identify some of Mexico’s wild cats.</td>
<td><a href="http://www.scholastic.com/teachers/activity/mexican-wildcats">http://www.scholastic.com/teachers/activity/mexican-wildcats</a></td>
</tr>
<tr>
<td>Fact or Opinion – Jaguar</td>
<td>6-12</td>
<td>2-3 hours</td>
<td>Analyze articles while learning the differences between facts and opinions.</td>
<td><a href="http://kidsplanet.org/tt/jaguar/pdf/critical_thinking_exercise.pdf">http://kidsplanet.org/tt/jaguar/pdf/critical_thinking_exercise.pdf</a></td>
</tr>
<tr>
<td>Cougar or Humans – Which Needs Protection?</td>
<td>9-12</td>
<td>2 hours (a few additional days to a week for optional project)</td>
<td>Learn the natural history of the mountain lion. Human/wildlife interactions will be emphasized and discussed.</td>
<td><a href="http://www.pbs.org/wnet/nature/lesson_plans/cougar2.html">http://www.pbs.org/wnet/nature/lesson_plans/cougar2.html</a></td>
</tr>
<tr>
<td>Scientific Observations</td>
<td>10-12</td>
<td>1 hour (one week for assignment)</td>
<td>Observe camera trap photos and note seasonal changes in animals.</td>
<td><a href="http://www.evergladesplan.org/education/lesson_plans_pan_observations.aspx">http://www.evergladesplan.org/education/lesson_plans_pan_observations.aspx</a></td>
</tr>
<tr>
<td>Design a Florida Panther Baseline Study</td>
<td>11-12</td>
<td>2 hours (one week for assignment)</td>
<td>Research the everglades and Florida panthers; research design.</td>
<td><a href="http://www.evergladesplan.org/education/lesson_plans_pan_baseline.aspx">http://www.evergladesplan.org/education/lesson_plans_pan_baseline.aspx</a></td>
</tr>
</tbody>
</table>
**Phase II- Develop classroom lesson plans and materials**

**Lesson plans and data**

After evaluating pre-existing lesson plans, we: 1) modified pre-existing lessons specifically for Arizona jaguars and ocelots, and 2) developed new lessons on topics and/or concepts where needed. Additionally, we compiled data in various forms for use by teachers and students with these lesson plans or others that teachers may develop in the future. Data included graphs of publically available information about the UA’s jaguar and ocelot detections, field photos, wildlife camera pictures (that have been released), maps of study sites, weather data, habitat maps, historical records, etc. (Image 2). Data is included in each educational kit and will eventually be posted on the U.S. Fish and Wildlife Service (USFWS) Arizona Ecological Services Office website: [www.fws.gov/southwest/es/arizona/jaguar.htm](http://www.fws.gov/southwest/es/arizona/jaguar.htm).

**Educational materials**

We compiled jaguar and ocelot “toolkits” containing activities and materials related to jaguar and ocelot conservation in Arizona, including: lesson plans, PowerPoint presentations, Arizona resources, etc. We decided on items to include in the kits by maximizing materials that promote visual learning as well as providing resources to teachers and students who want to learn beyond the scope of the lesson plans. We also included items that could stimulate individual learning and question-based inquiry, such as rubber track sets. We discussed teacher needs prior to compiling the kit and added maps based on their feedback. After strategizing, we compiled three toolkits: 1) used in Tucson by UA personnel involved with this project, 2) used in southeastern Arizona by Gray Hawk Nature Center (GHNC), and 3) available to teachers and the public via a check-out system. The latter toolkit is currently housed at the USFWS office in Tucson: US Fish & Wildlife Service, 201 N Bonita Ave, Suite 141, Tucson, AZ 85745; Phone- (520) 670-6150.

The three assembled jaguar and ocelot toolkits are constantly being adapted depending on the needs of instructors. The core contents of each kit includes:

- Resin cast skulls from a jaguar, puma, bobcat, and ocelot
- Resin cast jaguar claws
- Replica rubber tracks from Arizona mammals
- Pictures of Arizona’s wild cats with natural history information
- Printed camera trap pictures of wildlife from the Jaguar Survey Project
- Arizona wildcat posters
- Arizona gazetteer and maps
- Flash drives with all lesson plans and data
- A folder with printed versions of data and lesson plans (where needed)
- Books about jaguars
• Books about wild cats
• Printed scientific articles about wildcats
• Jaguar print table cloth
• An action-packer to hold all materials

In addition, we compiled one supplemental kit for advanced/more in-depth lessons comprised of:
• Resin and/or real prey species’ skulls
• Extinct and ancestral felid skulls (such as *Similodon* and the American lion)
• Resin skulls from wild cats not found in Arizona in other lineages
• Resin skulls of sympatric carnivores not in Felidae for comparison
• Telemetry equipment
• Sherman traps
• Camera traps
• More detailed reference books that can be borrowed by teachers

We designed two PowerPoint presentations about Arizona jaguars and ocelots directed at K-12 students. One presentation was made for K-5 grade and another for 6-12 grade, with more detailed talking points for more advanced classes. These presentations are included in the jaguar and ocelot toolkits, above.

Additionally, we worked with a professional graphic designer and artist to develop a poster about the wild felids of the borderlands region of southeastern Arizona and southwestern New Mexico (Image 3). We also developed a smaller design (Image 4) to promote wild felid conservation on the border that can be used for education promotional materials. We ordered stickers, pins, and tote bags.
Phase III- Focused work with select Tucson schools

We worked closely with several Tucson schools, including: Flowing Wells Elementary/Middle, Flowing Wells High, Robins Elementary, and Hermosa Montessori. We taught the developed lesson plans and modified them as needed based on feedback from students and teachers (Image 5). We focused on ensuring the range of K-12 classes were reached. Schools were selected based on interest from teachers, a key component to continuing to teach these materials in the future. We stratified our schools to include both public and charter schools to ensure our lesson plans were applicable to various teaching scenarios.

Once lesson plans were solidified, we added new classes based on additional interest from teachers. Most lessons were taught as part of the traditional science curriculum; however, some were additional lessons outside of the required content (especially for public elementary schools). Several lesson plans were adjusted based on the time and schedule constraints placed on various schools and/or grades (usually associated with standardized testing). Topics covered in the lessons included aspects of jaguar, ocelot, puma, and bobcat natural history and ecology, including:

- Home range and space use
- Diet
- Role in the ecosystem and communities
- Predator/prey interactions
- Conservation concerns and what people can do to help conserve wild cats

Phase IV- Teacher cooperation

We devoted time over three months to meeting with teachers about their needs to ensure we developed resources that had continuity and would be used in classrooms past the end of this project (Image 6). The three primary messages we received from teachers were:

1. They wanted more scientific training so they felt comfortable presenting content.
2. They were less interested in predesigned lesson plans (although they said these were useful), but preferred scientifically-verified data and materials they could adapt into lesson plans and training. They preferred lesson plans to have enough information that they could use them independently when expert scientists were not available. Elementary
school teachers felt work-pages were helpful, especially for days with substitutes.

3. They would appreciate having web site(s) that they can go to (or send their students to) to find accurate content and/or data for projects. They were overwhelmed with misinformation on the internet and often did not have the expertise to distinguish facts from fiction.

Communicating and working with K-12 school teachers

We worked closely with the Flowing Wells School District to specifically address their needs, and, in particular, collaborated with their Science Coordinator. In August 2014, we taught part of a workshop for all junior high and high school science teachers in the district. This workshop incorporated the Next Gen Science standards (www.nextgenscience.org) and focused on Claim Evidence Reasoning (CER) thinking skills (Image 7). CER is where students learn to make a claim, find the evidence, and develop reasoning to support their claim—the trifecta of argument. Developing the reasoning component requires training, allowing students to become more cognizant. One of the demonstration topics all teachers learned about and worked through the CER process was the question: What influences the presence of endangered cat species (jaguar and ocelot) in Arizona? This demonstration was then used by teachers to introduce CER into their classrooms. In several classrooms this generated interest that drove the introduction of additional wild cat lesson plans.

Teacher outreach

We also gave “TED” (Technology, Entertainment, and Design) style talks for teachers. These were provided to Flowing Wells as part of a new lecture series to bring pertinent scientific topics to teachers. These talks were also given at the Biosphere 2 for five different teacher outreach/education days (Image 8), as well as one talks at the Tucson Festival of Books and
another at the Southwest Wings Festival. We estimate that through these workshops and talks we reached over 34 teachers with comprehensive training (at least 6 hours), and at least 650 additional teachers were exposed to this project, our lesson plans, and wild cat research.

After extensive work with teachers, at least 12 of our teaching partners stated they felt comfortable presenting all of our lesson plans independently and all felt comfortable incorporating at least 2 lessons plans into their classroom independently. However, all stated they would like to have a contact person to serve as a resource if they have questions.

Phase V- Field education programs at Gray Hawk Nature Center

We worked closely with GHNC (Image 9) to develop and conduct jaguar and ocelot educational programs that could be presented onsite to children from rural school districts in southeastern Arizona. We shared all resources and provided GHNC with its own jaguar and ocelot toolkit. We also collaborated with GHNC’s education volunteers, field teachers, and general volunteers in wild cat natural history, field identification, and tracking. GHNC included jaguar and ocelot educational lessons for each class that visited the Center. This allowed the project to reach over 2,300 rural school children from southeastern Arizona, including all second graders from the city of Sierra Vista.

Phase VI- Training others

University Interns

We mentored 17 UA undergraduates in the School of Natural Resources and the School of Science on how to effectively disseminate advanced scientific information to K-12 students (Image 10). These interns learned selected lesson plans and, after observing lesson plan presentations, gave the same lesson plan presentations to K-12 students and the community.
Interns were observed for at least one presentation to ensure quality control and for us to provide assistance where needed. Interns presented in Tucson classrooms, at the Biosphere 2, Gray Hawk Nature Center, Tucson Festival of Books, and Science Fairs.

We also had two interns register for official UA semester-long internships and obtain credit as part of this project (both through the School of Natural Resources and the School of Science).

Citizen Scientists

We worked closely with four of the citizen scientists working to survey and monitor jaguars and ocelots under the same Intra-Agency agreement as our study. The citizen scientists had access to all of our educational resources and gave presentations to classes and local Girl/Boy Scout troops. This opportunity allowed the citizen scientists to incorporate their work into the educational materials they presented. One citizen scientist became an instructor/educator of the wild cat curriculum at GHNC.

Phase VII- Evaluation

In three classrooms we conducted informal pre- and post-lesson knowledge assessments (n=68). This permitted us to rudimentarily assess our materials and determine how student knowledge and perceptions changed and how well conservation messages were retained. For example, prior to our wild cats of Arizona lessons students could identify the following cats living in Arizona: bobcat (81%), puma (64%) jaguar (11%) and ocelot (2%). After our lesson students could name all four cat species 100% of the time. Students also thought other cat species were found in Arizona: tiger (18%), leopard (8%), African lion (4%), and jaguarundi (1%). In addition, students also thought other species were ‘cats’ such as: ringtail (22%), fox (3%), and coati (1%). When initially asked what Arizona jaguars look like, 38% thought they were all black. When asked “what cats eat?” 49% said only meat, 43% said meat and plants, and 8% thought only plants. After our lessons students were able to answer these questions correctly 100% of the time. When asked if they “like living in a state with wild cats” the pre/post answers in percentages were: Yes (54/96)%, No (18/1)%, Unsure (38/3)%. When asked to whether they agree that “wild cats serve an important role in the environment” the pre/post answers in percentages were: Yes (31/94)%, No (20/0)% uncertain (49/6)%.

We also sought out and received feedback from all teachers we worked with to determine: What was effective? What could be modified? Were there any additional topics they wished we would have covered? What needed to be clarified? How likely were they to use our materials with future classes? What could we do to improve knowledge retention?

Each lesson plan now incorporates feedback and modifications suggested from teachers while trialing them. The primary concern we had from teachers was that they needed to be able
to use lesson plans independently when they had time (i.e., in between the mandated lessons they had to teach). For this reason we ensured that lessons, while building upon each other, each could be used autonomously. The secondary concern we received from teachers was that they wanted an in-depth background section on lesson plans, even if they did not share all the details with their class—this helped them feel more prepared for the lesson. For this reason, all lessons now incorporate a thorough background section. Several teachers also suggested having topics clearly listed so they could assess if their students needed concepts introduced prior to the lesson or reviewed after the lesson to maximize knowledge retention. Teachers were most likely to use lessons that were hybrids (i.e., incorporating another subject such as math, social studies, writing, etc.), as this allowed teachers to justify additional time spent on lessons while fulfilling mandatory content allocations.

Discussion and Conclusions

Project goal and objectives

The goal of this study was to increase knowledge and awareness and, in turn, positively affect perceptions of wild cats among the southern Arizona, K-12 population. Our goal was successfully accomplished and will be addressed in each specific objective:

Specific objectives of this project were to:

1. Develop stimulating education materials about jaguars and ocelots. We developed lesson plans and curricula pertaining to both jaguars and ocelots. We tested and adaptively revised these lesson plans on classes to ensure they were motivating and captivating for students. The lesson plans are templates that may be adjusted based on classroom size, teachers, allotted class time, student knowledge base, student behavior, etc.

2. Develop educational toolkits that can be used independently. We completed 3 general educational toolkits, strategically placed in 3 different locations. In addition, we have compiled an additional kit of more advanced materials.

3. Provide Tucson teachers with a solid scientific platform for understanding wild cats. The teachers we worked with felt comfortable with the content and can teach lesson plans independently.

4. Develop an educational poster that promotes the four cats of Arizona/northern Sonora. We successfully developed posters in both Spanish and English and had them printed. We far exceeded this objective by developing additional educational materials like stickers, badges, and tote bags.

5. Show measurable changes in K-12 student knowledge about jaguars and ocelots. We were able to document changes in student knowledge; however, this was very preliminary. Of our nine objectives this one left the most room for improvement.

6. Instill a wildlife conservation ethic in K-12 students exposed to this project. We witnessed a contagious change in students once they became aware of how amazing these cats are. We also saw students want to help make a positive difference for the environment.

7. Get K-12 students excited about science. Students were instantly captivated by these majestic cats. They inspired students to want to learn more about carnivores, wildlife, and ecology.
8. Incorporate systems-based learning into the 8-12 learning curriculum. Through collaboration with the Flowing Wells District, we were able to develop training workshops using systems-based learning using jaguars as the subject. This is important for training young people in the ability to think critically, a vital component to the scientific process.

9. Be a positive role model for K-12 students, particularly girls. We were able to show young girls that women can be scientists, specifically field biologists.

**Phase I- Synthesize felid lesson plans and curricula**

There are hundreds of felid/carnivore-related lesson plans available to teachers; however, a majority of them are either outdated or inaccurate. This posed a tremendous problem for teachers who usually lack the scientific expertise to discern fact from fiction in advanced ecological concepts.

Of the top 75 lesson plans, plans that had high scores for both the quality of the content and the applicability/pertinence to the goals for this project and Arizona wild cats were considered priority for use in this project. See Appendix I for the entire list. We hope to eventually have a web presence (ideally linked to on the USFWS Arizona Ecological Services page) that can serve as a reference for teachers for current, scientifically accurate materials. Additionally, we plan to post these resources with links on the USFWS Arizona Ecological Services Office webpage: [www.fws.gov/southwest/es/arizona/jaguar.htm](http://www.fws.gov/southwest/es/arizona/jaguar.htm). Teachers expressed that such a website would be a helpful resource for them as a place to send students to for information; they are concerned about students getting information from web resources that may or may not be scientifically accurate.

**Phase II- Develop classroom lesson plans and materials**

The disconnect between science and effective dissemination is apparent. According to the American Association for the Advancement of Science, the reform in science education should be founded on “scientific teaching” in which teaching is approached with the same rigor as science at its best. Reform has been initiated by a few pioneers, but most scientists have actively resisted changing (Handelsman et al. 2004). We feel this program is part of this reform engaging scientific thinking in all lessons.

By focusing on training teachers we are able to help teachers feel more confident with the scientific method and advanced scientific concepts, thus allowing them to better teach science, even beyond the scope of this project. This is necessary if they are to teach their students independently and encourage the next generation of critical thinkers.

**Lesson plans and data**

We encountered challenges by incorporating the Claim Evidence Reasoning (CER) framework into our lessons. In CER, students learn to make a claim, find the evidence, and develop reasoning to support their claim. We found that many classes struggled with the reasoning component and that it took longer than expected to train students on how to contemplate their reasoning for an answer/position. CER thinking has been linked to students becoming more cognizant and thus better scientists (McNeill & Krajcik 2011), but we found this aspect particularly challenging with older students in public schools.
Compiled data including graphs of publically-available information about the UA’s jaguar and ocelot detections, wildlife camera pictures (that have been released), maps of study sites, weather data, habitat maps, historical records, and journal articles are included in each educational kit. Several items had to be edited/expanded upon based on student needs. Most students found pictures the easiest to interpret and found tables and articles the most difficult to incorporate into the CER framework.

**Educational materials**

We developed an educational poster and a smaller design related to the wild felids conservation in Arizona that can be used as a sticker, badge, or patch to apply to hats, shirts, and bags. We had stickers made to distribute widely to the general public; since there is nothing considered more effective and influential than word-of-mouth marketing and endorsements from trusted sources. Research shows that over 90% of word-of-mouth marketing takes place off-line. Stickers are considered one of the best tools to help strengthen relationships and encourage conversations (Nicholson 2015). Tote bags were suggested by teachers as something helpful that they would use daily in their classrooms. We also had pins made; these are helpful in labeling citizen scientists and people associated with border cats work. We prioritized items that would maximize impact while minimizing unnecessary waste. Once printed, these media will be distributed to southern Arizona schools, other educational facilities, and nature centers throughout southeastern Arizona and southwestern New Mexico for educational and outreach purposes. These materials will help the general public better recognize border cat conservation and promote dialog.

The educational toolkits have been vastly successful. However, we have not had the 3rd toolkit checked out independently by teachers yet. We might need to reevaluate where this toolkit is housed to promote maximum use. After initial conversations from teachers on the toolkits, we included laminated pictures and more books as resources because teachers felt these were needed. Both teachers and students agree that the resin cat skulls are the best part of the educational kits and are items they did not have access it.

We designed two PowerPoint presentations about Arizona jaguars and ocelots directed at K-12 students. One presentation was made for elementary school and another for junior high and high school students, which includes more detailed talking points for more advanced classes. We needed two separate PowerPoints because the style of teaching is vastly different for these two demographics. The elementary presentation is shorter in length and focuses on identifying the cats of Arizona and understanding basic ecology. The junior high and high school presentation introduces historical data and critical thinking concepts.

These PowerPoint presentations were developed as a way to share our message with large classes in a consistent way. Both PowerPoints were designed so they can be given by a novice with access to the notes pages or by an expert that can incorporate more details and anecdotes. They can easily be shared and do not require the step-up time of many of lesson plans. The PowerPoints are best used as the initial lesson plan and are a great introduction to all the other curricula. By incorporating many incredible pictures, they instantly captivate curiosity in wild cats.
Phase III- Focused work with select Tucson schools

Working with fewer schools allowed us to focus on the quality of the lesson plans and the information within them instead of diluting the message across a greater area. We selectively worked with teachers that were interested in advancing their scientific understanding, this allowed us to maximize our message and reach during this short time frame.

Phase IV- Teacher cooperation

Communicating and working with K-12 school teachers

K-12 teachers typically have neither the resources nor the training to incorporate advanced science and content knowledge into their classroom instruction, afterschool activities, or mentoring of science fair participants. Even if teachers wish for assistance, many scientists and researchers, who may wish to work with K-12 students, teachers, and the general public, generally lack an understanding of the constraints under which public schools operate, and often have difficulty translating their knowledge and its applications into ideas that K-12 students or the general public can understand. Our workshops were designed to provide detailed information about the cats of Arizona and improve scientific understanding by teachers. They were also intended to gain insight into the barriers preventing teachers from collaborating with researchers and the scientific needs teachers have. We feel this was the most important part of our project, as training teachers is the best way to ensure effective transmission of scientific methods and content.

Teacher outreach

Teachers expressed that they will need to have continued support, particularly scientists who can serve as a resource if they run into problems. Many teachers stated that they are reluctant to use advanced lessons without a “safety-net” in case unforeseen questions and/or problems emerge.

We have developed a strong working relationship with several influential teachers and science coordinators. We will continue to serve as a resource to these teachers in the future (primarily via email and/or phone). We feel this is key to the long-term success of this project, as many teachers will be using the materials for the first time independently in 2015-2016 and will almost certainly experience snags. Teachers also stated that they need access to credible resources such as text books. Most schools have dramatically cut school library budgets and do not have access to university libraries. Teachers will be able to borrow text books from the supplemental educational kit when they need them.

Phase V- Field education programs at Gray Hawk Nature Center

Our collaboration with GHNC was a great success. In addition to training the Center’s staff and volunteers, the project reached over 2,300 rural school children from southeastern Arizona, including all second graders from the city of Sierra Vista. Gray Hawk Nature Center will continue to teach about the four wild cats of Arizona to all students who come to their facility. This is vital because these kids are often from rural backgrounds and need to be informed about wildlife they might encounter.

Not only were we able to teach more material by spending a day at GHNC, or in some instances camping overnight, we were able to devote more time to experiential learning in a
natural system; this is among the greatest ways to promote independent discoveries. We also noted that students who went to GHNC left with strong memories that will hopefully translate into a lifelong conservation ethic.

**Phase VI- Training others**

**University Interns**

All interns were grateful for the mentorship they obtained from their internship and felt they were given practical training in environmental education, a topic not formally taught in the most programs. The two formal UA undergraduates involved in this program obtained in-depth experience in K-12 teaching techniques and environmental education. In both instances they mastered a few lessons that they shared multiple times. Both interns expressed that they want to continue working in environmental education after graduation.

**Citizen Scientists**

This opportunity allowed the citizen scientists to incorporate their work into the educational materials they presented. One citizen scientist became an instructor/educator of the wild cat curriculum at GHNC. This not only helped disseminate the jaguar educational program to a wider audience, but provided citizen scientists an opportunity to demonstrate their “expertise”—a component that can help retain volunteerism.

**Phase VII- Evaluation**

The evaluation aspect of this project is very preliminary. By targeting teachers that were actively interested in wildlife science we may have biased our results. We predict that we might not have had such strong knowledge retention or initial awareness results if we randomly went to and worked in classrooms where teacher engagement was not as high. For a thorough evaluation of the effectiveness of this work, we would need to collaborate with an education evaluation specialist². It is also important to note that our post-surveys were taken immediately following our lessons and knowledge retention could be lower if surveyed on a later date.

We were dumbfounded by the initial lack of knowledge Arizona students had pertaining to Arizona’s wildcats. There was not a significant difference between students of different ages, showing that these topics are not being covered in any stage of the current K-12 educational system. In fact, a fourth grade class had higher wild cat knowledge in the pre survey then the ninth grade class surveyed. This demonstrated a clear need for ecological training. We did not ask specific background questions to students; this would have allowed us to examine how time spent outside in activities such as hiking and hunting could influence natural history knowledge.

Our student evaluations showed that our materials engendered an effective change in learning about Arizona wild cats, as demonstrated by an improvement in both the students’ basic natural history knowledge and ecological understanding. Our lessons also resulted in more students thinking cats were “an important part of the ecosystem” and that they deserved to be “conserved.”

² Several education evaluation specialists exist at the University of Arizona’s College of Education: https://www.coe.arizona.edu/.
We consider this project to be a success for two reasons. The first is that lessons plans and/or data will be used in classrooms after the duration of this project. Second, all 34 teachers who received comprehensive training (at least 6 hours) expressed that they felt comfortable now using the materials independently in their classrooms, meaning that these teachers felt like they had a comprehensive understanding of the cats of Arizona and could share this information with their classes. These teachers have our contact information and can continue to be in contact with us if they need support.

Future Directions

We plan to continue the work of this project into the future. We hope to secure additional financial support for this work allowing us to reach more teachers and students. We feel we are at a stage now where we can have maximum effectiveness with our message, now that a threshold of lessons have been developed and materials have been obtained. We aim to post all lessons online and to add to the USFWS Arizona Ecological Services Office’s webpage, which can serve as a teaching resource for the Borderland’s endangered cats. We also plan to continue to have a presence in classrooms and already have confirmed presentations at almost a dozen schools in fall 2015.

GHNC plans to see thousands more children over the next year and all will be exposed to our program. We hope to obtain additional funds to bring more urban children to GHNC so they can experience this amazing place as well. In addition, we hope to start a student-friendly wild cat research project on the San Pedro River. We can use data to plot movements, graph distributions, quantify diet, etc., and provide opportunities for students to be involved. We feel that teaching in the field is the most effective way to share many of the major topics emphasized in this program. With materials from the supplemental education kit we are able to add advanced lessons on telemetry, mark-recapture, collecting morphological data, sampling, etc. These lessons not only pertain to wild cats, but also wildlife biology and ecology in general.

University interns

We have plans to opportunistically incorporate UA interns into this project over the next year. These students will focus on collecting and editing resources/compiling materials that could be used for a website. Interns will also present lesson plans to Tucson classrooms where desired and time permits.

Materials needed for educational kits

We hope to secure additional funds to add the following materials to our kits:

- Resin and/or real prey species’ skulls
  - Deer
  - Jackrabbit
  - Javelina

- Skulls from extinct ancestral felids and/or Felidae ancestors to demonstrate morphology and evolutionary lineages:
  - *Hoplophoneus occidentalis* (Sabertooth Cat)
  - *Machairodus giganteus* (Sabertooth Cat)
• *Megantereon nihowanensis* (Chinese Sabertooth Cat)

• Replica skulls of other *Panthera* lineage felids:
  - Snow leopard skull
  - Siberian tiger skull

• Replica skulls from other carnivores or members of the order Carnivora for comparison:
  - Tasmanian wolf
  - Wolverine
  - Polar bear
  - Mexican wolf

• Human skull replica for demonstration purposes

• Pelts from wildcats

In addition we hope to eventually acquire the following field equipment for teaching purposes:

• Pesola scales
• Calipers
• Carnivore traps
• Binoculars
• Additional telemetry transmitters

**Additional evaluations**

Finally in the future we hope to collaborate with educational evaluators to more methodically document changes in knowledge and strengthen this portion of the project. We will continue to serve as a resource for teachers by answering questions, visiting classrooms, and assisting in workshops.

**Message distribution**

Products generated from this program will be distributed widely. We will distribute posters to southern Arizona schools, other educational facilities, and nature centers throughout southeastern Arizona and southwestern New Mexico for educational and outreach purposes. Totes will be primarily given to teachers and pins will help brand those with expertise on the subject. These materials will help the general public better recognize border cat conservation and promote dialog. We also hope to eventually translate all lesson plans into Spanish to ensure these messages reach the maximum amount of people and that language is not a barrier to border cats conservation.

We do not yet know the full impact this program can have in the future, especially once our posters have been disseminated. They could become permanent classroom fixtures, inspiring generations to come.

**Acknowledgements**

We would like to thank all of the amazing students and teachers we worked with during this project. We especially acknowledge Yaro Neils for her remarkable work on the poster and two dimensional designs (above and beyond what was asked of her), and Chris Bugbee for his
artwork. We would also like to thank Carlos López-Gonzáles for translating the poster into Spanish. We also acknowledge our interns Katelyn Martin and Kristin Uhlenhorst and the other UA undergraduates who participated in the project. A special thanks to David E. Brown, Jack Childs, and Randy Babb for their contribution with the PowerPoint presentations, historical data, and general support. We are indebted to Manny Metzler for his outstanding contribution interviewing the citizen science program at GHNC. And we can never express enough gratitude to Sandy Anderson for her devotion in sharing the San Pedro River with the next generation so that it will be conserved, and for her love of all creatures, especially cats.

We are immensely grateful for aspects of this project being implemented by Gray Hawk Nature Center and Southwest Wildlife. We would like to acknowledge Anna Heyer for her assistance in understanding the Next Generation Science Standards. We would also like to thank the NSF BioMe Fellowship, which inspired the initial networks catalyzing this work in 2010. Finally, we thank Marit Alanen and Erin Fernandez for all of their thoughtful comments on the draft and final report, ordering materials for the education kit, justifying spending, and overwhelming support throughout every aspect and hurdle of this project!

Disclaimer: Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Literature Cited


Appendix I. Ranks and information for 75 most pertinent lesson plans

## Wild Cat Related Lesson Plans

**K-12 updated March 2015**

<table>
<thead>
<tr>
<th>App*</th>
<th>Qual**</th>
<th>Activity Title</th>
<th>Grades</th>
<th>Description</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>5</td>
<td>Endangered Ecosystem Activity</td>
<td>4, 5, 6, 7, 8</td>
<td>Become an explorer! Listen to case studies to learn about Mexican wildcats</td>
<td><a href="http://www.scholastic.com/teachers/activity/mexican-wildcats">Website</a></td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>Big Cats (Discovery School)</td>
<td>6, 7, 8</td>
<td>Make a list of big cats and have students research them and present, understand niche</td>
<td><a href="http://www.discoveryeducation.com/teachers/free-lesson-plans/big-cats.cfm">Website</a></td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>Jaguar Lesson and Mountain Lion Lesson and Worksheet</td>
<td>3, 4, 5</td>
<td>Read passage, answer questions about jaguar (including behavior)</td>
<td><a href="http://www.instructorweb.com/les/jaguars.asp">Website</a></td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>Lions, Tigers, and Leopards, Oh My!</td>
<td>1, 2, 3</td>
<td>Compare and contrast domestic cats with big cats, folk lore, food chain, endangered species</td>
<td><a href="http://www.nwf.org/pdf/2011/Controversy-Over-Wild-Cats-5-8.pdf">Website</a></td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>Skull Science Controversy Over Wild Cats</td>
<td>3, 4, 5, 6</td>
<td>Role Play to understand positions on wild cats, learn about different NA species</td>
<td><a href="http://www.dec.ny.gov/docs/administration_pdf/lpskullscience.pdf">Website</a></td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>Wild Cat (Smart Exchange)</td>
<td>1, 2</td>
<td>Compare and Contrast different big cats, choose favorite to write about, learn about maps (Lessons 1 and 2) Compare mountain lion abilities with yours, learn about diet</td>
<td><a href="http://exchange.smarttech.com/details.html?id=f7929e47-d106-4d76-806e-165fc900bc8">Website</a></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>Mountain Lions in AZ Disney Nature (African Cats)</td>
<td>6,7,8,9,’011,12</td>
<td>Understand niche and habitat, learn about African cats</td>
<td><a href="http://www.azgfd.gov/i_e/ee/focus/lessons_lion.shtml">Website</a></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>Panther Net Cougar or Human- Which needs Protection?</td>
<td>3,4,5,6,7,8,9,10</td>
<td>Several activities (scavenger hunt, &quot;become an expert&quot;, etc) pertaining to pumas</td>
<td><a href="http://www.floridapanthernet.org/index.php/lessons/#.VC77fGOBUUg">Website</a></td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>Regions of the US</td>
<td>4, 5, 6, 7, 8</td>
<td>Habitat/regions</td>
<td><a href="http://www.pbs.org/wnet/nature/lesson_plans/cougar2.html">Website</a></td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>Cougar Hunt</td>
<td>8, 9, 10, 11, 12</td>
<td>Ocelot habitat and interactions (TX), includes math problems as well</td>
<td><a href="http://ljhs.sandi.net/faculty/DJames/Biology/Chapter%202/Cougar%20Hunt.pdf">Website</a></td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>A Home in the Brush</td>
<td>3, 4, 5, 6</td>
<td>Natural history of cats, what makes a cat a cat, other activities</td>
<td><a href="http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_if_w7000_0026.pdf">Website</a></td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>Sonoran Desert Discovery</td>
<td>4,5,6,7,8,9,10</td>
<td>Natural history of cats, what makes a cat a cat, other activities</td>
<td><a href="http://sdd.arizona.edu/sites/default/files/BigCats-fall2010_0.pdf">Website</a></td>
</tr>
<tr>
<td>Lesson Plan</td>
<td>Title</td>
<td>Pages</td>
<td>Description</td>
<td>Details</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>-------</td>
<td>-------</td>
<td>-------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>Jaguar Conflict Resolution</td>
<td>6, 7, 8</td>
<td></td>
<td>Difference between fact and opinion, analyze articles</td>
<td><a href="http://kidsplanet.org/tr/jaguar/pdf/conflict">http://kidsplanet.org/tr/jaguar/pdf/conflict</a> resolution.pdf</td>
<td></td>
</tr>
<tr>
<td>Fact or Opinion - Jaguar Bobcats in Your Backyard!</td>
<td>6, 7, 8, 9, 10, 11</td>
<td>Natural History of bobcats, interactions, importance</td>
<td>Predator/Prey interactions, dispel bad perceptions of predators, importance</td>
<td><a href="http://www.eebweb.arizona.edu/Courses/Ecol464_564/BobcatsWorkshop-2011-05-03.pdf">http://www.eebweb.arizona.edu/Courses/Ecol464_564/BobcatsWorkshop-2011-05-03.pdf</a></td>
<td></td>
</tr>
<tr>
<td>(SDD) Eat or be Eaten in the Sonoran Desert</td>
<td>4, 5, 6, 7, 8, 9, 10, 11</td>
<td>Importance of Apex Predators, which are in AZ, appreciation</td>
<td>Adaptations of bird beaks, how they help, differences</td>
<td><a href="http://sdd.arizona.edu/sites/default/files/WillyongLeitman-eco464%20lesson%20template%20final_FINAL_FINAL_FINAL_FINAL.pdf">http://sdd.arizona.edu/sites/default/files/WillyongLeitman-eco464%20lesson%20template%20final_FINAL_FINAL_FINAL_FINAL.pdf</a></td>
<td></td>
</tr>
<tr>
<td>Apex Carnivores</td>
<td>4, 5, 6, 7, 8, 9, 10, 11</td>
<td></td>
<td>Information on Mammals</td>
<td><a href="http://www.projectwild.org/documents/ProjectWILD.pdf">http://www.projectwild.org/documents/ProjectWILD.pdf</a></td>
<td></td>
</tr>
<tr>
<td>Animal Adaptation</td>
<td>3, 4, 5</td>
<td></td>
<td>Information on Mammals with more focus on species</td>
<td><a href="http://www.angelfire.com/dc/childsplay/masks.htm">http://www.angelfire.com/dc/childsplay/masks.htm</a></td>
<td></td>
</tr>
<tr>
<td>Mammals</td>
<td>4, 5, 6</td>
<td></td>
<td>Information on Mammals</td>
<td><a href="http://www.evergladesplan.org/education/lesson_plans_pan_observations.aspx">http://www.evergladesplan.org/education/lesson_plans_pan_observations.aspx</a></td>
<td></td>
</tr>
<tr>
<td>Meet the Mammals</td>
<td>4, 5, 6</td>
<td></td>
<td>Information on deserts and wildlife species found in deserts</td>
<td><a href="http://www.evergladesplan.org/education/lesson_plans_pan_baseline.aspx">http://www.evergladesplan.org/education/lesson_plans_pan_baseline.aspx</a></td>
<td></td>
</tr>
<tr>
<td>Deserts</td>
<td>4, 5, 6</td>
<td></td>
<td>Research an animal and write a report and draw a picture</td>
<td><a href="http://www.savewildtigers.org/sites/default/files/Tigers.lesson.ideas.pdf">http://www.savewildtigers.org/sites/default/files/Tigers.lesson.ideas.pdf</a></td>
<td></td>
</tr>
<tr>
<td>Where Creatures Live</td>
<td>3, 4, 5</td>
<td></td>
<td>biomes and adaptations</td>
<td><a href="http://www.pbslearningmedia.org/resource/idc02.sci.life.reg.lp_adapt/adaptation/">http://www.pbslearningmedia.org/resource/idc02.sci.life.reg.lp_adapt/adaptation/</a></td>
<td></td>
</tr>
<tr>
<td>Adaptation</td>
<td>3, 4, 5</td>
<td></td>
<td></td>
<td><a href="http://www.pbslearningmedia.org/resource/tdc02.sci.life.oate.lp_environment/where-creatures-live/">http://www.pbslearningmedia.org/resource/tdc02.sci.life.oate.lp_environment/where-creatures-live/</a></td>
<td></td>
</tr>
<tr>
<td>Your Own Backyard</td>
<td>1, 2, 3</td>
<td></td>
<td>environment introduction</td>
<td><a href="http://www.pbslearningmedia.org/resource/tdc02.sci.life.oate.lp_environment/where-creatures-live/">http://www.pbslearningmedia.org/resource/tdc02.sci.life.oate.lp_environment/where-creatures-live/</a></td>
<td></td>
</tr>
<tr>
<td>Mouthparts and Digestion</td>
<td>3, 4, 5</td>
<td></td>
<td>adaptations of mouths and digestive systems</td>
<td><a href="http://www.pbslearningmedia.org/resource/idc02.sci.life.colt.lp_mouths/animal-mouth-structures/">http://www.pbslearningmedia.org/resource/idc02.sci.life.colt.lp_mouths/animal-mouth-structures/</a></td>
<td></td>
</tr>
<tr>
<td>Get to Know Nature</td>
<td>1, 2, 3</td>
<td>habitats, guide to nature in your neighborhood</td>
<td><a href="http://www.pbslearningmedia.org/resource/plum14.sci.lifemapguide/get-to-know-nature/">http://www.pbslearningmedia.org/resource/plum14.sci.lifemapguide/get-to-know-nature/</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Needs of Living Things Exploring Endangered Species</td>
<td>1, 2, 3, 4, 5</td>
<td>what animals need to survive</td>
<td><a href="http://www.pbslearningmedia.org/resource/idc02.sci.life.colt.lp_stayalive/the-needs-of-living-things/">http://www.pbslearningmedia.org/resource/idc02.sci.life.colt.lp_stayalive/the-needs-of-living-things/</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dare to Care for a Grizzly Bear</td>
<td>3, 4, 5</td>
<td>facts and myths about bears, management art project, learn about why endangered, habitat/ geography</td>
<td><a href="http://www.pbslearningmedia.org/resource/plum14.sci.lifependanger/endangering/explored-endangered-species/">http://www.pbslearningmedia.org/resource/plum14.sci.lifependanger/endangering/explored-endangered-species/</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tigers are Not Rubbish Design a Florida Panther Baseline Study</td>
<td>1, 2, 3, 4, 5</td>
<td>design a baseline study, research everglades habitat/ geography</td>
<td><a href="http://www.savewildtigers.org/sites/default/files/pages/33/files/tigers-lesson-ideas.pdf">http://www.savewildtigers.org/sites/default/files/pages/33/files/tigers-lesson-ideas.pdf</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scientific Observations</td>
<td>10, 11, 12</td>
<td>Observe camera trap photos, note seasonal changes</td>
<td></td>
<td><a href="http://www.evergladesplan.org/education/lesson_plans_pan_observations.aspx">http://www.evergladesplan.org/education/lesson_plans_pan_observations.aspx</a></td>
<td></td>
</tr>
<tr>
<td>Florida Panther Mobile</td>
<td>1, 2, 3</td>
<td></td>
<td>construct a mobile, learn about radio collars and ranges/territories</td>
<td><a href="http://www.evergladesplan.org/education/lesson_plans_pan_baseline.aspx">http://www.evergladesplan.org/education/lesson_plans_pan_baseline.aspx</a></td>
<td></td>
</tr>
<tr>
<td>Printable Masks</td>
<td>1, 2</td>
<td>make mask of favorite cat</td>
<td></td>
<td><a href="http://www.angelfire.com/dc/childsplay/masks.htm">http://www.angelfire.com/dc/childsplay/masks.htm</a></td>
<td></td>
</tr>
<tr>
<td>Project Wild</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9, 10</td>
<td>many lesson plans</td>
<td></td>
<td><a href="http://www.projectwild.org/documents/ProjectWILD.pdf">http://www.projectwild.org/documents/ProjectWILD.pdf</a></td>
<td></td>
</tr>
</tbody>
</table>
Deserts (Core Knowledge) 5, 6, 7  desert geography, adaptations, characteristics http://www.coreknowledge.org/mimik/mimik_uploads/lesson_plans/1055/Deserts.pdf

What’s Your Habitat? 2, 3, 4, 5  human/animal needs, how we survive http://www.nwf.org/pdf/Schoolyard%20Habitats/whatsyourhabitat2.pdf

Habitat Hunt 3, 4, 5, 6  determine if an area is a good habitat, understand interactions between biotic and abiotic elements http://www.nwf.org/pdf/Schoolyard%20Habitats/HabitatHunt.pdf

Habitat Web 1, 2, 3, 4, 5 (kind of like food web) http://www.nwf.org/pdf/Schoolyard%20Habitats/HabitatWeb.pdf

Links in a Food Chain 1, 2, 3, 4  create/understand a food chain http://www.nwf.org/pdf/2011/Links-in-a-Food-Chain-K-4.pdf

Habitat Hunt (TPW) 4, 5, 6  visit outdoor area, create food chain, note adaptations http://www.tpwd.state.tx.us/learning/resources/activities/habithunt.phtml

Mammal Scrabble 3, 4, 5  crossword with mammals in TX (can change to key words about cats) http://www.tpwd.state.tx.us/publications/nonpwdpubs/young_naturalist/animals/mammal_scrabble/index.php

Skull Matching 3, 4, 5  pictures of skulls and animals, matching game http://www.tpwd.state.tx.us/publications/nonpwdpubs/young_naturalist/animals/skulls/index.phtml

Animal Tracks Matching 3, 4, 5  pictures of tracks and animals, matching game http://www.tpwd.state.tx.us/publications/nonpwdpubs/young_naturalist/animals/animal_tracks/index.php

Patagonia Animals 5, 6, 7, 8, 9  find, look at adaptations, wolf relocation, social/political issues, defending stance http://www.pbs.org/edens/patagonia/tcreatur.htm

Wild Wolves 6, 7, 8, 9, 10, 11  understand limiting factors http://www.pbs.org/wgbh/nova/education/activities/2415_wolves.html

Oh Deer! 3, 4, 5, 6, 7, 8  understand limiting factors http://alex.state.al.us/lesson_view.php?id=24097

Animal Camouflage Organisms and Their Environment 3, 4, 5, 6  how camouflage helps animals, how it works http://ecosystems.psu.edu/youth/sfrc/lesson-plans/wildlife/k-5/camo

Wildlife Habitat What do Bears Eat and How do They Walk? 9, 10, 11, 12  habitat suitability http://ecosystems.psu.edu/youth/sfrc/lesson-plans/wildlife/k-5/organisms

Wildlife Habitat Where do Bears Eat and How do They Walk? 1, 2  understand what bears eat, motion, draw a picture http://education.illinois.edu/YLP/Units/Mini_Units/94-95/Heyen.Bears/bears.2b.html

Conservation and Big Cats 6, 7, 8  learn about what is affecting big cats http://education.nationalgeographic.com/education/activity/conservation-and-big-cats/?ar_a=1&ar_r=99

Tiger Trouble 5, 6, 7, 8  conservation of tigers, poem, compare and contrast species http://education.nationalgeographic.com/education/activity/tiger-trouble/?ar_a=1

Cheetah Adapations 3, 4, 5  answer questions about adaptations to run so fast http://www.cheetah.co.za/resource/english/grade_4_lesson_3.pdf

Endangered! 1,2,3,4,5,6,7,8,9,10  answer questions about endangered species to advance on game board http://howtosmile.org/record/5106

Invent an Animal 1,2,3,4,5  camouflage, habitat, creativity. Create and hunt for hidden animals (classroom or outside) http://www.outdoorbiology.com/files/resources/activities/InventAnAnimal.pdf

Deer Me 3, 4, 5, 6  predator prey simulation http://www.wolfquest.org/pdfs/Deer%20Me%20Lesson.pdf


Wolf Limiting Factors Survival is Just a Roll Away 4, 5, 6  limiting factors, population fluctuations http://www.wolfquest.org/pdfs/Wolf%20Limiting%20Factors%20Lesson.pdf

Wolf Quest 4, 5, 6, 7, 8, 9, 10, 11  limiting factors, human influence http://howtosmile.org/record/9753

<table>
<thead>
<tr>
<th>Rank</th>
<th>Grade</th>
<th>Topic</th>
<th>Content Details</th>
<th>Resource Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3</td>
<td>Wild or Domestic?</td>
<td>Differences between wild and domestic animals</td>
<td><a href="http://www.petweek.org/assets/pdf/GradeLevel3_WD.pdf">http://www.petweek.org/assets/pdf/GradeLevel3_WD.pdf</a></td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>The Tiger, <em>Panthera tigris</em></td>
<td>Learn about tiger, make a tiger out of &quot;found objects&quot; (maybe relevant to species)</td>
<td><a href="http://www.kidsfortigers.org/docs/lesson5.pdf">http://www.kidsfortigers.org/docs/lesson5.pdf</a></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>Nutrition Part 2</td>
<td>Species nutritional needs</td>
<td><a href="http://www.cheetah.co.za/resource/english/grade_5_lesson_4b.pdf">http://www.cheetah.co.za/resource/english/grade_5_lesson_4b.pdf</a></td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>Habitats</td>
<td>Availability of resources in different habitats, animal's best habitat choice</td>
<td><a href="http://www.cheetah.co.za/resource/english/grade_5_lesson_2.pdf">http://www.cheetah.co.za/resource/english/grade_5_lesson_2.pdf</a></td>
</tr>
</tbody>
</table>

*Rank applicability to the project  
** Quality of content
Do I Need More Room Than a Jaguar?
Home Range Activity
Lesson Plan
Designed and written by: Aletris Neils
University of Arizona
Project C.A.T.

Objectives:
- Teach mapping skills (how to observe and duplicate)
- Demonstrate space use
- Provide introduction to mapping and approximating distance
- Facilitate an appreciation for natural history
- Show parallels to human and animal needs
- Provide context for students to connect with and admire nature
- Allow students to reflect on how they move, use space, and resources
- Teach space use in relation to other objects (more advanced adaptations)

Topics:
- Math and Graphing
- Geography
- Science: Ecology, Earth Science, and Natural History

Grades: This activity is appropriate for students from 4th grade up

Materials:
- Board
- Maps of jaguar and other species’ home ranges
- Pencil
- Graph paper
- Notebook to write down their movements

Background:
Home range is the area where an animal lives and travels in. It is closely related to, but not identical with, the concept of “territory.” The home range of an animal is the area where it spends its time; it is the region that encompasses all the resources the animal requires to survive and reproduce. Competition for food and other resources influences how animals are distributed in space. Even when animals do not interact, clumped resources may cause individuals to aggregate.

Think about all the places you go during the week – to school, to the store, to the park – all of these places are important to you. They are your home range – every animal species needs a
certain amount of space to survive and thrive. The amount of space an animal uses on a regular basis is called its **home range**. Home ranges can stretch for many miles or they can be only a few feet. The size of a home range often depends on the size of an animal. Large animals, like the puma, need more space to survive than smaller animals like the desert mouse.

Many animals, like the jaguar, bobcat, or coyote, mark and defend some or all of their home range. When this happens, they have established a **territory**. When an animal establishes a territory, it usually only defends it against other members of its species. Many male animals will establish a territory and share it with more than one female but defend it against other males. This helps ensure that other males won’t mate with the females in his home range.

Animals **move** around for a variety of reasons. They move for food, for shelter, to care for their young, to find a mate, and to escape predators. Some animals move seasonally from one location to another; this is **migration**. All animals move around within their habitat on a daily basis. The area an animal uses to meet its daily needs is its home range.

Having a home range is important for an animal’s survival. They become familiar with their range. They know where the food and water is, where the danger is, and where the good hiding spots are. They also learn to identify when something has changed or invaded their home range. Many animals are as familiar with their home range as you are with your neighborhood! In fact, some animals are so attached to their home ranges that when they are removed from them, they will sometimes travel many miles to return!

Jaguars, like most cats, are solitary animals, except during mating season. They mark their territory with urine, feces, scent markings, scratches, and scrapes (piles of dirt and debris marked with scent). A male’s home range may overlap with the home range of a couple of females and often another male. Females’ home ranges usually don’t overlap. Jaguar home ranges are very large and can be over 50 square miles. Bobcat home ranges can vary in size from less than a square mile to more than 20 square miles, depending on the season of the year and the geographic location.

Some animals have one location in their home range, like a den or a nest, which is their home. They may move around their home range during the day or at night, but they always return to that one place to sleep! Other animals don’t have a single place in their home range that is their home. They may rest wherever they can find a safe, comfortable spot! Other animals may have a few spots within their home range that they use to rest.

Ways to calculate a jaguar (or another animal’s) home range:
- Radio collars (best way)
- Remote camera traps (gives you an approximate idea)
- Tracks, scat, scrapes – animal sign (can delineate home range borders)
More advanced background for older students:
The concept of home ranges can be traced back to publications in 1939 and 1943 by Nobel and W. H. Burt, who constructed maps delineating the spatial extent or outside boundary of an animal’s movement during the course of its everyday activities. Associated with the concept of a home range is the concept of a utilization distribution, which takes the form of a two dimensional probability density function that represents the probability of finding an animal in a defined area within its home range. The home range of an individual animal is typically constructed from a set of location points that have been collected over a period of time identifying the position in space of an individual at many points in time. Such data are now collected automatically using collars placed on individuals that transmit through satellites or using mobile cellphone technology and global positioning systems (GPS) technology, at regular intervals.

The simplest way to draw the boundaries of a home range from a set of location data is to construct the smallest possible convex polygon around the data. This approach is referred to as the minimum convex polygon (MCP) method, which is still widely employed, but has many drawbacks including often overestimating the size of home ranges.

Lesson Plan:
Start by discussing the importance for research into understanding where an animal goes. What does this tell scientists? How do you measure where they go?

Discussion Questions:
Which method is the best for trying to measure a jaguar’s home range?

Activity (part 1):
- Have the students look at home range maps from different animals. What do they tell you? What can you tell about each animal from looking at its home range map?
- What are places you visit each day?
  - School
  - Home
  - Extra activities (dance, sports, etc.)
  - Grocery store
  - Relatives’ houses……
- Are these places part of your home range? Yes – they are part of the area you live and travel in.
- Record the distance to each place you go:
  - Example: School to home is 3.4 miles
  - To record the distance you can:
    - Use the odometer in the car
    - Look it up on a map
    - Use a distance mapping software, for example MapQuest
- For more advanced students record compass directions from each point, too.
  - Example: School is 2.1 miles north of the supermarket. Market is 0.6 miles south of home.
Activity (part 2):
- Have each student display their distances (talk about what point is the furthest?).
- Use graph paper to plot each location/distance.
  - Tip: help students determine a scale – usually each square is ½ mile.
- Connect the dots and form the polygon – this is their HOME RANGE.
- Have them count the squares inside their polygon – what is the total area?
- Compare home ranges between students and wildcats – which one is larger?
  - Jaguars
    - 19-53 miles\(^2\) – we don’t know HR for AZ jaguars
  - Ocelots
    - 19 miles\(^2\) (~31km\(^2\)) – we don’t know HR for AZ ocelots
  - Pumas
    - 30-125 miles\(^2\)
  - Bobcats
    - In Arizona: 2-5 miles\(^2\) (4.8 km\(^2\) for females/9.1 km\(^2\) for males)

Extra Credit:
Determine which species has a home range the same size as theirs.

Using math – how else could they determine the size of their home range?

Thought Provoking Questions:
If you included the location of where the food you ate came from, how big would your home range be? What can you do to make that area smaller?

If you had to walk everywhere (like a jaguar) how would that change your home range? Would it change how and where you traveled?
Appendix III. Draft lesson plan 2.

Why Aren’t Deer Blue?  
A lab to introduce Natural Selection  
Lesson Plan  
Designed and written by: Aletris Neils  
University of Arizona  
Project C.A.T.

Objectives:  
• Introduce the concept of natural selection  
• Facilitate an appreciation for natural history  
• Demonstrate adaptations

Topics:  
• Adaptation  
• Natural selection  
• Predator-prey relationships  
• Math and graphing  
• Randomization

Grade: 4-8 grades (can be modified for older and younger students)

Materials:  
• Colored construction paper that matches at least 5 M&M colors  
• M&Ms (*note peanut M&Ms could cause peanut allergies)  
• Coins

Time: 45-60 minutes, more time for detailed introduction or discussion

Background:  
Natural selection is the process by which those heritable traits that make it more likely for an organism to survive and successfully reproduce become more common in a population over successive generations. It is a key mechanism of evolution.

The natural genetic variation within a population of organisms means that some individuals will survive and reproduce more successfully than others in their current environment. For example, the peppered moth exists in both light and dark colors in the United Kingdom, but during the industrial revolution many of the trees on which the moths rested became blackened by soot, giving the dark-colored moths an advantage in hiding from predators. This gave dark-colored moths a better chance of surviving to produce dark-colored offspring, and in just a few generations the majority of the moths were dark.
Natural selection acts on the phenotype, or the observable characteristics of an organism, but the genetic (heritable) basis of any phenotype which gives a reproductive advantage will become more common in a population. Over time, this process can result in adaptations that specialize organisms for particular ecological niches and may eventually result in the emergence of new species. In other words, natural selection is an important process (though not the only process) by which evolution takes place within a population of organisms.

**Process:**
In this lab, students will simulate natural selection occurring on a prey species. During the exercise students will utilize M&Ms to represent both a predatory animal such as a “puma” and its prey, such as “deer.” “Deer” are represented by M&Ms that have been randomly distributed over various “ecosystems,” which are in turn represented by colored construction paper. Some of the “deer” will blend into the “ecosystem,” while others will clearly stand out. The “puma,” represented by a red M&M, will serve as the driver for natural selection and during the game will remove prey not suited for their environment. Students should work in groups of 2-4.

**Steps:**
- Ask the students to relate the colored paper to 5 different “ecosystems” (examples: green=forests; yellow=grasslands; blue=water; orange=desert; brown=mountains). Have them arrange the “ecosystems” in any order, so that each “ecosystem” is touching at least one other.
- Have the students count out 3 M&Ms for each of the 5 “ecosystem” colors for a total of 15 “prey” M&Ms. Then give each student 1 red M&M to represent the “predator.”
- Randomly place 3 of the “prey” M&Ms on each of the 5 pieces of paper. Randomly place one red “predator” M&M on an “ecosystem.”
- Record the number of each M&M color they have on each “ecosystem.”
- Have a student flip a coin: (heads= eat a “prey” item and remove it from the “ecosystem” & tails=“prey” are safe).
  - Start with the “predator” on any “ecosystem.”
  - “Predators” can only eat those “prey” that do not match the “ecosystem” in which they have been placed. If the “prey’s” color matches the “ecosystem,” it is considered camouflaged (adapted) and avoids detection so it does not get eaten.
  - If all the “prey” match the “ecosystem’s” color where the “predator” is hunting, then there is nothing for the “predator” to eat. At this point, the “prey” reproduce. In this scenario, each time a “predator” lands on that “ecosystem” add another “prey” M&M of the same color to the “ecosystem.”
  - If you flip tails, then the “prey” are safe and one “prey” M&M can move to the next nearest “ecosystem.” Note: “prey” that match their “ecosystem” would not want to leave, but “prey” that don’t match have a chance to get to an “ecosystem” for which they are better adapted.
  - After each generation (i.e., the “predator” made a rotation around all 5 “ecosystems”) add an M&M to any “ecosystem” that has at least 2 “prey” that match their “ecosystem.” This represents reproduction of species that are adapted to their environment.
  - Play the game for at least 3 generations or until time permits.
• At the end of the game, tally the number of colors on each “ecosystem.”
• Ask the students what they observed:
  o Did any color go extinct? What does this represent? Does it happen in nature?
  o How many groups had at least 3 colors survive all generations?
  o What does it mean if there is 1 matching M&M on the “ecosystem”? Can this animal reproduce?

Optional Components:
• Have the students modify the game any way they want to that makes it more realistic to nature (examples: add additional “predators,” add more “ecosystems,” etc.).
• For older students, try using a die and have each number represent something different.
• Have the students graph their results. I had my students record the population sizes after each flip so they could have a line graph for each color and see the change in population over time.

Additional follow-up questions:
1. So why aren’t deer blue? Would a blue deer be easier to spot than a brown deer? In what ecosystems would a blue deer have camouflage? Do you find deer in the water or in the sky?
2. What other animals in nature have camouflage that helps them blend in with their habitat?
3. Why is it important to have predators in the ecosystem? What would happen if we removed the predator?
4. In addition to predators, what other factors could drive natural selection?
Appendix IV. Draft lesson plan 3.

What Makes Animal Tracks Unique?

Puma & Wildlife Track Ornament Making Activity

Lesson Plan

Designed and written by: Aletris Neils
University of Arizona
Project C.A.T.

Objectives:
• Teach tracking skills (how to observe and duplicate)
• Facilitate an appreciation for natural history
• Provide context for students to connect with and admire nature
• Allow students to make a unique keepsake that they can display

Grade:
This activity is appropriate for students from 3rd grade up

Materials:
• Rubber tracks from jaguar educational kit or wildlife field guides with track examples
• Plaster of Paris (4 lbs per class or 1-2 cups per child)
• Modeling Clay (10 lbs per class or one handful per child)
• Paper towels
• 2-3 straws per class
• Scissors
• String

Background:
Identifying animal tracks and sign are primary skills of the wildlife tracker. Historically, animal tracking skills helped people find food, avoid potential predators, and read stories on the landscape. Wildlife tracking skills continue to be valuable today and are being employed in wildlife research, conservation, and outdoor education.

Detecting animal tracks and sign can open up an unseen world, a window into the lives of shy and elusive animals. Tracks, scat, feeding sign, beds, scent marking, trails, and other types of animal sign point to which animals passed by, what they did, where they went, and much more. Seemingly barren ground becomes alive with a diversity of fascinating information. Trackers can obtain a lot of scientific information about wildlife from animal sign.

Lesson Plan:
Start by discussing the importance of documenting tracks for research. What do tracks tell scientists? How do you read tracks? How do you measure tracks?
Discussion Questions:
How do you distinguish various carnivores’ tracks? What do predator tracks look like compared to tracks left by prey species? Which carnivore families have 5 toes and which ones have 4 toes per foot? What natural processes will deteriorate tracks? Which animals’ tracks are most obvious/easy to encounter?

Activity:
- Have each student select a rubber wildlife track from a local animal that they would like to make. Or look through wildlife field guides for track examples. Draw the track on paper for practice (older students draw to scale with the exact track measurements).
- Give each student a large handful of clay and have them shape it into a shallow bowl with thick edges.
- Each student should then make the imprint of their track into the center of the clay bowl, as if they are the animal stepping on the clay. Note: they need to make the imprint deep for it to turn out. Also, lightly sketching the track in the clay with a pencil helps provide an outline.
- Have all students place their clay bowl on a paper towel with their name on it. Place these towels on a table (preferably outside).
- Gently embed a piece of straw (slightly longer than the height of the bowl) near the top of the clay bowl (not too close to the edge). Do not poke the straw in too deep or it will poke out of the front of the plaster track. Note: this is an optional step that only needs to be done if the track is to be hung like an ornament.
- Mix the plaster of Paris with water until it is the consistency of soft yogurt. Note: all the clay bowls need to be ready to go once this is mixed because it will start to dry quickly. If the plaster is too watery it will not dry.
- Smoothly pour the plaster mixture into the bowls, taking care not to fill in the straws. A spoon is helpful.
- Allow the plaster to dry for at least an hour...you might be tempted to test them earlier but it could ruin them. They are best left overnight.
- Once dry, gently peel the clay off the plaster. You will be left with a beautiful wildlife track imprint.
- Have the students write their name, wildlife species, and the year on the back of their track in pencil.
- Place a piece of string through the straw and your track ornament is ready to be hung on a tree or anywhere else!

Questions:
How do you distinguish between a jaguar track and a puma track? (Note: Use Jack Childs’ book in the education kit to help.) How do you distinguish between bobcat and ocelot tracks?

Extra Credit:
Go outside and look for wildlife tracks. Use field guides to help identify the tracks you find. The best time to study animal tracks is in the morning, before the ground becomes disrupted. Keep in mind the quality of the tracks will depend on the texture and depth of the substrate.
A student making a wildlife track in a shallow clay bowl.

Clay bowls made by students filled with plaster.
Appendix V. Lesson plan 4.

Cats in our Counties
Lesson Plan
Designed and written by: Aletris Neils
University of Arizona
Project C.A.T.

Objective:
• Learn Arizona counties (geography)
• Learn about the range of the four Arizona wild cats
• Be able to demonstrate the AZ range of the four wild cats based on county
• Understand how the range of these cats has changed over time

Grades: 3-7 (can be modified for older and younger students)

Time: 30 minute minimum (can be extended)

Materials:
• Four maps of Arizona’s counties per student (map attached to lesson plan)
  o May use map with or without rivers (see procedure to decide)
• Maps or tables of jaguar and ocelot sightings
  o Obtain from websites included at end of lesson plan
• Six different colored markers, colored pencils, pens, or crayons for each student or group of students

Keywords:
• County: a territorial division for local government in the U.S.
• Range (animal): geographic area in which a species can be found
• Ephemeral River: river that holds water only immediately after rainfall
• Intermittent River: river that flows only during wet seasons
• Perennial River: river that flows year round

Background:
There are four wild cats found in Arizona: bobcat, mountain lion, ocelot, and jaguar. Bobcats are found throughout North America and some of Central America; they are found all throughout Arizona. Mountain lions are similarly found throughout Arizona and have a range that encompasses the western portion of North America, a population in southern Florida, and much of Central and South America. Historically, these cats covered much more area in North, Central, and South America. Jaguars and ocelots are found in much of Central and South America with the northern extent of their range reaching into Southern Arizona.

Jaguars and ocelots are considered more “tropical” species than mountain lions and bobcats. This affects their habitat needs in Arizona. The “Sky Islands” are mountain ranges that extend from northern Mexico up through Arizona. These ranges and their attributes serve as
corridors and important habitat for wildlife. The mountains tend to have more water, vegetation, and a cooler climate than the desert “sea” they are surrounded by.

Currently there is one male jaguar living in Southern Arizona. He has been seen on camera traps in Arizona for multiple years suggesting that he resides at least part of the time in Arizona. In the past, however, jaguars could be found as far north as the Grand Canyon.

**Procedure:**

1. Begin by asking students where they are right now
   a. School → where is school?
   b. Tucson → Good. Do you know what **county** we are in?
   c. Example: Tucson is in Pima county
2. Ask if students know what a county is before defining it. Explain that there are 15 counties in Arizona.
   a. Ask if students know any other counties in AZ
      i. Will most likely hear Cochise, Pinal, and Maricopa
3. Ask students which four wild cats can be found in AZ and where each can be found
   a. Bobcat, Mountain Lion
      i. Throughout AZ
   b. Ocelot, Jaguar
      i. Southern AZ
4. Pass out copies of tables and/or maps of jaguar and ocelot sightings and explain briefly
5. Pass out the maps (4) and make sure students have six markers to use
6. Tell students that they will be figuring out where these cats can be found and marking it on the map. Students may use range maps and information shown during class or this may be a take-home assignment. (Since 1990)
   a. If you can find them in Pima county, Maricopa county, and Yavapai County, those three counties will be colored in.
   b. Students will complete these steps for each cat
      i. Bobcats and mountain lions are found throughout AZ (all counties)
7. Many animals no longer inhabit the same area that they used to. Human activity has greatly affected their ranges. Show map of mountain lion current and historic range to demonstrate.
   a. For the ocelot and jaguar have students map the historic range (since 1900) with a different color (map will have two different colors on it).
      i. Counties not inhabited in the past should be colored in with the second color and counties inhabited at both times should be outlined with the second color and filled with the first
8. Discuss what students have just learned. There are four wild cats in Arizona, but you can only find all four in the southern portion of the state.
9. You may also look at trends of jaguar sightings!
10. Have students put a dot in places where jaguars have been spotted on the map with rivers shown.
    a. Do you notice anything?
    b. Are jaguars more often found around rivers? On mountains?
       i. For older students, use the map of rivers that indicated **ephemeral, intermittent, perennial**
ii. Are they seen more often by one type that the others?
11. If time permits, have students map human density in Arizona.
   b. Examine other variables that could limit distribution from the same site, agriculture or roads: http://geology.com/cities-map/arizona.shtml

Follow Up:
- Why are jaguars and ocelots limited to the southern portion of AZ?
- Do you think it’s possible for these cats to inhabit their historic range again?
- Should we try to introduce these cats to their historic range? Or should we focus on preventing their current range from shrinking and see what happens?
- Why might you see jaguars (and ocelots) in areas around rivers?
- What else do you notice from other maps of jaguar sightings?
- Show the current and historic ranges of some other animals in America. Do you see a trend?

For Fun:
- See how many counties each student has been
- Form terms with each student representing one county they have been to- can you represent the range of any species? All the cat species?
Flow Status

- Perennial
- Formerly Perennial
- Regulated
- Effluent Dominated (May Be Formerly Perennial)
- Intermittent or Ephemeral

Flow status data created from TNC Freshwater Assessment, available from azconservation.org
Links to websites with maps/tables of sightings:

Jaguar maps:
  Past 100 years of reputable sightings on page 7.
  Pages 6-13 are interesting to show distribution patterns
  http://www.azgfd.gov/pdfs/w_c/jaguar/characterizing_mapping.pdf

Ocelot maps/tables:
  Pages 4, 5, 13
  Download PDF
  http://azmemory.azlibrary.gov/cdm/ref/collection/statepubs/id/13313

Page 194
Wild Cat Skulls
Lesson Plan
Designed and written by: Aletris Neils
University of Arizona
Project C.A.T.

Objectives:
- Identify Arizona border cat skulls
- Understand function of skull features
- Learn how diet and morphology are linked
- Basic anatomy of the head
- Inspire further learning about wild cats

Grades: 4-8 (can be modified for older and younger students)

Time: 45min-1hr

Materials:
- Skull replicas or images for bobcat, mountain lion, ocelot, and jaguar (may incorporate other types of cats as well) found in border cat kit (can be checked out by teachers)
- Pictures of corresponding animals (found in kit)

Key Terms:
- **Carnivore**: a meat-eating animal
- **Herbivore**: a plant-eating animal
- **Omnivore**: feeding on both animal and plant substances
- **Incisors**: nipping or chiseling teeth at the front of the jaw
- **Canines**: enlarged teeth between the incisors and premolars; usually a large stabbing tooth, occasionally bladelike, but sometimes small and similar to the teeth preceding them
- **Premolars**: deciduous teeth posterior to the canines
- **Molars**: the posterior teeth in the upper and lower jaws that are non-deciduous
- **Carnassials**: shearing; in the order Carnivora. The term often refers to the last upper premolar and the first lower molar, which oppose one another like scissor blades, and have a shearing action
- **Binocular Vision**: forward facing eyes, good for depth perception
- **Peripheral Vision**: sideways facing eyes, good field of vision
- **Auditory Bullae**: the inflated bony capsule that encases the middle and inner ear (bulla=singular)
- **Sagittal Crest**: ridge on the top of the skull where jaw muscles attach; a more pronounced crest indicates a stronger jaw
**Background:**

**Arizona Cats**

There are four different wild cat species in Southern Arizona. When asked, most people can name the two most common felines: bobcat and mountain lion. There are two other, more tropical species living here as well: the jaguar and ocelot. From 2012 to 2015, there was one confirmed male jaguar living in Southern Arizona and multiple ocelots. Contrary to what many people believe, the jaguarundi is not found in Arizona.

Bobcats are distributed throughout most of North America. These felines are small relative to many of the big cats we initially think of (lions, tigers, leopards), but they are still much larger than your average house cat. Bobcats weight approximately 20 pounds and stand 2 ½ feet tall. Like most felines, the males are larger. They have a spotted tan coat, tufts of fur on their ears, and a bobbed tail for which they are named. These cats feed primarily on cottontail rabbits and jackrabbits, but will prey upon a variety of other species (mostly birds, rodents, and reptiles).

Mountain lions have a very large distribution ranging throughout the Americas. These felines are much larger than bobcats; males weight about 150 pounds and females weight around 105 pounds. These cats are mostly tan in color and have a dark-tipped tail. They are deer specialists but will also eat smaller animals such as rodents. Other prey items of the mountain lion include porcupines, pronghorn, wild turkey, raccoons, skunks, javelina, black bear, bighorn sheep, and cottontail rabbits.

Jaguars used to be found as far north as the Grand Canyon in Northern Arizona, but now they are only known to come as far north as Southern Arizona where multiple male jaguars have been caught on wildlife cameras. Their range extends well into South America. These large cats can weigh between 150 and 200 pounds and reach a length of seven feet long. This species can have a few different color morphs including a spotted coat that closely resembles a leopard or a solid black coat. These cats favor javelina and capybaras for prey, but will also consume things such as caimans, tapirs, or fish. Jaguars are unique in that to kill their prey, they will pierce the skull with their powerful jaws.

Ocelots inhabit a range similar to that of the jaguar, but are much smaller in size. In fact, ocelots tend to be smaller than the bobcat as well, reaching a weight of only 17-24 pounds and 16-20 inches tall. They are similar enough that bobcats (and young mountain lions that are still spotted) are often mistaken for ocelots. Ocelots are usually a golden color with lots of spots covering them. Ocelots tend to eat nocturnal rodents, opossums, and armadillos with the occasional larger prey item (lesser anteater, deer, tortoise).

**Skulls**

Skulls can tell you a lot about an animal, especially what it ate. Dentition will often give you clues to whether the animal was a carnivore, omnivore, or herbivore. The condition of the skull and dentition may also give you a clue to whether the animal was young or old or if it may have been in a fight before it died. Teeth are not the only clues though. Many carnivores have a sagittal crest that provides muscle attachment for the jaw. The larger the crest, the stronger the jaw it had. The position/orientation of the eye sockets is also important. This will tell you whether the animal had binocular or peripheral vision. Carnivorous animals will most likely have binocular vision, but this isn’t always true. Binocular vision gives an animal good depth.
perception compared to those with peripheral vision. Peripheral vision, on the other hand, allows for a very wide field of vision.

**Procedure:**

1. Ask students how carnivores, herbivores, and omnivores are different. There should be a focus on what they eat. Once you’ve identified what these animals eat, ask whether herbivores are predators or prey animals? Do this for both carnivores and omnivores as well, but keep in mind that carnivorous and omnivorous animals may be both predator and prey.

2. Ask students if they know of any carnivores in Arizona. Try and get them to guess a cat species. Use this as a segue into discussing the four cats found in the Sonoran Desert.
   a. Ask what wild cats are found here
      i. Bobcat, mountain lion, ocelot, jaguar, UA Wildcats
      ii. Students might mention domestic or house cats- they are a “wild cat” but are not native and should not be outside.
   b. Name some key points about these cats
      i. Size, solitary vs group, habitat, etc.

3. Ask students what these cats eat
   a. Rabbits, deer, javelina, etc.
   b. Meat-eaters! All cats are hyper-carnivores= they only eat meat

4. Show students one of the skulls
   a. Ask them what features of the skull allow them to be good predators

5. Define key features of the skulls of wild cats with diagram and real skulls
   a. Teeth
      i. Incisors
         1. Like tweezers
         2. Used for plucking fur and feather before eating
      ii. Canines
         1. Large canines usually found in meat eaters
         2. Often used for killing prey
         3. Exception: Some species have large canines for defense and/or display. Javelina are not predators, but have large canines that may be used in defense or for stabilization while cracking hard seeds and nuts
      iii. Premolars
         1. In carnivorous species they are usually sharp to tear meat
         2. May look very similar to molars
      iv. Molars
         1. For grinding up food in plant eaters to make it more digestible
         2. Good for crushing bone in carnivores
      v. Carnassial Pair
         1. Found in Carnivora (the Order cats are in)
         2. Act like scissors
            a. Teeth slide past each other when mouth opens and closes
   b. Eye sockets
      i. Forward facing for binocular vision
1. Good for depth perception
2. Often found in predators, and Primates (people)

ii. Facing more sideways for peripheral vision
   1. Better field of vision
   2. Prey can watch for predators all around while grazing/browsing

   c. Muzzle (rostrum) length
      i. Shorter muzzle allows for different muscle attachment/ less room for teeth
         1. How many teeth do you have?
         2. How many teeth do the wild cats have?
      ii. Shorter muzzle allows for more rapid jaw movement
         1. Have students clap their hands together rapidly. Make a fist and clap again. Ask if their clapping was slower or faster?
         2. Good for predator who has to eat fast because something might want to take it.

d. Sagittal Crest
   i. For muscle attachment of the jaw
      1. Larger crest allows for more muscle attachment
         a. Results in stronger jaw/more powerful bites
      2. Males tend to have a larger crest than females (sexual dimorphism)
         a. Used to attract females (look sexy)
         b. Fight with other males to get females

e. Auditory Bullae
   i. House middle and inner ears
      ii. Size relative to skull size often indicates how well they hear
         1. If possible, show images of skulls with excellent and poor hearing for comparison with cat skulls
         2. Humans have poor hearing in comparison, with cats which have excellent hearing

f. Nose (nasals)
   i. Show students the inside of the nose on a skull
   ii. Notice all of the bones
      1. Purpose is to increase surface area
         a. More surface area results in more area for scent receptors
   iii. Consider how different animals will vary in sense of smell
   iv. Do you think cats smell better or worse than a dog? Hint: the dog has a longer rostrum, so more room for receptors.

6. Allow students to look at skulls on their own (pictures or replicas). Have pictures of the four cats and ask students to decide which skull belongs to which cat.

Discussion:

- How can you determine whether an animal eats meat or plants?
- What is the difference between binocular and peripheral vision? What do these cats have?
- Why do you think the skulls are small compared to their live counterparts?
  - On top of the skull is muscle, skin, and fur which make the animal appear much larger
• What do you think a coyote, bear, beaver, or another animal eat? What features suggest this? (give them experience with more skulls)
• Do you think skulls are helpful for mammalogists (people who study mammals)?
• How do you think you can age a skull? What would you look for? Hint: think about what happens to teeth over time.
For fun:

- Have each student draw a picture of an animal skull either real or imaginary (but ensure they use the information they just learned)

- Trade pictures with a friend and see what features they can identify in your skull. What can those features tell you about their animal?
Appendix VII. Lesson Plan 6 for K-3

Wild Cats of Arizona – Coloring Activity

Name: ______________________________  Date: ___________

There are four wild cats found in Arizona: the bobcat, mountain lion, jaguar, and ocelot. Each cat’s markings helps them hide in their habitat, making them camouflaged so they can sneak up on their food. Color in the mountain lion and the jaguar and draw their habitat. If there is time, draw a picture of a bobcat and ocelot in their habitat on the back of the paper.
Appendix VIII. Lesson plan 7.

**Jaguars and People – Which Needs Protection?**

**Lesson Plan**

*Designed and written by: Aletris Neils*

*University of Arizona*

*Project C.A.T.*

**Objective:**
- Understand that different people have different opinions
- Understand how various stakeholders affect conservation
- Learn about real Arizona conservation issues
- Discover how to work through complex problems
- See how different perspectives can influence how you think

**Grades:** 4-10 (can be modified for older and younger students)

**Time:** 1hr

**Materials:**
- Equal number of cards so that each individual in a group gets a different card
- Background information on jaguars for each student/group of students
- Cards that say “For” or “Against” jaguar conservation in the Santa Ritas (attached to this document)

**Key Words:**

*Stakeholder:* one who is involved in or affected by a course of action

*Captive Breeding:* program that involves cooperation between zoos to breed a species

*Critical Habitat:* an area of land that includes resources needed by a particular species to survive

*Reintroduction:* the process of releasing a species into habitat that it previously/historically occupied.

**Background:**

Jaguars are a tropical species of cat typically found in Central and South America, reaching the northern extent of its range in Arizona. Historically, it ranged as far north as the Grand Canyon in Northern Arizona. Jaguars are opportunistic feeders that will eat different types of prey species—often picking javelinas (or peccaries) where they both occur.

Home range of an individual jaguar can be over 100 square miles depending on the habitat and prey. Females tend to have smaller ranges than males who will often overlap their ranges with multiple females.
Jaguars were hunted by people for their beautiful pelt and for fear they would eat livestock. Jaguars were thought to be eliminated from the United States until two were photographed in 1996. The presence of these jaguars sparked interest and research into this species along the border. Recently, however, a new jaguar was caught on wildlife cameras in Arizona’s Santa Ritas Mountains. This new jaguar has been caught on camera several times since. From camera trap pictures, biologists have documented this jaguar in the Santa Ritas in every month of the year.

Around the Santa Ritas, 830,000 acres of land was proposed to be designated as critical habitat. In the end, 764,207 acres was designated. This is equivalent to nearly 1,200 square miles. This would help ensure the land is not changed in ways that will be harmful to the jaguar and the species it coexists with.

**Procedure:**

1. Ask students what wild cats they can think of that live in Southern Arizona. If not mentioned, introduce the jaguar as a species that was historically found here; then mention that one jaguar is still known to inhabit Southern Arizona.

2. Ask what students know about jaguars and go over some basic ecology (coloration, behavior, diet, etc). Find out what the students want to know about jaguars (if you do not know the answer, encourage the student to find out and tell the class tomorrow or assign homework to the class to find out something new).

3. Begin discussing conservation and the different forms it can take (managing prey populations, limiting human activity, declaring critical habitat, reintroduction, education, etc.)

4. Describe the habitat in the Santa Ritas Mountains. Tell students why conservationists and policy makers declared it “critical habitat” for the jaguar. If possible, show students pictures of the jaguar that were taken with camera traps.

5. Ask students if they would be for or against a mine being built in this jaguar’s range - why? Record their answers.

6. Pass out the role playing cards (one occupation per person per group) and position cards (for or against jaguar conservation).

7. Students will read their cards and begin debating conservation in their group. They should tell everyone who they are (zookeeper, rancher, etc.) before making their argument. Let the debate go for about ten minutes before stopping students and telling them to take a position based on their fictional occupation (some occupations will have more obvious answers). Then have students choose a position based on how they feel and what they have learned. Has this changed from the beginning? How?

**Follow up:**

1. Talk about current management practices that are being done with jaguars and inform them that the area in the Santa Ritas was declared critical habitat for the jaguar.

2. How does it change when not only a jaguar but an ocelot has also been documented in the area? This makes the Santa Ritas the only place in the United States where you can find both jaguars and ocelots.

3. If time permits or for larger classes have students create additional stakeholders.

4. Instead of debating, have students create skits based on their characters.
Roles:

Wildlife Biologist:
You have been studying the elusive jaguar for several years in an attempt to learn more about this species. You have collected close to 100 pictures of the cat plus tracks and scat. You know that not only are the Santa Ritas home to this jaguar but also bears, mountain lions, coati, bobcats, deer and so much other wildlife. You love hiking the canyons and learning about nature - you use your observations to help protect this incredible area. The biggest problem you are facing is that there is a proposal to build a large mine in the middle of this habitat. The noise, lights and chemicals would prevent shy animals from using the area. How can you share how special this place is with everyone else? How can you get them to understand that once it is destroyed it will never be able to be restored? Why won’t people understand that this is the home to the ONLY know jaguar in the United States?

Big Cat Zookeeper:
You have been working to care for big cats such as the jaguar for years. Your zoo began to participate, in conjunction with other zoos, in a captive breeding program. You know that once jaguars are gone reintroducing them into an area is very difficult and cubs need to learn to hunt in the wild from their mother. You have looked into the eyes of the jaguars your care for and see how special they are. Just knowing there is a wild jaguar in Arizona still makes you very happy and gives you hope for wildlife - even if you will never see it. You hope by showing people how beautiful jaguars are in the zoo that people will want to protect them in the wild. How can you share how special these cats are? What can you share with them about the cats you care for that will give people are personal connection?

Conservation Educator:
Your goal is to educate people on how wonderful jaguars can be. There is a lot of fear surrounding large carnivores and if people or their pets will be hunted by these wild animals. You know that attacks on humans are rare, but it is difficult to convince the public about this fact. You must educate people on the jaguar’s disposition and ecology. If people can learn about how this animal behaves, they may be more willing to accept their presence. Promoting them as a tourism highlight may also improve perceptions. Once people are willing to accept these animals, your job is to make people realize how WE (humans) affect them. The question is, are people going to be willing to listen?

Rancher:
You own and manage a ranch on the Santa Rita Mountains that has been in your family for 62 years. You know there is a jaguar in the area and found its tracks once but have never seen it. You can’t help but be concerned about your livelihood - however you have not had any problems with it. If this cat kills your livestock, it could cost you a thousand dollars that you need to make a living. However, there are some benefits to the cat being around. Jaguars might keep away other carnivores, such as coyotes, away from your ranch. In addition you don’t want to area to be developed - you need large, undeveloped areas to graze your cattle. The jaguar might help prevent development. You rely on well water for your animals and family, you are worried a mine will contaminate the water with dangerous chemicals. Having a jaguar around may not be such a bad idea after all. But is it worth risking? How can you express that your
family relies on the land? How do you help them understand that you hope to give the ranch to your grandchildren one day and don’t want it to change?

Housing Developer:
You have the opportunity to build a new subdivision in a pristine section of the Santa Rita Mountains where it is rumored that a jaguar roams. The designation of this land as critical habitat would put a stop to your plans and deny you and your workers needed jobs. How is it fair for the jaguar to monopolize thousands of acres when each human would occupy less than 1 acre? You know the mine will create power lines and roads that could help you but are worried about what it might do to the water that you need. Most people would buy a winter home to have views of the mountains and a mine could be an eyesore? However you know that working with the mine might be the only way to beat the conservationists. How do you sell the public on the benefits of this development?

Miner:
You’ve been contracted to work in the Rosemont Mine in Southern Arizona. You’ve been in need of a new job so that you can support your family and put your kid through college. However, now you’ve been hearing that some wildlife biologists are trying to prevent the mine all because of some cat that’s been seen in the area. As far as you’ve heard there is only one jaguar living in all of Arizona, but you know there are more down in Mexico. You don’t think it’s worth it to declare the area surrounding the mine as critical habitat for one individual. After all, what’s going to happen once that cat is no longer around? How do you express that it is only one cat and why can’t it just move?

Resident:
You are living in a neighborhood only 25 minutes from the Santa Rita Mountains. You have two children and a dog. You feel that having jaguars threatens their safety and the safety of your neighbors. You are not sure if anyone has ever been attacked by a jaguar but you don’t want to find out. You think having a mine might lead to more money into the community that would be beneficial. Plus with more people, you might get better restaurants nearby. You are not worried about your water since you get drinking water delivered on a truck each week. How do you express that this is a lot of fuss over nothing- its just a cat?

Hiker:
Outdoor recreation is a very important aspect of your life. You love to go hiking, mountain biking, river rafting, and even rock climbing. One of your favorite local destinations is the canyons of the Santa Rita Mountains. The quiet area is perfect to relax and think; plus, the scenery is beautiful- there a creaks with water even in the hot summer. After hearing all of the reports, you’re itching for the chance to see this wild jaguar that lives in the area. Even though you have spent hundreds of hours hiking the mountains you have never seen a wild cat- but you have seen almost 70 bird species and even a bear once! You don’t want a mine to destroy this area that you love so much. How do you express how special the mountain is even without the jaguar?
For Jaguar Conservation  Against Jaguar Conservation

For Mine Construction  Against Mine Construction
Appendix IX. Lesson plan 8.

Cat Eyeshine
Lesson Plan
Designed and written by: Aletris Neils
University of Arizona
Project C.A.T.

Objective:
- Learn about tapetum lucidum
- Understand how light can be utilized by animals at night
- Learn about an adaptation that many nocturnal animals possess

Grades: 3-5 (can be modified for older and younger students)

Time: 30-60 min

Materials:
- Construction paper or card stock or paper and cardboard
- Coloring utensils
- Metallic/shiny paper of different colors (white, green, red, blue, yellow, pink)
- Scissors
- Glue
- Flashlights

Keywords:
- **Tapetum lucidum**: biological reflector system common in the eyes of animals
- **Nocturnal**: an animal that is active mostly at night
- **Retina**: light-sensitive layer of tissue at the back of the eye
- **Tradeoff**: a balance between two desirable, but incompatible features

Background:
The tapetum lucidum is a layer of tissue in the eye of many species. Lying immediately behind the retina it reflects visible light back through the retina, increasing the light available to the photoreceptors, though blurring the initial image of the light on focus. This tissue reflects light back through the eye much like a mirror and makes it appear as though the animals’ eyes are glowing. The tapetum lucidum contributes to the superior night vision of some animals. Many of these animals are nocturnal, especially carnivores that hunt their prey at night. This essentially allows the animal to use as much light as possible to allow it to see in low-light condition. There is a tradeoff, however. In order to be able to see in low-light conditions, they must sacrifice some clarity.

Most primates, including humans, lack a tapetum lucidum, and compensate for this by perceptive recognition methods. Depending on the species eyes may glow multiple colors including red or
green. It’s important to note that this type of eyeshine is different than red-eye often seen in photographs of both animals and humans.

Procedure:
1. Begin by asking students if they have ever seen an animal’s eyes glow in the dark
   a. When?
      i. When light shines on it
      ii. Or maybe when you look at photo where flash was used
   b. Explain that many animals have a layer of tissue in their eye that reflects light
      i. Called tapetum lucidum
          1. Write this on the board
          2. Have students repeat this term with you
   c. How does this help the animal?
      i. Allows animal to use as much light as possible
      ii. They can see really well in the dark
      iii. HOWEVER, they don’t see as clear of an image
          1. Like when someone who wears glasses takes them off
2. Show students some examples of animal eyeshine
   a. Cats usually have yellow eyeshine (can vary depending on species)
   b. Coyotes have white eyeshine
   c. Javelina have red eyeshine
3. Now students can choose which species to draw/design
4. Pass out paper and coloring utensils
a. May want to reserve paper and cardboard for older students due to difficulty of cutting the cardboard

5. Students will draw and color their cat or prey species. Then students should glue on two pieces of metallic paper for the eyes. Students should then cut out their animal.

6. Once students have completed their animals and they have dried, have students “hide” their animals around the room. Animals should still be visible, especially the eyes.

7. Give each student a flashlight to use
   a. Easiest to have small groups of students do this part of the activity at a time
   b. Students should hold the flashlight up so that it is on the same level as their eyes

8. Have students explore the room using their flashlight to find as many of the animals as possible in a given time frame (usually 2 minutes).

**Follow Up:**

1. Have half the class go into the room as people (i.e. room dark no flashlight) and count animals they see, how many do they find? Compare this with half the class that are jaguars with a tapetum lucidum (i.e dark room with better visibility so allow flashlights) and see which group sees more. Why?

2. Have students try to determine what species they find based on eye shine in the dark? How accurate are they once the lights are on?

**Discussion Questions:**

- Discuss tradeoffs between features.
- Do you think you can use this when you’re walking around at night to find animals?
- What kinds of animals might you see?
- What would life be like for humans if we had this tapetum lucidum? What could we see better/ worse?
Appendix X. Lesson plan 9 for 3-5 grade

Name: _______________________

Instructions: Read the paragraphs and fill in the blanks with words and numbers from the word bank. Each word will be used. When you have filled in all of the blanks, you will use some of these same words to label the picture on the bottom of the page.

Word Bank:

- range
- desert
- impression
- rosettes
- Arizona
- habitat
- long
- Panthera onca
- Sky Islands
- belly
- tawny
- leopards
- Grand Canyon
- 4.8
- paws
- 100
- South
- black
- dog
- spots

Jaguars (*Panthera onca*) live in the Americas. Their range extends from deep within South America all the way up into Southern Arizona. Just 100 years ago you could even find them as far North as the Grand Canyon! Jaguars live in tropical environments, but you sometimes find them in desert regions too. In the northern portion of their range they are restricted to the mountains called Sky Islands. These mountains provide the habitat requirements they need, including food, water and shelter.

Jaguars and leopards (*Panthera pardus*), an African cat, are often confused in zoos because of their similar patterns. The biggest difference in their patterns is found in their spots. The spots, of jaguars are also called rosettes because they have a spot in the middle of them. Jaguars also tend to have a more stocky appearance than the leopard. Jaguars are often a tawny color with a white chest and belly, but some in the amazon are melanistic and appear fully black. Jaguars have large paws with very sharp claws. The paw print of a jaguar’s foot is about 4 inches long and 4.8 inches wide. Unlike dog prints, you rarely see an impression of the cat’s claws! Jaguars are the 3rd largest cat in the world and the largest cat in the United States.
Name: _______________________

Instructions: Read the paragraphs and fill in the blanks with words and numbers from the word bank. Each word will be used. When you have filled in all of the blanks, you will use some of these same words to label the picture on the bottom of the page.

Word Bank:
range  desert  impression  rosettes  Arizona
habitat  long  Panthera onca  Sky Islands  belly
tawny  leopards  Grand Canyon  4.8  paws
100    South  black  dog  spots

Jaguars (__________________) live in the Americas. Their _______ extends from deep within _______ America all the way up into Southern _______. Just _______ years ago you could even find them as far North as the _______. Jaguars live in tropical environments, but you sometimes find them in _______ regions too. In the northern portion of their range they are restricted to the mountains called _______. These mountains provide the _______ requirements they need, including food, water and shelter.

Jaguars and _________ (Panthera pardus), an African cat, are often confused in zoos because of their similar patterns. The biggest difference in their patterns is found in their _______. The spots, of jaguars are also called _______ because they have a spot in the middle of them. Jaguars also tend to have a more stocky appearance than the leopard. Jaguars are often a _______ color with a white chest and _______. Some in the Amazon are melanistic and appear fully _______. Jaguars have large _______ with very sharp claws. The paw print of a jaguar’s foot is about 4 inches _______ and _______ inches wide. Unlike _______ prints, you rarely see an _______ of the cat’s claws! Jaguars are the 3rd largest cat in the world and the largest cat in the United States.

______ inches

______ inches

______ inches
To obtain copies of any of the lesson plans or educational materials in this report, please contact:

Arizona Ecological Services Office
U.S. Fish and Wildlife Service
201 North Bonita Ave, Suite 141
Tucson, Arizona 85745
(520) 670-6150
incomingazcorr@fws.gov