The Wild Felid Monitor

The Newsletter of the Wild Felid Research and Management Association

Summer, 2020, Volume 13, Issue 2

A New Widescale Survey of Wild Felids in United States

Jaguar Predation on Unique Prey in Nayarit

Multi-method Assessments of Occupancy and Trends of Jaguars and Bobcats

Spacial Relationships of Five endangered Felids and Their Prey in Costa Rica

And More

WFA website: www.wildfelid.org

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The Wild Felid Monitor

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The publication is provided to current Association members. To join, renew your membership, or to obtain back issues of the newsletter, please visit our website at *www.wildfelid.org*.

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Editorial Policy

The *Wild Felid Monitor* encourages submission of articles, information and letters on ecology, research, management and conservation of wild felid species, and particularly of those species native to the Western Hemisphere. Preferred length of submissions is about 750 words. Submissions of photos, drawings and charts are encouraged. ***Please send photos, graphics and tables as separate files suitable for portrait page formatting. Graphics must be suitable for grayscale reproduction.*** Electronic submissions to *wildfelidmonitor@gmail.com* are preferred; otherwise mail to the address above. For more information on formatting requirements, go to *http://www.wildfelid.org/monitor.php*. The WFA reserves the right to accept, reject and edit submissions. The photos and artwork are copyrighted – please do not reproduce without permission.

From the President

Mark Lotz

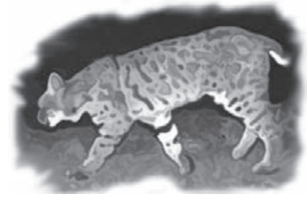
As much as I don't want to talk about Coronavirus, there is no ignoring it. And I would be remiss not to at least touch on something that has affected nearly everyone on the planet. I won't dwell on this long because, I, too, am tired of catch phrases like "a new normal." However, there is no denying that things have changed. I imagine your personal and work lives have been upended. And there's a good chance that you know someone who has been directly affected by Covid-19. I know this is the case for some of our WFA family and my heart goes out to them. Many of us are now working from home and have become Zoom experts (after learning what Zoom was in the first place). We're limiting our activities and contact with friends and co-workers. Travel and conferences were brought to a stand-still. The 13th Mountain Lion Workshop, originally planned for May 2020 in Hood River, OR, was postponed for a year and is now scheduled for April 12th-15th 2021. Hopefully, the situation improves and it won't be necessary to delay or cancel the workshop again. These disruptions to our lives even affected getting this newsletter out on time. I hope you can pardon this delay as people balanced home and work life. However, finding new ways to do things has led to more opportunities. For example, there seems to be a plethora of interesting on-line content available to a much wider audience now. We can attend things that were never made available before. Our concerns for the wild cats we work with were raised when we learned that tigers and lions at the Bronx Zoo in New York (USA) had contracted Covid-19. Biologists were quick to wear additional personal protective equipment (PPE) when working with study animals or to halt hands-on research altogether. The good news for wild felids is that cats seem to be poor hosts for the virus. However, caution is always warranted with a novel virus. I hope that each of you are staying safe during these difficult and unprecedented times.

I need to make a correction to my discussion in the last newsletter (Winter 2020) regarding WFA's formation. I inadvertently left out mentioning one of our founding members, Chris Papouchis. Not only was Chris there in the very beginning, he was also the first editor of The Wild Felid Monitor. My apologies, Chris, for that oversight.

A special thank you goes out our scholarship committee who has been hard at work and has selected three recipients for the 2020 Wild Felid Legacy Scholarship. This scholarship honors biologists that left us too early (*wildfelid.org/legacy*) and supports graduate level university students involved in wild felid research, primarily in the Western Hemisphere. Darby McPhail, Marlin Dart, and Camila Dunner are this year's recipients. Their research extends from the USA to Chile and looks into habitat management for bobcats in agricultural-dominated landscapes, often under-studied neo-tropical puma ecology and the interplay of carnivore response to anthropogenic disturbances and local conflict with subsistence livestock farmers. You can read more about their projects on page 6. WFA will continue to offer this important scholarship in future years, depending on funding. I want to extend my thanks to those members who have contributed to the scholarship fund; they have been a valuable source of support.

WFA ran a promotional Buy-One-Get-One membership for new members that ran through July. New members that joined for a year got a second year free. During the first year of membership, *The Wild Felid Monitor* is sent in traditional paper form. During the second year The Monitor is made available in PDF format. We generated several new members with this offer. In addition, we created a special reduced rate Latin American standard membership that includes the newsletter in PDF format. We also had a few members that sponsored student memberships. I would like to thank them and also extend a special appreciation to the International Society for Endangered Cats (ISEC), Canada who provided funds to sponsor 10 student memberships and 10 Latin American standard memberships. WFA is in the process of selecting those new members now.

A "snapshot" of wild felids is an appropriate invited article for this issue of The Wild Felid Monitor. Not only is Snapshot USA the title of the 2019 pilot study that compiled data across all 50 states into a standardized camera trap survey, but the articles in our Notes from the Field and Tools of the Trade also provide a snapshot of current research. It will be interesting to see the results of Snapshot USA as more data come in. We are also learning more about the diets of jaguars in mangrove forests in Mexico and ocelots in Peru, other factors that drive occupancy and detection of jaguars in Belize, bobcat trends in Oklahoma, USA, and how wild felids coexisting in fragmented habitats in Costa Rica may affect future conservation efforts. All of our research is a snapshot, really. It will take some time, but with enough snapshots we'll see the bigger picture.



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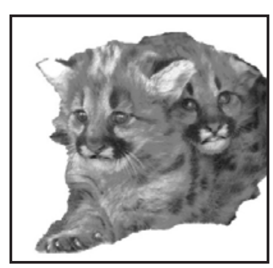
FOCUS: María Fernanda Puerto-Carrillo, Regional Representative-Venezuela

I was born in Guarenas, Miranda state, Venezuela. From my childhood my parents instilled in me love and respect for animals, and growing up, I became a lover of travel and began to understand the value of the different ecosystems that I visited. I understood that I had to study something that would unite my love for animals, travel and landscapes; that's why I studied Biology at the University of Zulia located in Maracaibo, a city where I had lived since I was 7 years old. During my university career, I had the opportunity to take courses and workshops on wildlife management and conservation, mainly threatened or little-known species that included big cats, cetaceans, sea turtles, and sharks, among others. In 2007, studying General Ecology, I decided to carry out a small project to learn about the diet of jaguars (*Panthera onca)* located in the southern region of Lake Maracaibo, Zulia state, and I discovered that this jaguar population had never been studied, despite being referred in the bibliography as one of the most critical populations in the country. It became, from that moment, my passion and research focus. I founded *Proyecto Sebraba*, a small NGO, with the goal of evaluating the situation of the jaguar and that of its natural prey, and to establish effective conservation programs for the protection of this species at least in Zulia state if not in the entire country. In 2013, I started my graduate work in Ecology at the Venezuelan Institute of Scientific Research (IVIC) in Caracas city, where I live currently, and obtained my Master's degree in Ecology this year. In addition to working with jaguars in the southern region from Lake Maracaibo, I am part of the research team of the *Sotalia Project*, an NGO in charge of studying the resident Guiana dolphin population (*Sotalia guianensis*) in Maracaibo Lake, and the *Caribbean Shark* project at the Center for Shark Research (CIT, acronym in Spanish), both in Venezuela. Recently, I was selected as one of the three winners of the Future for Nature Award 2020, a prestigious award given by the Future for Nature Foundation of the Netherlands, to young conservationists committed to the protection of species and ecosystems threatened worldwide.

*Nací en Guarenas, estado Miranda, Venezuela, y actualmente vivo en la ciudad de Caracas, que es la capital del país y se encuentra en la zona de la cordillera de la Costa, región nor-central de país. Desde mi infancia mis padres me inculcaron el amor y el respeto por los animales, y al crecer, me volví amante de los viajes y comencé a entender el valor de los ecosistemas de Venezuela. Por esa razón, entendía que debía estudiar algo que uniera mi amor por los animales, los viajes y los paisajes, por eso, decidí estudiar biología e ingresé a la Universidad del Zulia ubicada en Maracaibo, ciudad donde crecí. Durante la carrera universitaria, tuve la oportunidad de tomar cursos y talleres sobre manejo y conservación de fauna silvestre, principalmente especies amenazas o poco conocidas que incluyeron grandes felinos, cetáceos, tortugas marinas, y tiburones. En 2007 cursando la materia Ecología General, decido realizar un pequeño proyecto para conocer sobre la dieta de una población de jaguares en la región de sur del lago de Maracaibo, estado Zulia, y es cuando descubro que ha sido una población nunca antes estudiada y además, referida en la bibliografía como una de las poblaciones más críticas del país, convirtiéndose desde ese momento en mi foco de investigación. Fundé Proyecto Sebraba, una pequeña ONG, con la finalidad de evaluar la situación del jaguar (*Panthera onca*) y la de sus presas naturales, para enfocar esfuerzos y programas de conservación efectivos para la protección de esta población de jaguares. En 2013, inicié mi maestría en Ecología en el Instituto Venezolano de Investigaciones Científicas (IVIC) en la ciudad de Caracas que finalicé en 2020. Actualmente, además de trabajar con los jaguares la región de sur del lago de Maracaibo, soy parte del equipo de investigación del Proyecto Sotalia, una ONG encargada de estudiar la población de delfines estuarinos (*Sotalia guianensis*) residente del lago de Maracaibo, y del proyecto Caribbean Shark del Centro para la Investigación de Tiburones (CIT). Recientemente, he sido seleccionado como uno de los tres ganadores del Future for Nature Award 2020, un prestigioso premio otorgado por la Fundación Future for Nature de Países Bajos, a jóvenes conservacionistas comprometidos con la protección de especies y ecosistemas amenazados en todo el mundo.*



2020 Wild Felid Legacy Scholarship Recipients

This year WFA received 9 scholarship applications. The WFA Council is pleased to announce Darby McPhail, Marlin Dart, and Camilla Dunner as this year's recipients. Darby will receive the Deanna Dawn Scholarship award ($1500); Marlin and Camilla will each receive $1250. The decision was difficult given such a deserving group of applicants. WFA provided this year's scholarships due to generous support from an anonymous donor and WFA members. We thank all the applicants for their drive to understand, conserve and coexist with wild cats.

Darby McPhail, MS candidate, Virginia Tech; *dkm5ek@vt.edu*
Advisor: Dr. Marcella Kelly, *makelly2@vt.edu*
Thesis: The missing link: Determining puma densities to assess importance of meso-predator release versus umbrella species in a neotropical predator guild.
Objectives: 1) Produce spatially-explicit density estimates via spatial mark-resight (SMR) modeling for pumas across four sites in Belize incorporating habitat and landscape covariates. 2) Compare densities of jaguars, pumas, and ocelots, over 12 years to determine support for mesopredator release (MRH) versus umbrella species concepts (USC).
Darby explains, "My goal is to contribute to felid conservation by focusing on puma ecology. Pumas are overlooked in Neotropical research because most studies focus on jaguars. Yet, the puma might fill the "missing link" between jaguars and ocelots to address whether MRH or USC is more important structuring ecosystems. To date, ocelot density and survival have been completed for 12 years in Belize, and jaguar analyses are underway, yet no one has attempted puma estimates from the extensive data set. I plan to pursue a PhD and become a professor, where my goals are to inclusively disseminate knowledge to future generations, nurture passion for the natural world, and conduct research to ultimately further conservation of felids, while giving me a platform to empower women in this field. Dr. Kelly writes, "Her research plan to examine whether there is more support for jaguars as an umbrella species, or whether they suppress their closely related competitors, pumas, is compelling and exciting. While Darby has only been in graduate school since January 2020, it is clear that she is intelligent as she is on track to receive excellent grades in her first three courses. Darby is also diligent, highly empathic, focused, driven, and has the ability to overcome and problem-solve under extraordinary circumstances. She is committed to reaching out to women and unrepresented minorities to encourage them into STEM fields and has already mentored several such students."
Completion date: Spring 2022.

Marlin Dart, MS candidate, South Dakota State University; *Marlin.Dart@sdstate.edu*
Advisor: Dr. Robert Lonsinger; *Robert.Lonsinger@sdstate.edu*
Thesis: Influences of landscape patterns, land-cover features, and intraguild interactions on the spatial and temporal ecology of bobcats (*Lynx rufus*).
Research Objectives: Evaluate the influences of landscape patterns, land-cover features, and intraguild interactions on the patterns of occurrence of bobcats. Evaluate the influences of habitat loss and fragmentation on bobcat activity patterns and impact on competition with coyotes and potential for human-wildlife conflict.
Dr. Lonsinger writes: "Since starting his graduate research….Marlin has excelled in his coursework and has consistently displayed an impressive ability to learn and apply complex quantitative analyses with minimal guidance; his abilities in this area better reflect the levels expected of PhD students. He is currently enrolled in my advanced occupancy modeling course and …. has been regularly assisting other graduate students in understanding the modeling procedures…. This is not surprising, as Marlin regularly demonstrates a caring and compassionate disposition. Marlin has also demonstrated competence in the field, high integrity and care for data collection, and a positive attitude. His thesis focuses on better …manag[ing] agricultural-dominated landscapes in the Great Plains to promote bobcat conservation. Consequently, his research requires that he regularly interact with private landowners and obtain land-access permissions. Marlin has garnered broad support among local landowners…, a testament to Marlin's interpersonal skills. Marlin was a first-generation undergraduate student and succeeded despite considerable hardships (some of which required him to drop out of school for a period to assist his family in a time of emergency). Despite these hardships, Marlin remains a positive and inspiring individual."
Completion date: May 2021

Camila Dünner, PhD candidate, Andrés Bello University, Santiago, Chile; *cfdunner@gmail.com*
Major Advisor: Dr. Alejandro Simeone; *asimeone@unab.cl*
Dissertation: Humans and carnivores in the central zone of Chile: bidirectional responses in a growing interface.
Objectives: Evaluate the response of the carnivore community in the Metropolitan and Valparaíso Regions, Chile, to anthropogenic disturbance, as well as the human response to the local conflict that these species generate with subsistence livestock raising.
Camila writes: "I feel I have finally reached a point in my life where my dreams are becoming real. I have developed a more critical and holistic point of view of conservation, I have met amazing colleagues and my mind is now inspired with many new research ideas to achieve efficient conservation strategies. ….I aim to continue working nationally for our endangered cats, but also to collaborate with [other] international institutions……., sharing knowledge, experiences, passion and motivating future generations to get involved. …. Conflicts like the one we are studying have been widely recognized nationally but never characterized or quantified, therefore no mitigation measures have been proposed. Consequently, the lack of information results in a scarce allocation of resources from private and public institutions to face it. That is why scholarships like this can have an impact much bigger than just providing the necessary resources to complete vital objectives of the project. The scholarship could show the government that previous experiences and opportunities are out there, to generate the evidence they need to act with certainty and increase public awareness."
Completion date: December 2021

Thoughts on cougar research needs and goals

Harley Shaw

Some 56 years have passed since Maurice Hornocker began his seminal puma study in the Idaho Wilderness; 48 since I and a couple other state biologists began to mimic his work in places with different climate, terrain, vegetation, and prey. Since then, a host of new tools have become available to wildlife biologists: reliable radio-tracking equipment, satellite tracking capabilities, satellite imagery, foot snares, refined drug injection tools, trail cameras, remote tissue sampling and affordable genetic analyses, and smart phone technology. Creative application of drones is just beginning. On the whole, this surge of technology has helped answer questions, but it has also influenced the choice of questions asked and resulting direction of research.

Pumas have provided some surprises as new research tools were applied. They can live near humans more than we suspected, and some wander further than we would have imagined. They may interact with each other in nonbreeding situations more than we surmised.

But we still do not have an economical method to precisely estimate cougar numbers at a state or even management-unit scale, and we can't confidently monitor impacts of sport hunting or other forms of population control, especially impacts on the social structure and related behavior of populations. Our ability to gather and handle large volumes of data have improved immensely, but the data themselves remain predicated by the tools available to gather them. How often do researchers develop a question, then find a unique process to answer it? Conversely, how often are they diverted from their initial questions by the limitations or capabilities of technology?

Application of advanced technology may be beyond the training or time available to district wildlife personnel who are responsible for gathering data on the ground. In spite of the geometric increase in research on cougars during the past 50 years, the information resources available to the district manager remain estimated sport harvest and associated data, predator control results, and extrapolation of research from limited areas that may not apply broadly–or simply seeking local conventional wisdom, and following gut feelings. As district level recommendations move up the line, they are moderated by supervisors, commissioners, citizen pressures, and politicians. Even "experts" who are consulted may be selected on the basis of known prejudices. Ultimately, the "lore" of a species influencing its management may bear little resemblance to cutting-edge, objective, knowledge.

To me, the ultimate goal of research should be to modify the way that citizens, including personnel of agencies, interpret the information they receive via their own daily experience. In the case of species such as the puma, this might be seen as modifying the human cultural perspective. This is something deeper than education. At any point in history, we begin with the existing lore of a species. For pumas, the pinnacle of lore at the time Hornocker started his research resided in the knowledge and skills of the houndsmen. Their knowledge was based upon extensive and detailed experience from hunting and killing the species, and few in their larger community questioned their knowledge. When the time came to bring science to bear, biologists wisely sought out the Wilbur Wiles, George Goswicks, Frank Smiths, etc. to show us how to catch the critters. Days afield with such individuals gave us a view of puma lore. What we had to add was new technology and reframed questions. The lore of the houndsman might be considered our first working hypothesis. Once we began to develop a body of new data, using new tools, our perspective regarding factors affecting puma populations and impacts of pumas on prey shifted and we began to develop new hypothesis. Having spent most of my adult life in smaller communities away from university campuses and agency headquarters, I'm constantly made aware that all of the high tech work we've done hasn't changed everyone's mind. In fact, many people living closest to the land take a certain pride in resisting new knowledge created by the "intelligencia." That is, while we romp ahead with scientific facts, the lore on the land changes slowly, if at all. Such change can take generations and may even resist going in the directions supported by evidence.

Although assessments of public attitudes toward species crop up now and then, I'm not aware of any effort, perhaps by a historian, to evaluate the long-termed effects of new knowledge on a culture's perception of a species, or of wildlife in general. Given recent politics and trends in land use, such a study might well suggest that American wildlife lore is not traveling in the same direction as science. Perhaps we preach only to ourselves and a small, ineffective scientific choir? So much of ecological research amounts to the study of effects of x (name the factor) on y (name the biological trait). Perhaps it's time for a study wherein x is the history of our efforts and y is the broad-based attitude, ergo lore, of the affected culture.

Invited Article

A snapshot of wild felids in the United States: Results of the first coordinated camera trap survey and how you can participate in 2020

Michael Cove, North Carolina Museum of Natural Sciences, Raleigh, NC *mvcove@ncsu.edu*

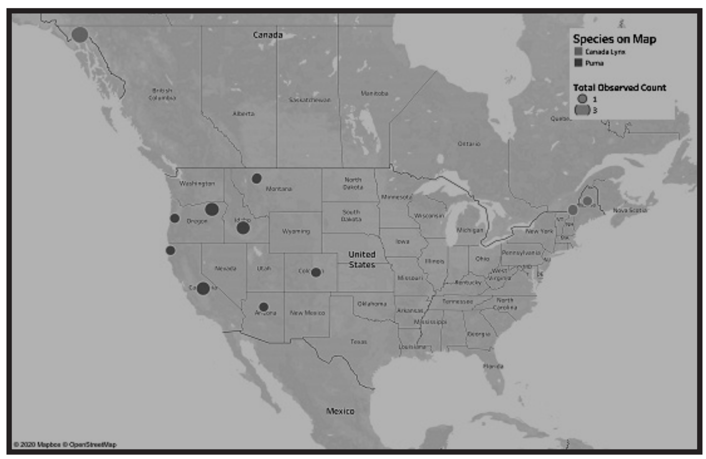
Puma from Snapshot USA site in central Colorado, Courtesy of Dr. Kellie Kuhn, US Air Force Academy.

Expansive landcover change, climate change, new and emerging diseases, environmental toxicants, and human-wildlife conflict are all causes for concern for carnivores (Ripple et al. 2014). Indeed, many North American carnivores were nearly extirpated a century ago, but continued protections and productive management has helped spark regional and even national population recovery for many species. Yet, with new threats and rapid changes on the horizon, we need near-real-time inventories of wildlife for effective management and conservation planning. Wild felids are no exception to these trends and causes for concern, but recent expansion and apparent recovery of some populations also brings hope for the future of North America's cats.

Wild felids, like many carnivores, are elusive, cryptic, and wide-ranging, which are all traits that contribute to the difficulty of surveying their populations. Fortunately, we have expanded the use of non-invasive surveys to strengthen our inferences when tracking wild felids, either via camera trapping, scat surveys paired with genetic analyses, or classic tracking surveys (Long et al. 2008). Camera traps have become among the most popular survey methods for wild felids, especially those that can be individually identified, because they provide insights into the abundance and distribution of the cats and their potential prey and competitors. These data can provide timely information about the distributions of many species, but there are still gaps in our knowledge due to the lack of data. Although most surveys are done at the local and regional scale, we know that many felids occur across larger landscapes than those surveys. In 2013, the eMammal platform (*https://emammal.si.edu/*) was developed at the Smithsonian Conservation Biology Institute to help manage and create a repository for camera trap data to help better track the distribution of wildlife. The platform now hosts over 100 projects with over 1 million detections of wildlife from around the world. However, there had never been a nationwide coordinated wildlife survey of the United States until we completed a pilot study in 2019 called 'Snapshot USA'.

The Snapshot USA project is led by Dr. Bill McShea from the Smithsonian Conservation Biology Institute, and Dr. Roland Kays and myself, both of the North Carolina Museum of Natural Sciences. In our first years' effort, we worked collaboratively with over 150 cooperators to compile data across all 50 states during a 14-week period (17 August - 24 November of 2019). We sampled wildlife at 1530 camera trap sites from 109 survey arrays covering 12 different ecoregions across four development zones (urban to wild). This effort resulted in 165,426 unique detections of 80 species of mammals, including pumas (*Puma concolor*), Canada lynx (*Lynx canadensis*), bobcats (*Lynx rufus*), as well as important prey and competitor detections. All images were processed through the Smithsonian's eMammal camera trap data repository and included an expert review phase to ensure taxonomic accuracy of data, with all pictures reviewed at least twice. The results of this survey are the first standardized camera trap survey of the USA, and possibly the largest mammal assessment of its kind. All of the 2019 survey data are publicly available as part of a forthcoming data paper and through eMammal (*https://emammal.si.edu/analysis/data-download*). So what did we find out about our wild felids?

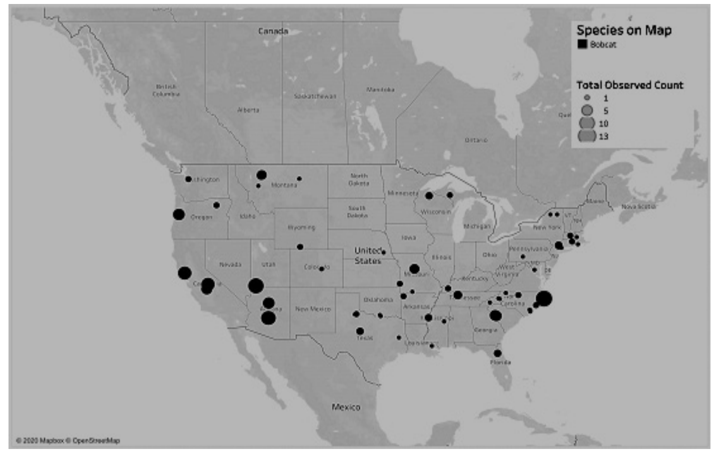
With the largest global distribution of all the Western Hemisphere felids, pumas are often associated with pristine wilderness across North and South America. However, they have also recolonized



anthropogenic landscapes from the urban forests of southern California to some of the agricultural landscapes of the Midwest, highlighting their potential adaptability, if the prey base is there. Pumas were detected 29 times at nine of the 109 camera trap arrays resulting in a naïve occupancy of 8% of sites occupied – all in the western United States. While most of these arrays were within large forest tracts and ranchland mosaics, some observations came from just outside of urban sprawl in central California and coastal Oregon. All of these sites showcased abundant mule deer (*Odocoileus hemionus*) detections and some exhibited even higher detections of white-tailed deer (*Odocoileus virginianus*) as well. While all of the puma observations were in the western US, that was not unexpected given their prominence in the region, both historically and contemporarily. However, we might expect to see more pumas in future iterations of Snapshot USA, particularly as their populations expand eastward and potentially track reintroduced elk (*Cervus canadensis)* populations and abundant white-tailed deer populations east of the Mississippi River (LaRue et al. 2019).

Canada lynx were detected 8 times at three of the 109 camera

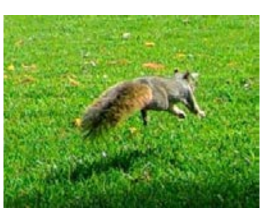
Canada lynx from Snapshot USA site in northern New Hampshire. Courtesy of Jillian Kilborn, New Hampshire Fish and Game, and Dr. Alexej Siren, University of Massachusetts.



arrays in the northeast – Maine and New Hampshire, and in Alaska, resulting in a naïve occupancy [*Naive occupancy in this sense is the proportion of camera arrays where we detected the species of interest and they are known to be present with certainty, but we must also acknowledge that cats are elusive and there remains the possibility that the species is present but undetected by the cameras during the surveys. Eventual analyses of these data will explicitly estimate and account for this detection probability bias.*] of just 3% of sites occupied. Although this occupancy rate is low, it is encouraging because the vast majority of lynx habitat occurs to the north of the United States and they are suggested to only occur in suitable habitat in a few of the northernmost states (e.g., additionally Washington, Montana, and Minnesota) and Colorado where they were reintroduced. Camera trap sites in New Hampshire and Maine were also among sites with the highest counts of snowshoe hare (*Lepus americanus*) detections, although no hares were detected in Alaska, likely due to some inherent sampling bias at those sites. Other sites including those in Montana and Minnesota also exhibited high snowshoe hare densities, suggesting that there is a healthy prey base if lynx disperse and colonize these sites. We hope to gain more detections and better estimate the distribution of this felid as we target additional northern sites for camera array expansion in 2020.

Arguably the most successful of the native North American cats, bobcats were detected on 352 occasions across 51 of the 109 camera trap arrays (naïve occupancy of 47% of sites). The only larger carnivore that was more commonly detected than bobcats was the coyote (*Canis latrans*) with a naïve occupancy of over 90% of sites. Interestingly, we observed co-occurrence among the two mesocarnivores at all but two of the sites with bobcats, particularly in the eastern US, suggesting that they are mutually benefitting from the rarity of apex predators in that portion of the country and that they may benefit from high resource subsidies leading to high densities of lagomorphs, rodents, and seasonal fawns. Some of these camera detections have showcased that bobcats have expanded into areas where they were not previously considered to occur, even in areas with high densities of humans and urbanization. For example, the first bobcat was detected within the nation's capital as part of the D.C. Cat Count and Wildlife Survey that contributed data to the Snapshot USA project. Similarly, bobcats were detected at camera trap arrays in Connecticut, Massachusetts, and southern New York – all high human population areas where bobcats were historically extirpated. We obtained relatively few bobcat detections in the Midwest and Great Plains – areas where they are slowly recolonizing historical habitat, but still tend to occur at low densities. However, this could also be the result of a combination of low-density populations and less camera trap coverage compared to other parts of the country, particularly given some of the sparse sampling of our camera traps in those regions. While the current data are presence/absence across the 1530 camera trap sites, future researchers might benefit from reviewing the raw photos themselves and identifying individual bobcats based on their unique spot patterns to better estimate population densities across the entire country (*sensu* Heilbrun et al. 2006).

We are already coordinating to repeat surveys in September-October, 2020 and we offering the opportunity to other institutions and cooperators, particularly other wild felid biologists, to expand coverage of all the urban-wild gradients and ecophysiographic regions of the country. We are flexible with participation and contributions, so if you can contribute a subset of ~400+ camera trap nights from 10-20 locations in your study area, then please feel free to join the growing list of cooperators from all 50 states. While our goal is to make a public wildlife database for all to use for better ecological inference, conservation planning, and public outreach and engagement, we also strive to make this opportunity work with everyone's ongoing projects and only ask for a subset of data to avoid any concerns about giving away all data to avoid competing interests with their own research. If you are interested in participating and contributing some of your camera trap data please contact me (*mvcove@ncsu.edu*) and register *eMammal.si.edu/snapshot-usa*. We are also on social media with the hashtag #SnapshotUSA – lot's of great photos available from 2019 surveys. The contributor network is growing to help fill in gaps from our pilot survey in 2019 and these data will be available and useful for local and macroecological research including the examination of effects of environmental and anthropogenic factors, effects of fragmentation, as well as estimating species-specific population dynamics and conservation action plans for all of the nation's wild felids. Thanks again to all of our many cooperators and partners and we look forward to sharing more with you in the future!



In 2019 over **100 collaborators** across **all 50 states** collected more than **100,000 detections of 82 mammal species**.

Snapshot USA

Snapshot USA is recruiting more organizations and researchers from across the nation to help us capture the amazing diversity of wildlife inhabiting the United States

- **Who**: Ecologists from universities or organizations who will collaborate on this national survey.
- **What**: Using camera trap images and metadata to track relative abundance and distribution maps for significant wildlife species.
- **When**: Deployments during September and October 2020.
- **Where**: Anywhere across the 50 United States.
- **How**: 400 camera nights of effort (7 to 40 camera traps); data submitted to eMammal.si.edu.
- **Interested**: To learn more and register visit our website at http://emammal.si.edu/snapshot-usa

Images from: Urban to Wild Project; North Carolina's Candid Critters Project; Smithsonian BioAcoustic Monitoring Project; Montana Range Survey; Montana Range Survey; APR Prairie Dog Towns Project; Fresno Mammals Project
Logo by: Dan Herrera (@HerreraWildlife)

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NCMNS

Brazil

Based on IUCN methodology and built upon participation of several sectors of society, National Action Plans (NAPs) are tools for public policies, planning, and prioritization of conservation actions directed to species and natural environments. NAPs are official instruments lasting for five years, which can be renewed in case threats are still occuring. Since Brazilian small cats face several common threats, at the end of 2019, Brazil's Chico Mendes Institute for the Conservation of Biodiversity (ICMBio) coordinated the elaboration of the 2nd cycle of the NAP for the Conservation of Small Cats.

This NAP includes six species threatened at the national level, including the critically endangered Northern tiger cat (*Leopardus tigrinus*), and five vulnerable species: jaguarundi (*Herpailurus yagouaroundi*), pampas cat (*L. colocolo*), Geoffroy's cat (*L. geoffroyi*), Southern tiger cat (*L. guttulus*) and margay cat (*L. wieddi*). Largest threats to these species are vehicle strikes, killing and capturing of cats, poaching of prey, habitat degradation and knowledge gaps linked to species conservation.

The 2nd cycle was attended by 32 people from 22 institutions and has the following general objective: "To promote and integrate actions for mitigating threats and increasing knowledge on small cats populations, aiming to reduce their extinction risk in five years." This general objective was divided into six specific objectives, comprising some 40 actions. Charismatic, small cats are less studied than other threatened felids and, some of the proposed actions aim to increase disclosure of information regarding small cat conservation issues to the general public.

The document will soon be available online at the ICMBio official webpage: *https://www.icmbio.gov.br/portal/faunabrasileira/plano-de-acao-nacional-lista/2835-plano-de-acao-nacional-para-a-conservacao-dos-pequenos-felinos.* ~Marina Portugal

~Henrique Villas Boas Concone

Costa Rica

As a laboratory for innovation in environmental conservation, Costa Rica encourages public and private organizations to collaborate under a reframed policy promoting human-wildlife coexistence. Here I summarize some of the recent and ongoing initiatives for research and practice on wild felid conservation. Contacts of persons in charge are included for further reference; please note this list is not exhaustive and many valuable projects are not included due to communication lags.

Policy news: In 2019, the Ministry of Environment signed an agreement with the National Insurance Institute to cover felid damage via a renewed livestock insurance scheme (Damian Martinez, Ministry of Environment, *dmartinez@minae.go.c*r). Many technical challenges are yet to be resolved, such as the acceptability and intention of stakeholders to purchase insurance (Lizeth Corella, student at National University UNA, *lissce20@gmail.com*). Based on data generated by Coastal Jaguar Conservation, the zone of absolute protection of Tortuguero National Park was extended to protect jaguar habitat (Stephanny Arroyo Arce, Coastal Jaguar Conservation, *sturnina@gmail.com*). The Ministry of Environment also convened a working group of experts to complete the long-awaited action plan for jaguar management this year (2020).

In 2015, Adolfo Artavia (independent researcher, *adolfo.artavia@gmail.com*) identified challenges that continue to plague wild felid monitoring, including the need for better information sharing and standardization. A GIS analysis followed in 2018 (Manuel Spinola, National University UNA, *mspinola10@gmail.com*). Since 2015, Jaguar Osa, a collaborative research and monitoring project between Northland College and ACOSA-National System of Conservation Areas (SINAC), has assessed terrestrial wildlife of Corcovado and Piedras Blancas National Parks. Recently, the project identified one of the oldest recorded wild jaguars (Erik R. Olson, Northland College, *eolson@northland.eduand* Guido Saborío-R., ACOSA, *guido.saborio@sinac.go.cr*). Park rangers from Corcovado have also been recording mammal tracks since 2013. Corcovado NP contains healthy mammal populations, including charismatic species such as jaguars and white-lipped peccaries; however, poaching and goldmining are still important concerns.

Panthera conducted camera-trapping projects with other collaborators from the private sector and SINAC from 2011 to2019 in several areas in the country: Braulio Carrillo National Park, Maquenque, San Juan-La Selva, Barbilla-Destierro, Cordillera Volcánica Central Reserve, Barbilla National Park, Golfo Dulce Reserve, Montes del AguacateandTortuguero National Park (Roberto Salom-Pérez,Panthera, r*salom@panthera.org*). The project "The Golden Shadow" by Tico's Wild Studio has monitored the Osa Peninsula since 2014, resulting in more than 100 records of at least 7 different jaguars (Tico Haroutiounian, photographer, *ticoharoutiounian@gmail.com*). Coastal Jaguar Conservation has a long-term monitoring program (2005-present) examining the relationship between jaguars and sea turtles in Tortuguero National Park (Ian Thomson, Coastal Jaguar Conservation, *ianitthomson@hotmail.com*). The Gente y Fauna Program has used camera traps to document human-felid interactions around rural towns in Siquirres, Guatuso, Bagaces and Upala (Natalia Valverde-Zuñiga, Gente y Fauna, *nat.valverde@gmail.com*).

In a collaborative project titled "Wild Felid Genetics", Panthera and the Conservation Genetics Lab at University of Costa Rica collected around 1300 biological samples, all possible feces, blood, hair, tissue (2002-present) from the 6 different felid species in the country. Products include 5 theses, 6 scientific papers and one manual. Panthera's tracking dog has detected around 400 feces, mainly jaguar and puma, within the country (Stephanny Arroyo Arce, *sarroyo@panthera.org*; Gustavo Gutierrez, *gutierrezespeleta@gmail.com*). Highway impact monitoring on routes relevant to felid landscape connectivity is being conducted through a joint effort by Panthera, Ministry of Public Infrastructure and Transportation, Group Vías Amigables con la Vida Silvestre, CCT, APM Terminals, Ministry of Environment, California 49, Tilajari, and Península Papagayo y RECOPE (Daniela Araya-*Gamboa,daraya@panthera.org*). The project will help identify wildlife crossings and infrastructure placement. Since 2013, more than 200 ocelots have been killed on roads; the national database on road kills was developed by Panthera, Las Pumas Sanctuary and Rescue Center, Group Vías Amigables con la Vida Silvestre and SINAC (Vías Amigables con la Vida Silvestre, *vavscr@gmail.com*).

Since 2013, documented human-felid interactions have been mainly attended by the Felid Conflict Response Unit (UAC Fel) as part of the agreement between the Ministry of Environment and Panthera. Public officers were trained to provide technical assistance on livestock predation prevention

(Angie Sanchez Nuñez, SINAC, *angie.sanchez@sinac.go.cr*). In one of the top conflict sites, there has been no recorded livestock predation in the last 12 months (Las Lomas de Tortuguero, from February 20, 2019 to-January 20, 2020; Daniel Corrales-Gutiérrez, *dcorrales@panthera.org*). Coastal Jaguar Conservation produced informative materials entitled "Protocol of Conduct: What to do in case of a jaguar encounter in Tortuguero National Park?" (Stephanny Arroyo Arce, *sturnina@gmail.com*).

Finally, community-based strategies are emerging for reducing conflict and promoting local wildlife governance. The Centro Socioambiental Osa leads a project titled "Community-based Jaguar Conservation in Osa Biological Corridor"; the project studies conservation from local people's actions related to jaguars. Social and biological data combine to identify important connections between Osa and the highlands of Talamanca (Roberval Almeida, researcher, *centrosocioambientalosa@hotmail.com*). The Gente y Fauna Program developed a project called "Welfare for Coexistence with Jaguars and Pumas" where participant communities at "conflict hotspots" in Upala become entrepreneurs under a green label (AMIGOS DE FELINOS) that represents how local production integrates wildlife protection and monitoring, and provides benefits to families coexisting with felids.

~Ronit Amit, *jaguar.rar@gmail.com*

Panama

Kaminando's habitat connectivity initiative began in 2016. It assesses the effects of forest fragmentation on the dispersal of felid and prey species in the narrowest section of Panamá. Kaminando's research focuses on jaguar survival within a tropical montane cloud forest ecosystem, home to high biodiversity and endemism. The study area encompasses three land tenure types with different conservation priorities: 1) the Mamoní Valley, 2) the eastern section of Chagres National Park, and 3) the south end of the Narganá Wildlands, part of the Guna Yala Indigenous Territory.

Kaminando's research aims to understand the determinants of jaguar demography and habitat selection. The jaguar is considered threatened throughout its range and endangered in central Panamá. Three anthropogenic pressures threaten the species: habitat loss and fragmentation due to the expansion of the agricultural frontier, the decline of prey species due to illegal poaching, and increasing human-jaguar conflict resulting in the retaliatory killing of jaguars.

Kimberly Craighead, as part of her dissertation research at Antioch University New England, used a multiscale optimization analysis to study factors that determine seasonal jaguar distribution. Since habitat selection is scale-dependent, Craighead focused on identifying the optimal scale(s) in space and time at which jaguars interact with their environment. By applying presence/absence records derived from systematic, long-term monitoring with camera-traps, and applying the most relevant predictor variables to build habitat suitability models, Craighead tested for: 1) the predictor variables that most strongly influenced jaguar habitat selection and the optimal scale of each variable, and 2) seasonal differences in habitat. Her results will inform conservation and management decisions for the jaguar in one of the most critical regions of Panamá.

Craighead's study has prompted recommendations for three further research objectives: 1) validate the habitat suitability models throughout the country, 2) determine the viability of wildlife corridors in the stepping-stone landscape of the Mamoní Valley and assess connectivity with adjacent protected areas (Chagres National Park and Guna Yala Indigenous Territory), and 3) place GPS-collars on jaguars in the region to follow their movements in fragmented habitats, identify corridors and priority areas for conservation, and mitigate human-jaguar conflict.

Since its commencement, this program has gained support in the local community. To achieve lasting conservation of the cloud forest and its biodiversity in the region, Kaminando is developing practical, economically sound solutions to mitigate forest degradation and illegal poaching while building upon the community's inherent appreciation of the forest and its ecological value.

~Kimberly A. Craighead

Venezuela

The research of wild cats in Venezuela began decades ago; this can be verified through the diverse and numerous scientific articles available, especially refereed articles. However, the publication of books and compendia have been limited, and the existing information dates back more than 20 years. Two examples include The jaguar: American tiger published by Hoogesteijn & Mondolfi in 1992 and Felines de Venezuela: Biology, ecology and conservation compendium published by FUDECI in 1992.

Updating of scientific data depends on advances in research, and when it comes to threatened species that face increased survival challenges, there is an urgent need for current scientific information that allows planning and executing conservation actions. For this reason, Alberto Blanco-Dávila (*blancoalb@gmail.com*), Executive Director of the EXPLORA Nature Projects Group (*https://www.exploraprojects.com/*) along with other renowned scientists who have worked for decades in the study of wild cats in Venezuela, elaborated the compendium Felinos de Venezuela under the adage of "you love what you know and you take care of what you love" and based on the slogan of the editorial: "Knowing is Conserving". This work has updated information on natural history, ecological requirements, conservation, current status and anecdotes typical of the Venezuelan culture of the species of wild cats present in the country: *Panthera onca, Puma concolor, Leopardus pardalis, Leopardus wiedii, Leopardus tigrinus, Herpailurus yagouaroundi*.

Blanco-Dávila, who is one of the two editors of this book, points out the importance and the need to continue studies on this important group of carnivores due to their role as architects within the ecosystems they inhabit. Their disappearance could have a negative impact within these natural environments, generating an increase in infectious diseases for both wild animals and domestic species, which can also have an impact on humans. In turn, Blanco-Dávila recognizes such documents contribute to the recognition of the current status of these species, and can be used to help evaluate these species at regional and international levels. Although this book has been written and revised successfully, due to lack of funds has caused a delay in printing. However, the publishers and authors have not lost hope and are working to find sponsors so they can finish their important work.

~María Fernanda Puerto-Carrillo

Arizona

A new PhD student in the Koprowski lab at the University of Arizona, Ganesh Marin, will focus his dissertation on this subject of movement, dispersal and connectivity at the Arizona-Mexico border. The northeastern corner of Sonora, Mexico is important for jaguars, ocelots and black bears that use riparian forest and mountain ranges to move along the Sky Islands and Marin's study area includes a ranch called Cuenca Los Ojos which covers 52,000 hectares. Cuenca Los Ojos has been dedicated to conservation since 1990 with the principal aim to preserve Cajon Bonito creek, which is the principal water source of the region and one of the last conserved rivers in northwest Mexico. Cajon Bonito creek is the home of vulnerable and endangered amphibian and fish species that depend on the permanence of this water flow. Furthermore, in 2019 a team of researchers documented in Cajon Bonito the presence of four endangered species of mammals in Mexico: American beaver, black bear, ocelot, and jaguar.

Despite the ecological uniqueness of Cuenca Los Ojos area and Cajon Bonito creek, human activities have a strong impact in the region. One of these impacts is represented by the vehicle barriers that have existed since 2008 in many protected natural areas in the USA-Mexico borderlands. The current expansion of the border wall and additional fences is making this area less permeable for wildlife movements between the countries. Additionally, the Mexican Federal highway No. 2 was recently expanded to four-lanes during 2018, posing a risk for wildlife.

In this context, the main focus of Marin's Ph.D. is to assess how the diversity and habitat use of mammals change along this modified but biodiverse landscape. His research will generate models for habitat connectivity of mammals, focusing on felids and black bears. These models will also help to identify priority sites to mitigate the impact of the highway and the border wall. For more detail information, contact Ganesh Marin – *ganeshmarin@email.arizona.edu*.

~Marianela Velilla

Montana

Researchers at Montana Fish, Wildlife, and Parks (MTFWP) and Montana State University (MSU) are completing final analyses on a study describing the effects of cougar harvest management on cougar population abundance and elk calf recruitment. In 2012, MTFWP implemented cougar harvest regulations designed to reduce cougar populations and increase elk calf survival in portions of west-central Montana using a before-after-control treatment approach. A main project goal is to estimate cougar population abundance in a treatment (Bitterroot) and control (Clark Fork) area before and four years after the higher harvest quotas were implemented. To date, researchers have estimated a cougar population of 72 animals (90% CI = 47, 105) within their control study area, corresponding to a density of approximately 2.1 cougars/100 km^2 (90% CI = 1.4/100 km2, 3.1/100 km^2). This abundance estimate in the control area was similar between December 2013 and December 2017, suggesting that the management objective of maintaining a stable cougar population in the control area was achieved. Researchers at MSU have also found that increased harvest quotas of cougars coincided with increases in elk calf survival. These increases were short term, with elk calf survival rates falling to intermediate levels after 4-5 years. These modest long-term effects on elk calf survival may be a result of cougar predation being partially compensatory, and sustained periods of decreased cougar predation resulted in increases in mortality from other causes. They suggested that increased cougar harvest may be a favorable option for wildlife managers considering short term relief for ungulate recruitment, but that it may not be a sustainable strategy. Final analyses, reports and manuscripts for this study are set to be completed later this year.

~Jennifer Feltner

Oregon

Elizabeth Orning (Dugger lab, Oregon State University) completed her PhD in 2019 on the interspecific relationships between cougars and recolonizing gray wolves in northeastern Oregon. The research, in coordination with Oregon Department of Fish and Wildlife (ODFW), identified several aspects of cougar predation and space use that changed post-wolf recolonization. For example, female cougars killed fewer mule deer in summer, had lower summer kill rates, lower biomass intake rates, and longer search times relative to female cougars pre-wolf colonization. Additionally, the spatial distribution of cougar predation sites changed after wolves recolonized such that cougars killed prey at higher elevations and closer to water after wolves returned to the landscape. Finally, cougar movement rates were lower post-wolf recolonization, and cougars shifted their activity patterns such that they were less active at night and more active during morning. Female cougars also selected for less open habitats in winter. Dr. Orning's research will help guide management of predators and prey as the state continues to undergo a restructuring of its carnivore community.

Joel Ruprecht (Levi lab, Oregon State University) continues his dissertation focusing on multispecies carnivore monitoring and interactions in collaboration with ODFW. He evaluated whether cougar, bobcat, black bear, and coyote population densities are most efficiently estimated using remote cameras and mark-resight methods versus genetic capture-recapture methods. He is currently evaluating the complex tradeoffs of risk versus reward when mesopredators scavenge cougar kills.

ODFW is monitoring cougars in two wildlife management units (WMUs). Researchers in the Alsea WMU are deploying GPS collars and using bio-darting to collect genetic samples for population density estimation. In the Starkey WMU, researchers continue to monitor cougars using GPS collars and have deployed over 200 remote cameras to analyze occupancy relationships between cougars, bobcats, and coyotes.

~Joel Ruprecht

Utah

In January 2020, the Utah Division of Wildlife Resources (UDWR) announced an emergency change to their cougar management goals. They announced increases in cougar harvest objectives by 117 over 11 hunt units throughout the state. The increased quotas are in response to struggling mule deer populations and in hopes of stabilizing declining mule deer herds in areas where cougars are their primary predators and have also been hit hard by either heavy winters or drought seasons. In August 2019, UDWR set cougar hunting permits at 690, which was an increase of 46 and the 4th consecutive year of permit increases. The cougar population in Utah is estimated to be over 2500 adults in 2019.

~Sarah Hegg

Wyoming

Scientists from the Panthera Puma Program, the Teton Cougar Project and the University of California, Davis reported findings on the prevalence of plague (*Yersinia pestis*) in a cougar population in Northwest Wyoming, in a study recently published (March 2020) in the journal Environmental Conservation. Over the nine years of the study, they detected antibodies to *Y. pestis* in 8 of 17 (47%) cougars, and the bacteria itself in 4 of 11 (36%) cougars tested during necropsy. This prevalence of cougar exposure to plague was similar to that found on Colorado's western slope adjacent to the Four Corner's region which is considered the plague hotspot in the USA. The study found that plague was a significant source of mortality for local cougars (nearly 7% of sub-adult and adult mortalities), but that at least one cougar appeared to survive repeated exposure to the disease (multiple positive tests over the span of years) with no apparent disease symptom development. The studies authors' believe that cougars likely contracted plague from eating infected rodents or other carnivores that eat rodents. Their findings suggest that plague may be present at higher levels in Northwest Wyoming than previously thought, and that hunters or researchers handling cougars in the region should be made aware of the risk of exposure. At least one case of a human infected by the plague in the region was documented over the course study, and an Arizona biologist died of plague he contracted from a necropsied cougar in 2007.

A team of researchers from Utah State University and Yellowstone National Park recently published a study (August 2019) in the journal Ecology Letters examining elk response to predation risk from cougars and wolves in Yellowstone National Park over the course of four years. They reported that elk selected for areas outside the high-risk hunting domains of both cougars and wolves, enabling elk to avoid one predator without necessarily increasing their exposure to the other. The study's authors further reported that elk seemed to respond most strongly to risk of predation from male cougars, rather than wolves, contrary to the generally held notion that wolves exert the most influence on elk habitat selection via predation risk in systems where other large carnivore species are also present. The authors suggest that ecologists should pursue a multi-predator, spatiotemporal understanding of predator-prey interactions to better understand carnivore-ungulate dynamics in systems with a diverse large carnivore guild.

~Jennifer Feltner

Alberta

After the Alberta Tree Hound Association raised concerns about the possibility of harvest rates driving down the age structure of the resident cougar population, Alberta Environment and Parks (AEP) committed to re-evaluating cougar abundance in the province. Habitat-use patterns of GPS-collared cougars (n=79) monitored from 2016 to 2019 were used to determine the total area of viable habitat within each cougar management area (CMA) and multiplied by regional cougar densities (ranging from 0.2 to 4 cougars per 100 km^2) to yield a provincial population estimate of approximately 1,600 cougars. Although this number aligns closely with the province's goal of maintaining a minimum population of 1,500 cougars, similar methods estimated 2,050 individuals in 2012. This apparent decline prompted AEP to reduce quotas in 19 of 32 CMAs across the province (Alberta Environment and Parks, 2020). Specific quota reductions were assigned to ensure adult harvest rates within each CMA were either at or below the assumed population growth rate of 14%, reported by Beausoleil et al. (2013) for cougars in Washington. Reducing the maximum annual harvest by 27%, these quota reductions should promote an older age structure and more socially stable population, resulting in fewer conflicts with humans (Teichman et al. 2016; Beausoleil et al. 2013). The province will continue monitoring human-caused cougar mortality to inform future quota adjustments and to test the predictions of the social stability hypothesis.

In a regressive move from previous commitments to protected area management, the provincial government has announced plans to remove 175 of 473 sites from the Alberta Parks system, including 16 provincial parks and 9 natural areas (Government of Alberta, 2020). The proposed changes will remove legal protections from public lands and risk compromising the integrity of Alberta's protected area network by enabling the leasing or sale of park facilities and assets to private partners for extractive industries and commercial development. The announcement was made without any public consultation and has been opposed by the vast majority of Albertans (Canadian Parks and Wilderness Society, 2020).

~Mitchell J. Flowers

British Columbia

While the first official management plan for cougars is being updated after previous drafts failed to be approved in 2012, the province assessed the feasibility of using statistical population construction (SPR) for assessing population trends of cougars from 1991 to 2015. The modelling platform PopRecon 2 was used to pair age-at-harvest and hunter effort (i.e. days spent hunting) with auxiliary data on survival rates to estimate the abundance of ≥1-year-old male and female cougars. Age-at-harvest was determined from teeth collected during mandatory inspections and hunter effort was measured from voluntary questionnaires. Regional population trends were highly variable and only the most reliable estimates from the Kootenay Region were subject to model verification and tested for correlation with other harvest indices to determine their utility in monitoring population trends. Abundance estimates were most highly correlated with cougars killed per hunter effort ($r = 0.66$), mean age of total males harvested ($r = 0.63$), and proportion of ≥ 6-yo cougars harvested ($r = 0.63$). Reliability of the SPR estimates would be improved by increasing the number of harvested cougars that are aged (currently ranging from 21–78%) and accounting for cougars killed in wildlife conflicts, incidental trapping, and vehicle collisions (Hatter, 2019).

British Columbia is the only province in Canada with a pursuit-only season, allowing hunters to track and tree mountain lions (without carrying firearms) after reaching annual bag limits. Currently practiced in the Kootenay Region and proposed in the Okanagan, the pursuit-only season was intended to provide houndsmen with exercise and training opportunities for their dogs. The regulation has drawn considerable opposition from several wildlife advocacy and conservation organizations (Rainforest Conservation Foundation, 2010). The proposed removal of this regulation, described as an "illegitimate wildlife use", has since been requested by the Provincial Hunting and Trapping Advisory Team (Government of British Columbia, 2020). Public commenting on the regulation removal ended in January 2020 and the decision is pending.

~ Mitchell J. Flowers

Predation events of the jaguar (*Panthera onca*) recorded with camera traps in mangroves of Nayarit, western Mexico

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Abstract

The jaguar (*Panthera onca*) is an opportunistic predator whose diet is based on the prey that are most available in the ecosystems in which it lives. In Mexico, studies have been conducted on their diet in various ecosystems, excluding mangroves and western wetlands. We report 9 photographic events, evidence collected by camera traps, of prey (4 mammals and 3 birds of which 2 are novel species: the white heron *Ardea alba* and American stork *Mycteria americana*) captured by jaguars in mangroves and marshes in a highly anthropomorphic altered landscape of the Coastal Plains of Nayarit, western Mexico.

Key words: Jaguar; *Panthera onca*; prey; mangrove; Nayarit

Resumen

*El jaguar (*Panthera onca*) es un depredador oportunista cuya dieta se basa en las presas que están más disponibles en los ecosistemas en los que habita. En México, se han llevado a cabo estudios sobre su dieta en varios ecosistemas excluyendo los humedales y manglares del occidente del país. Reportamos aquí nueve eventos fotográficos, evidencia colectada con cámaras trampa, de presas (4 mamíferos y 3 aves de las cuales 2 son nuevos registros para la dieta del jaguar: la garza blanca* (Ardea alba*) y la cigüeña (*Mycteria americana*) capturadas por jaguares en manglares y marismas en un paisaje altamente modificado por actividades antropomórficas en la Planicie Costera de Nayarit, Occidente de México.*

Palabras clave:Jaguar; Panthera onca*; presas; manglar; Nayarit*

Introduction

The jaguar is an opportunistic predator whose diet is based on the prey that are most available in the ecosystems in which it is extant (Mondolfi and Hoogesteijn 1986; Rabinowitz and Nottingham, 1986; Emmons 1987; Sunquist and Sunquist 2002; Harmsen et al. 2010). More than 110 species have been reported in their diet, ranging from small rodents to cattle weighing more than 200 kg (Hayward et al., 2016).

In Mexico, several studies to determine the diet of the jaguar have been completed in the rainforests of the Yucatan Peninsula (Aranda and Sánchez-Cordero, 1996; Ávila-Nájera et al. 2018), tropical deciduous forests of the west (Núñez et al. 2000), and northwest (Villordo-Galván et al. 2010; Rueda et al. 2013; Hernández-Saint-Martin et al. 2015), as well in the desert thorn scrub in northern Sonora (Cassaigne et al. 2016). These studies document jaguar prey in Mexico, particularly white-tailed deer (*Odocoileus virginianus*), collared peccary (*Pecari tajacu*), coati (*Nasua narica*) and nine-banded armadillo (*Dasypus novemcinctus*). However, despite the fact that Mexico's jaguars are extant in a variety of habitats throughout the country, there is little known about the diet of jaguar sub-populations (Luja et al. 2017). This is particularly true in mangrove and marsh habitats of Nayarit, in western Mexico.

Study Area

Our study area was 72 km^2 in the ecological sub-province of the "Delta of the Rio Grande de Santiago" (INEGI 1991). The northern limit of our study area was defined by the townsite of Los Corchos (21.732469 ° N, -105.469970 ° W, 3 m elevation; Municipality of Santiago Ixcuintla); the southern limit was the estuary mouth called "La Boca Cegada" (21.596216 ° N, -105.400016 °, 0 m elevation; Municipality of San Blas); the western boundary was the Pacific Ocean; while the eastern boundary was approximately 6 kilometers from the coastline. The climate is humid with mean temperature 31^0 C. The predominant native tree species is the mangrove (*Avicennia germinans* and *Conocarpus erectus*) interspersed with patches of low deciduous palapar forest. These fragmented mangrove forest are being replaced by farm crops and shrimp farm aquaculture (Luja et al. 2017).

Methods

We used the methodology described by the National Jaguar Census project as described in CENJAGUAR by Chávez et al. 2013. Using Google Earth Pro®, we established a grid of cameras covering an approximate area of 72 km^2 divided into 8 quadrants of 9 km^2 each. For every 9 km^2 quadrant we selected 3 camera sites to set a camera trap. Each site was separated by a minimum of 1 km for a total of 24 camera sites. Cuddeback®, HCO Scoutguard®, and Bushnell® cameras were used at 17single-camera stations and at 7 sites we set two cameras facing each other. Cameras were set at a height of between 35 and 50 cm and perpendicular to wildlife paths, as described by Chávez et al. 2013.

Results

Between 2016 and 2020, we captured 9 photographs of 5 different jaguars (3 females and 2 males) carrying 7 species of prey in their jaws (Figure 1). Prey items consisted of 4 mammals: nine-banded armadillo (*Dasypus novemcinctus*) (Figure 1a), coati (*Nasua narica*) (Figure 1b), raccoon (*Procyon lotor*) (Figure 1c), and a domestic cat (*Felis catus*) (Figure 1d). Additionally, we documented 3 birds: a white heron (*Ardea alba*) (Figure 1e), black vulture (*Coragyps auratus*) (Figure 1f), and an American stork (*Mycteria Americana*) (Figure 1g) as prey species. The species with the most photo records as prey was the nine-banded armadillo (3 events), while 6 additional species were photographed once, each.

Discussion

The nine-banded armadillo was previously documented as one of the most frequent prey species in the diet of the jaguar (Hayward et al. 2016). This is supported by our documentation as the most common species in the photographs of this study. All 3 photographs of nine-banded armadillo as prey were obtained during night-time hours (20:55; 22:12; 03:31 h). Jaguars are considered as both diurnal and nocturnal predators in our study area, with many visual

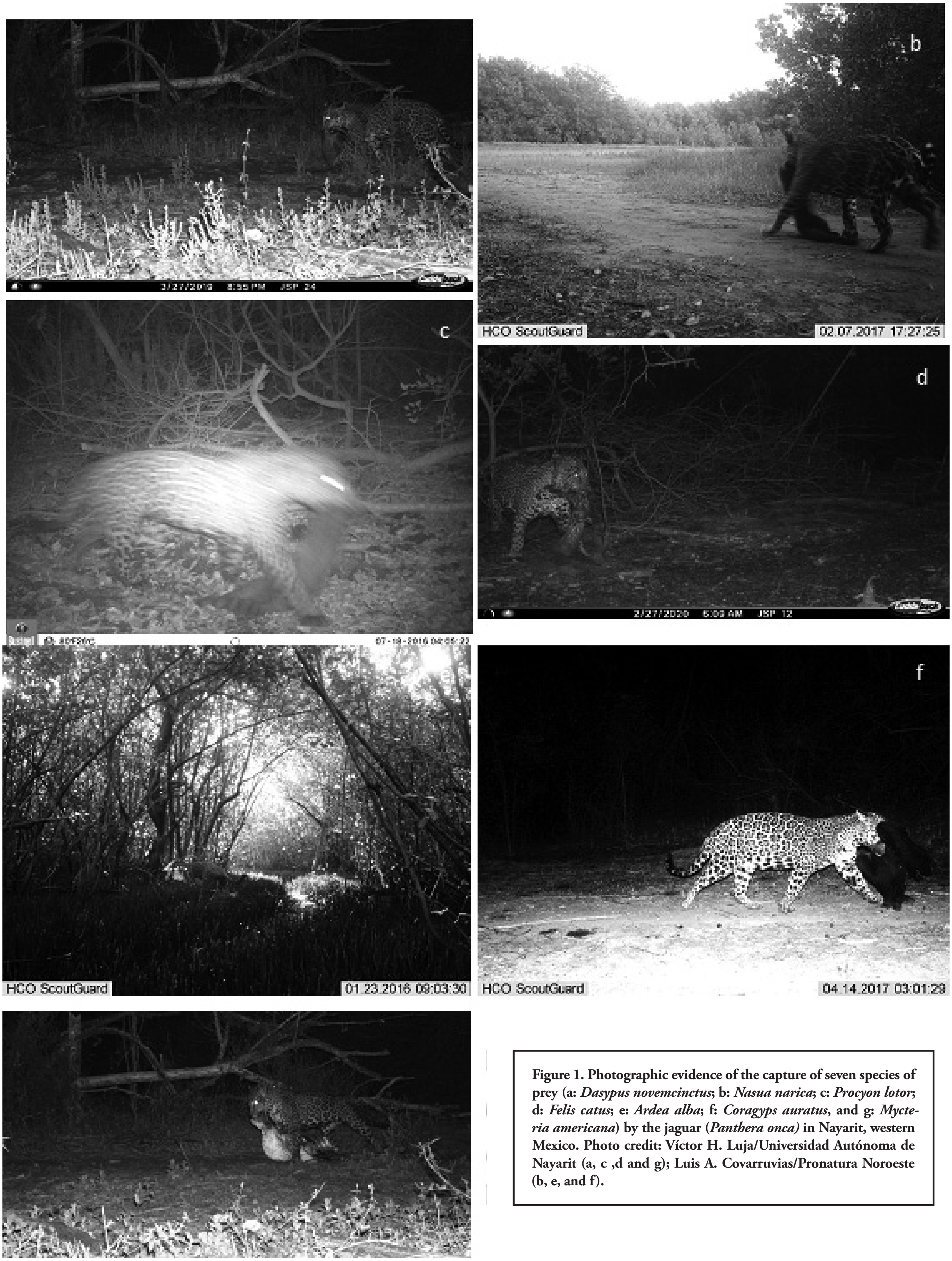

Figure 1. Photographic evidence of the capture of seven species of prey (a: *Dasypus novemcinctus*; b: *Nasua narica*; c: *Procyon lotor*; d: *Felis catus*; e: *Ardea alba*; f: *Coragyps auratus*, and g: *Mycteria americana*) by the jaguar (*Panthera onca)* in Nayarit, western Mexico. Photo credit: Víctor H. Luja/Universidad Autónoma de Nayarit (a, c ,d and g); Luis A. Covarruvias/Pronatura Noroeste (b, e, and f).

observations by area fishermen during both daylight and night hours. Raccoon and coati are both commonly reported as prey of the jaguar (Hayward et al. 2016). Our photo of a jaguar with a coati, considered a diurnal species, was captured in daylight (17:27 h) while the jaguars with nocturnal raccoons were captured at night (04:05 h). Jaguar predation on domestic cats has been poorly documented. In a study in Tamaulipas northeastern Mexico, Carrera-Treviño et al. (2016) collected only verbal testimonies of domestic cat predation by jaguars as evidence. During this study we obtained photographic evidence of an adult male jaguar with a domestic cat as prey while in a mangrove habitat during the early morning hours (06:09 h).

Although very rare, the black vulture *C. auratus* had already been reported as prey of the jaguar in the Yucatan peninsula (Cassaigne et al. 2016; González-Gallina et al. 2017). The photography of the jaguar with the black vulture was obtained during the night (03:01 h) in a dirt road in a mangrove forest. Due to the time of the picture, presumably it was inactive so it is likely that the jaguar hunted it while perching. The other two species of birds (white heron and stork) are, to our knowledge, novel items as prey of the jaguar. The white heron was preyed inside a mangrove forest at 9:03 am. Two photographs show how an adult female jaguar jumps approximately 3 m to capture the bird. Seconds later, a second photograph shows the jaguar with the bird in its mouth. The photograph of the stork predation was obtained in a patch of secondary vegetation at 20:35 h. From the direction the jaguar (adult female) was heading, it is inferred that it captured the bird in an "aguaje" (artificial waterhole for cattle to drink) located at 250 meters east from the photo site. It is common to see flocks of herons, storks, spoonbills, ducks and other birds sleeping in these artificial waterbodies, a situation that takes advantage of the jaguar. Birds can be an important food resource for this jaguar population since the marshes and coastal wetlands have been internationally recognized by the large diversity and abundance of birds (key site for bird conservation, Ramsar Site for the conservation of wetlands, and Area of Importance for Conservation of the Birds) (Cervantes-Abrego 2000; Mendoza et al. 2019).

This paper presents information on both common and novel prey consumed by jaguars in declining costal mangrove habitats of western Mexico. Our photographic evidence of novel prey items of an American stork and white heron, when combined with predation of a freshwater turtle endemic to Mexico (Luja and Zamudio 2018), suggest that the diet of the jaguar in the mangrove region of costal western Mexico is adaptive to prey availability of the region. Future studies incorporating the DNA identification of prey in scat collections and prey site investigations are needed to document statistically significant diet information relative the diet of this iconic Mexican predator. During our study we identified garbage landfills as a possible source of a cat as one prey item. Both cats and dogs are often seen abandoned by people within these humane waste sites. One of these dumps is 200 m from our photo site. The establishment of garbage dump sites within highly fragmented jaguar habitat not only provides an available source of domestic prey species for jaguars, but also a source of habituation to easy prey associated with humans and eventual human-predator conflicts. Additionally, domestic animals are a documented source of feline diseases that may severely affect the survivorship of jaguars on an already anthropogenically altered landscape. We suggest this cause and effect relationship may additionally support a threatened species' existence in an endangered habitat – the mangrove swamps of costal western Mexico.

Aknowledgements

Thanks to P. Virgen, R. Virgen, I. Vallarta, M. Zamudio, D. Guzmán, A. Ponce, L. Ramírez and other people who collaborated in the field work. To Ron Thompson because his observations substantially improved this manuscript. This work was possible thanks to the financing granted to VHL by the National Council of Science and Technology (CONACYT) to project 3369 "Ecology and Conservation of the jaguar (*Panthera onca*) and its potential prey outside the Natural Protected Areas of Nayarit, Mexico.during the early morning hours (06:09 h).

Co-occurrence modeling uncovers potential sex-mediated trends in occupancy and detection of jaguars

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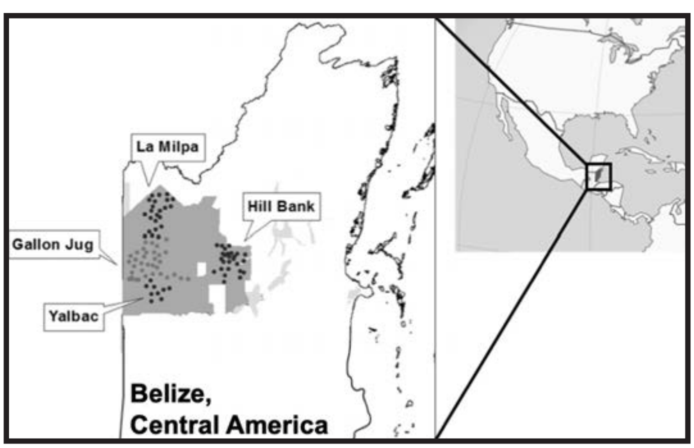
Co-occurrence modeling can be used to understand species interactions and aid in implementation of wildlife conservation efforts (Witting et al. 1995). However, little research has been conducted on interactions between sexes within a species. Conde et al. (2010) found that male and female jaguars (*Panthera onca*) exhibited different habitat use patterns and that ignoring sex in population modeling missed the importance of covariates like distance to road. They also found that females avoided open and anthropogenic areas, while males more commonly used such areas. Additionally, it is known that some felids exhibit infanticide where males will kill cubs (especially if cubs are not likely their own) to bring females into estrus sooner to increase mating opportunities (Soares et al. 2006). Therefore, females may attempt to avoid areas that males frequent due to fear of aggression or infanticide, while males may seek out females for breeding opportunities.

We used camera trapping data to examine interactions between male and female jaguars in a co-occurrence modeling framework to determine the influence of each sex on the detection and occupancy of the other sex. With camera trapping data, researchers often combine daily capture events into 3 to 7-day periods to aid in modeling, with each period being considered a single encounter occasion. However, this could potentially miss interactions between species (or sexes) due to the coarse scale of analyses. Therefore, we compared results from two temporal scales by collapsing camera-trap data into 7-day groupings (i.e., weekly basis) versus using 1-day groupings (i.e., daily basis), to determine if a finer scale would reveal more insight on occupancy and detection of males and females.

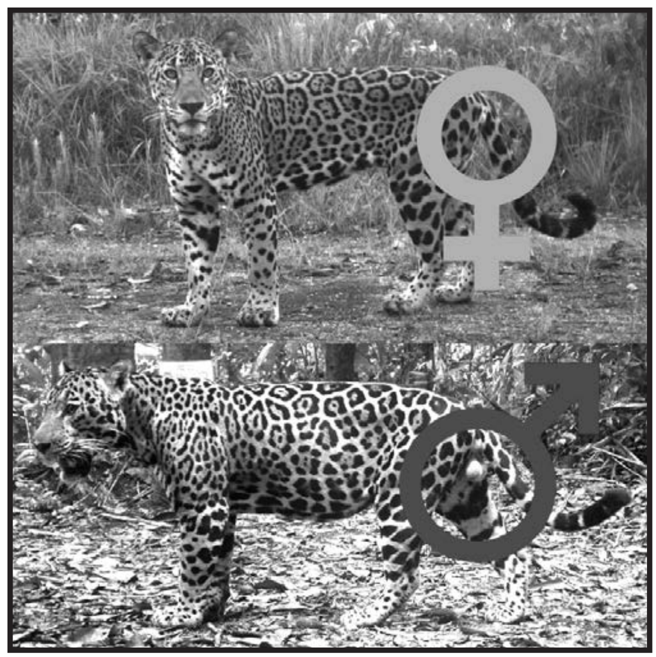
We used data from 112 camera traps, spaced 2-3 km apart in 2016, located across four contiguous study sites in northern Belize, Central America (Yalbac Ranch, Gallon Jug Estate, and Rio Bravo Conservation and Management Area: Hill Bank and La Milpa) as part of a long-term jaguar population monitoring project (Figure 1). Within program PRESENCE, we used 2-species, co-occurrence modeling techniques with the phi/delta parameterization (MacKenzie et al. 2004) and we set "species 1" as male jaguars and considered females as "species 2".



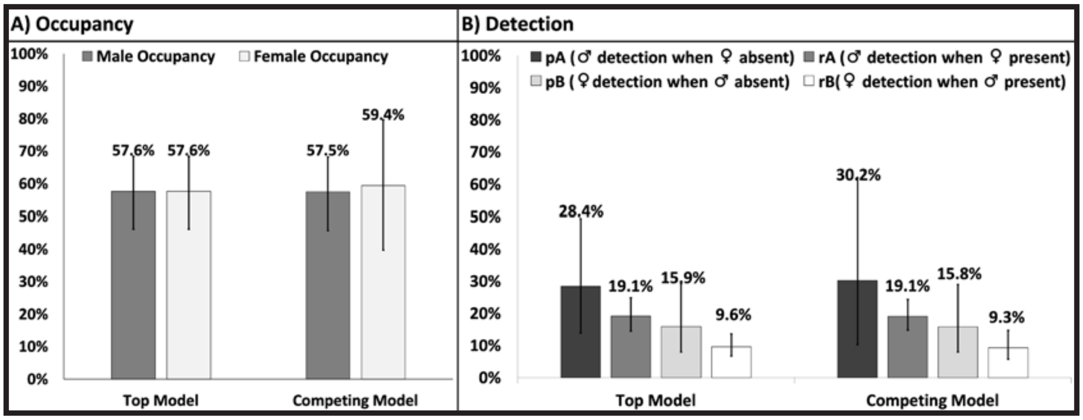
We created input files for each camera station, where '1' meant the sex was captured during that week or day and '0' meant the sex was not captured during that week or day. We used AIC model selection with competing models denoted by ΔAIC<2.0. We estimated occupancy and detection of males vs. females when the other sex was present and absent. In this case, occupancy is equivalent to habitat use since multiple camera stations could be within the ranges of multiple individual animals.

We hypothesized that males, with larger ranges and greater movements, would have higher occupancy and detection in general, and also at stations where females were present, as they can cover multiple female home ranges when searching for mates. We expected that females, having smaller home ranges, would have lower occupancy and detection in general, and at camera stations within their ranges where males were present, to avoid aggression from males.

In 2016, we had a total of 299 jaguar events (187 males, 104 females, and 2 unknown sex that were discarded). Thus, we confidently identified the sex of 99.32% of jaguars (Figure 2).

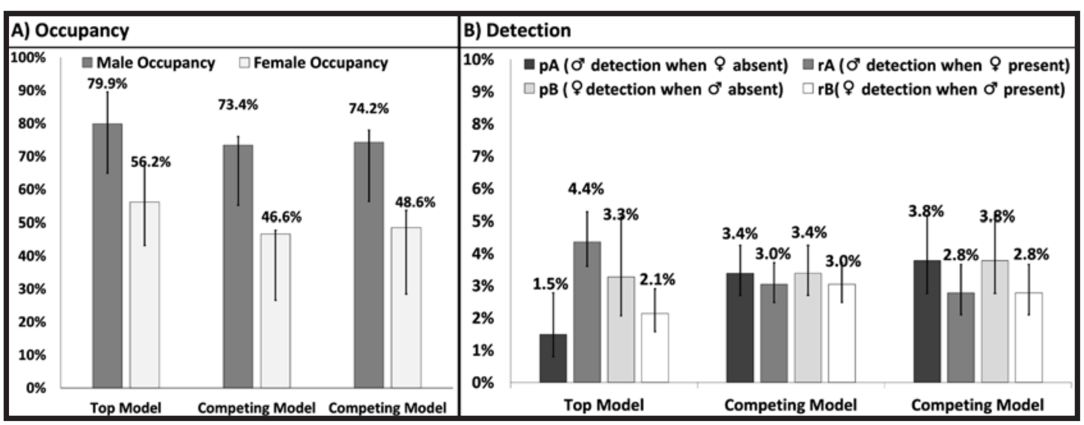


For our weekly encounter occasions, we had two competing models with the top model indicating equal occupancy (57.6%) between sexes, while the competing model predicted higher occupancy for females (59.4%) than males (57.5%), (Figure. 3A). For jaguar detection, the two competing models gave nearly identical results, where both the top and competing models allowed detection to vary for both sexes when the opposite sex was present or absent. Contrary to predictions, detection for males when females were absent (pA) was higher (28.4 - 30.2%) compared to detection at sites with females present (19.1%) (Figure 3B). Detection for females followed our predictions, with higher detection at sites without males (15.8%) than at sites with males present (~9%) (Figure 3B). In all cases, how-



ever, CIs overlapped for both occupancy and detection indicating a lack of support for real differences between sexes.

Using daily encounter occasions however, we had three competing models that all indicated occupancy varied by sex, as expected, and was substantially higher for male occupancy (74.2% - 79.9%) than female occupancy (46.6% - 56.2%) with models having non-overlapping (or nearly so) CIs (Figure 4A). For jaguar detection, the top model allowed detection to vary for both sexes when the opposite sex was present or absent. This model aligned with predictions where male jaguar detection was lower (1.5%) when females were absent from sites and increased to 4.4% when females were present at sites, and CIs did not overlap, indicating support for differences in male detectability. Female jaguar detection in the top model also aligned with predictions and was higher when males were absent (3.3%) and decreased when males were present (2.1%), however, CIs overlapped.Both competing models had detection set to equal in the presence of the opposite sex (pA=pB) compared to the absence of the opposite sex (rA=rB) and differed in that one model considered detection to be dependent on detection of the other sex, while the other model did not. Detection rates for the 2 competing models were all low (2.8-3.8%) and CIs overlapped.



Our results indicate that when encounter occasions were constructed on a weekly basis we did not uncover differences between sexes in occupancy or detection. This is likely due to loss of resolution in detection when collapsing data at such a coarse scale. For example, a jaguar of either sex could be captured many times at a single station during a week, (e.g., our maximum was 5 captures in 1 week), but that would be considered only 1 detection using weekly encounter occasions. Daily detection rates at camera stations were lower than weekly detection rates, but it is more likely that interactions between sexes occur on a finer time scale through recognizing scents, scrapes, vocalizations, or even sightings of the opposite sex; whereas awareness of the opposite sex near a camera station 2-7 days previously, may not affect behavior at that camera station today.

By using daily encounter occasions, we found that male occupancy was always higher (by ~25%) than female occupancy across the landscape. Additionally, male detection rates were higher at stations where females were present, a result not seen with weekly encounter occasions. Females trended towards higher detection when males were absent from stations, but our results were inconclusive. All overarching trends for daily analysis aligned with our predictions, but the generally low daily detection rates for jaguars, especially females, may have hampered the ability to model female detection on such a fine-scale. We note this may be a limitation in implementing co-occurrence models for sexes in other studies. Nonetheless, we provide an example of how finer resolution in defining encounter occasions allowed us to gain greater insight into how occupancy and detection vary between sexes, and in response to the opposite sex, across the landscape.

Moving forward, including habitat variables in co-occurrence models would add more insight into whether patterns in occupancy and detection are more likely sex-mediated versus habitat-mediated, or are a combination of the two. Additionally, conducting finer-scale analyses between two species (i.e., conventional co-occurrence modeling) may result in greater insight on coexistence between species than when data are defined on a coarse scale. Our preliminary analyses revealed interactions between sexes not captured at the broader scale commonly used for defining encounter occasions, and our approach may provide more insight from which to build conservation management strategies that might differ between species or sexes.

Multi-method assessment of bobcat (*Lynx rufus*) occupancy, abundances, trends, and ecology in Oklahoma.

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Bobcats (*Lynx rufus*) have shown surprising resilience to the ever-increasing pressures exerted upon them by human activity. However, over-harvest (Rolley 1985; Knick 1990; Woolf and Hubert 1998), habitat fragmentation (Riley 2006; Litvaitis et al. 2006; Litvaitis et al. 2015) and reductions in the abundance of their major sources of prey (Bailey 1974; Knick 1990) can negatively impact their populations. In Oklahoma, bobcats are the most heavily harvested furbearer in the state, with an average of 4,585 bobcats harvested annually between 2008 and 2015, whilst roadside surveys have indicated a decline in bobcat numbers over the past decade (J. L. Davis, Oklahoma Department of Wildlife Conservation [ODWC], pers. comm.). Current monitoring methods for the bobcat population in Oklahoma include roadside surveys and fur sales, which may not necessarily reflect true trends in the populations. Therefore, a reliable, non-invasive alternative method, that is independent of the fur market, is sorely needed.

In an effort to determine bobcat occupancy and densities in Oklahoma, specially designed (Rounsville 2018) hair-snare cubbies (Figure 1) are deployed in a genetic capture-recapture (GCR) framework at three distinct ecoregions of the state, whilst state-wide presence/absence data is collected annually by student volunteers. These data, in combination, will be used to map bobcat occupancy and densities throughout the state to aid in management of the species. Student volunteers are recruited from universities across Oklahoma, taught how to attract bobcats and acquire data with help from an experienced trapper, and deploy cubbies in their home counties for three weeks during winter. Hair samples are studied microscopically to determine species, based on distinct morphologies (Oyer 1946; Knecht 2012), and bobcat captures are logged for analysis in an occupancy modelling framework. At our GCR study sites, cubbies are deployed for six weeks (Jan-Mar) annually across three Wildlife Management Areas (WMA) of Oklahoma, with hair samples analysed genetically (see Anderson et al. 2015) to obtain capture histories for individual bobcats. These data will provide important information on the drivers of bobcat occupancy and density, as well as habitat associations, home range sizes and the effect of human activity (such as habitat fragmentation, urban sprawl, agriculture) on bobcat occupancy and population trends.

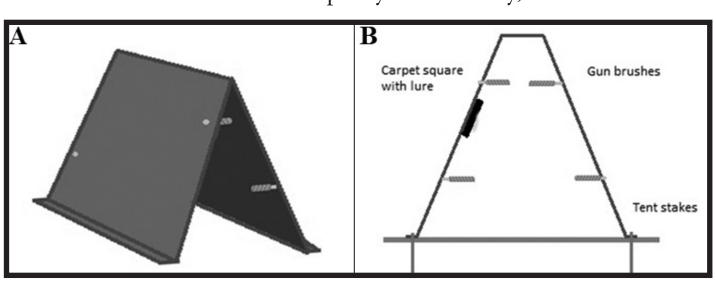

Figure 1. Hair-snare cubby design exterior (A) and interior (B). Cubbies are constructed from corrugated plastic with gun brushes fixed to entrances at alternate heights, carpet squares fixed to cubby interior for scent lure application, and tent stakes to anchor the cubby in place. Diagrams courtesy of K. Branham (University of Central Oklahoma).

In addition to hair-snare cubbies, camera traps (Stealth Cam STC-G42NG) are deployed at half of cubby locations to aid in identification of bobcat individuals based on fur markings (Heilbrun et al. 2003; Larrucea et al. 2007) and obtain abundance data for other species (coyotes [*Canis latrans*] and leporids [*Lepus californicus*, *Sylvilagus floridanus*]). In 2020, small mammal trapping, using Sherman live-trap transects, as well as bobcat and coyote scat collection, was conducted. This sampling will continue annually (Mar-May). Since bobcat prey preferences differ significantly between ecoregions of the state (Ellis and Schemnitz 1957; Whittle 1979; Litvaitis 1981; Rolley and Warde 1985; Rolley 1985), determining bobcat diet, as well as abundances of their major prey, will allow us to better understand determinants of bobcat space-use. Additionally, obtaining diet data for coyotes, a similarly sized sympatric mesocarnivore with similar metabolic demands, will allow us to better understand the niche partitioning between the two species. Bobcats and coyotes co-exist across much of North America, overlapping in diet (Major and Sherburne 1987; Koehler and Hornocker 1989), space use (Litvaitis and Harrison 1989; Chamberlain and Leopold 2005), and activity patterns (Witmer and deCalesta 1986; Thornton et al. 2004), yet the degree of competitive exclusion between the sympatric mesopredators is widely debated and poorly understood. Since coyotes have dramatically increased their range across North America over the last century (Hody and Kays 2018), and have the ability to alter community assemblages (Crooks and Soulé 1999; Levi and Wilmers 2012) and even initiate species decline (Ripple et al. 2013), understanding the modalities of niche partitioning between bobcats and coyotes can aid in management of both species where they occur sympatrically, especially where coyotes have recently colonized (e.g. Florida [Thornton et al. 2004]).

Initial multi-species occupancy models based on our 2019 data suggest bobcats are negatively associated with coyotes, and positively associated with rabbits, and especially rodents. However, these data also show asynchronous activity patterns between bobcats and their rodents and rabbits, with fewer night-time bobcat observations (n = 21 out of 43) than expected, especially considering the high nocturnality of rabbit (n = 100 out of 116) and rodent (n = 55 out of 55) observations. Temporal partitioning of activity patterns to reduce competition in sympatric species is common and may contribute to partitioning of niche between these mesocarnivores. Continued collection of camera data over several years, in combination with genetic data from hair-snares, scat samples and small mammal data, will provide better understand of this relationship and bobcat ecology as a whole.

This project is funded by the Oklahoma Department of Wildlife Conservation.

From jaguars to margays: spatial distribution and conservation of five feline endangered species and their prey in Golfo Dulce Forest Reserve, Costa Rica

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E. Chacón-Madrigal.

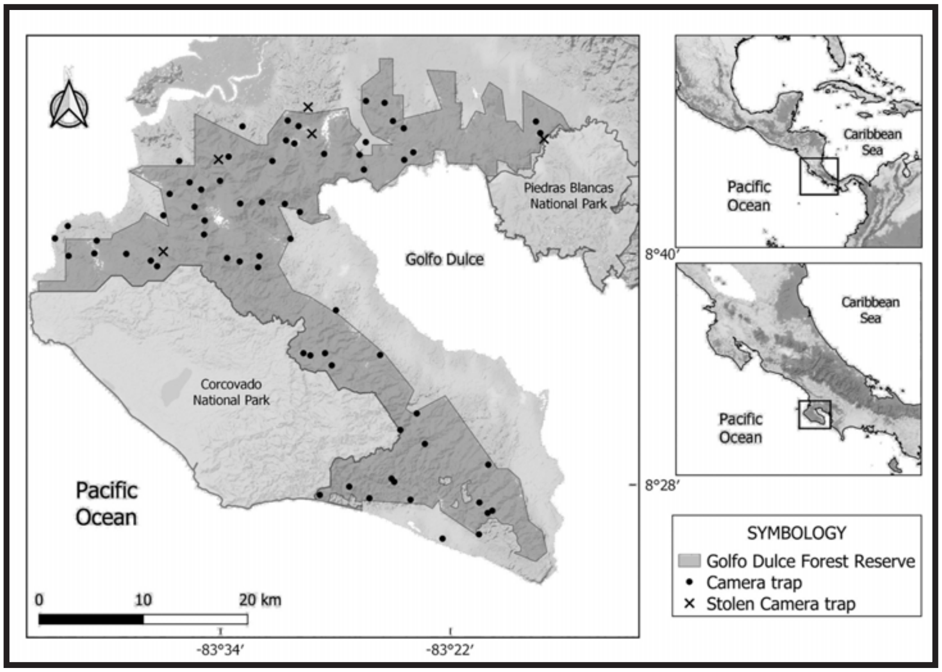

Figure 1. Distribution of sampling points, stations of one camera trap, across the study area, Golfo Dulce Forest Reserve, Costa Rica

The Golfo Dulce Forest Reserve (GDFR) is located in the heart of the biodiverse Osa Peninsula, in Costa Rican Southern Pacific, connecting two protected areas (PA), Corcovado National Park (CNP) and Piedras Blancas National Park (PBNP) (Figure 1). The GDFR is also a protected area, but with less restrictive conservation regulations, as it has a sustainable development purpose. One remarkable condition of this PA is that human populations are coexisting with wildlife, with land tenure divided between the government and local landowners (CONAC 2019). This leads to a perfect scenario to study congruency of anthropogenically modified landscapes and economic activities with biodiversity integrity (Muench&Martínez-Ramos 2016, Pringle 2017). Moreover, such studies may answer urgent questions regarding how threatened species can survive in an increasingly fragmented habitat, hence where we might need to rethink conservation outside PAs (Boron et al. 2019, Petracca et al. 2018, Velho et al. 2015).

Our objective is to determine how landscape and management factors inside the GDFR affect the distribution of endangered terrestrial mammals, like big and medium-sized felines and herbivores. Furthermore, we will analyze the spatial overlap of habitat use between these species. Based on this, we aim to recommend high-priority management and conservation actions for specific GDFR sites.

To accomplish these objectives and monitor elusive terrestrial mammals, since January 2019 we have established, with collaboration of landowners, (Figure 2) 72 sampling points across the 627 km^2 of GDFR (Figure 1). Each sampling point consisted of a camera trap that was active for 90 days. Four sampling points provided no data because the camera traps were stolen, and a fifth only had 30 days of data, because it was taken after its first review. Our functional cameras documented the presence of hunters and/or their dogs, and we geo-referenced illegal logging in or near camera stations.

For spatial analysis, we are using official governmental layers of forest coverage, terrain, roads, rivers, and land use (*http://www.snitcr.go.cr/*).

One of our most valuable results was to record jaguars (*Panthera onca)* continually using habitat within GDFR. We found adult males and females actively moving through, and even interacting in courtship behavior (Figure 3). We reported the first known sighting of a young female, which means there is a reproductive population and juveniles might be dispersing from the area (Kanda et al. 2019, Morato et al. 2016). We also got the first record of long-lived male "Macho Uno" (Olson et al. 2019) outside of PNC, which amplifies considerably his known home range size. These records constitute the until now unpublished evidence of the key role of GDFR to assure the survival of the Osa Peninsula endangered jaguar population.

An intriguing result that deserves more analysis is the inter- and intra-specific coexistence within the same area.We have documented in our camera traps the continuous presence of puma (*Puma concolor*) males and females across the GDFR, including mothers with their young (Figure 3). We have recorded consistent use of the habitat and presence of juveniles for the more common ocelots (*Leopardus pardalis*) and the diurnal but more elusive jaguarundi (*Puma yagouaroundi*) (Figure 3). Unexpectedly, we have also found several records of the smallest cat of the Osa Peninsula, the arboreal margay (*Leopardus wiedii*), among specific places of GDFR (Figure 3). In our study, we have found very few records of the endangered and hunted white-lipped peccary (*Tayassu pecari*), one of the jaguar's preferred prey, helping to confirm the alarming downward trend of of this species (Thornton et al. 2020). In contrast, we have detected the presence of key herbivores , including collared peccary (*Pecari tajacu*), red brocket (*Mazama temama*), Baird's tapir (*Tapirus bairdii*) and the in-demand spotted paca (*Cuniculus paca*) across the GDFR.

As of April 2020, we still have some sampling and monitoring to complete. Given the GDFR significance in terms of valuable habitat fundamental to the healthy maintenance of these endangered mammal populations, we are consulting with landowners and governmental authorities to improve protection strategies. Authorities must assist hunting and logging denouncements, and urgent patrolling to

Figure 2. Example of landowners of Golfo Dulce Forest Reserve setting camera traps on their properties. Top left: Douglas Valverde and Sandra González. Top right: Erlin Chaves. Bottom left: Edier Sánchez, Heizel Herrera and "Tuco" Sánchez, Bottom right: environmental activist don Alcides Parajeles.

specific "hotspots" is needed, along with logistic and financial funding to landowners and communities that are willing to participate in wildlife protection and monitoring programs. Under current circumstances, residents are legally constrained from obtaining Payments for Ecosystem Services (PES), and in some cases ignored when they report illegal activities.

We should give support to communities seeking alternative, sustainable work options to reduce pressure on the forest and its biodiversity. Such economic resources for conservation are often distributed among high profile conservation non-governmental organizations and do not reach the communities inside the GDFR or the most deprived people that may be key actors in conservation. Working with all involved and finding solutions to legal contradictions seems to be one of the immediate steps we need to address in our larger goal of conserving these vital species that remain in the Osa Peninsula.

Acknowledgements

We deeply want to thank the GDFR landowners and families for their appreciated collaboration during the development of this research, as well as their commitment to protect wildlife and continue participating in the future. For financial or logistical support thanks to University of Costa Rica, Rufford Foundation, The Wild Felid Research and Management Association, Fondo de Biodiversidad Sostenible, Nature Conservancy, SINAC and FONAFIFO. In addition, we want to thank thesis committee professors J. Lobo and G. Saborío, researchers R. Amit, H. Solís, R. Aguilar, A. Giordano, J. Carazo, A. Artavia, R. Almeida, and photographer T. Haroutiounian, for their help or assistance in the progress of this project.

Figure 3 (clockwise).

Jaguar *(Panthera onca)* male following female in Golfo Dulce Forest Reserve, Osa Peninsula, Costa Rica.

Puma (*Puma concolor*) female (left) with her young (right) passing through their home range in Golfo Dulce Forest Reserve, Osa Peninsula, Costa Rica.

Margay (*Leopardus wiedii*) captured passing on the ground in Golfo Dulce Forest Reserve, Osa Peninsula, Costa Rica.

Jaguarundi (*Puma yagouaroundi*) female (center) with a juvenile (left) and kitten (right) crossing a trail in Golfo Dulce Forest Reserve, Osa Peninsula, Costa Rica.

Ocelot *(Leopardus pardalis)* Diet in the Lowland Peruvian Amazon Rainforest, with comments on diet of the Jaguar (*Panthera onca*) and Puma (*Puma concolor*)

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Carnivores come into competition with people not only for space but also for prey (e.g., Leite & Galvao 2002; Salvatori et al. 2002). Their survival is jeopardized by reductions in prey availability, either through direct competition with humans and overhunting or indirectly through habitat loss (Fuller & Sievert 2001). Under conditions of globally diminishing diversity and abundances of prey species, the long-term persistence of large felids like jaguars and pumas may depend on dietary flexibility and their ability to use anthropogenically-modified areas (Avezedo 2008). Having a thorough understanding of prey consumption and constraints on predation helps us to evaluate roles of carnivores in their ecosystems (Wachter et al. 2012; Chakrabati et al. 2016) and diagnose anthropogenic disturbances (Rocha-Mendes et al, 2010).

Patterns of prey availability have been researched (Herrera et al, 2018) and positively correlated with habitat use by jaguar (*Panthera onca*), puma (*Puma concolor*), and ocelot (*Leopardus pardalis*) (Santos et al. 2019), with prey abundance being more important than species interaction for local co-occurrence of Neotropical felids. Interspecific food competition is likely a controlling factor structuring neotropical felid assemblages which is common when species live in sympatry (Silva-Pereira et al. 2011). Where prey are thought varied and abundant, predators may co-occur (Michalski et al. 2015) and will not be 'limited' by food. The depletion of prey bases can alter population sizes, making dietary studies a priority for appropriate conservation action (Karanth & Chellam 2009; Sollmann et al. 2013).

The ocelot is a medium sized cat and opportunistic mesopredator (Abreu et al. 2007; Massara et al. 2016). Studies of ocelots have found them to choose small mammals weighing <1kg, especially rodents (Silva-Pereira et al. 2011). Throughout Central and South America, the puma, a sympatric predator to the jaguar, preys predominantly on paca and brocket deer, supplemented by armadillo and peccary. The jaguar is known to prey mostly upon peccary and armadillo, but diet studies have found over 85 species consumed by jaguars, including giant anteaters (Foster et al. 2013). No diet studies have been conducted in the Madre de Dios region of Peru, where we expect different results.

Methods

The study area is located in the Madre de Dios region, along the Las Piedras river (~300 km^2) It is currently unprotected rainforest, nestled between nationally protected areas like the Tambopata National Reserve, Manu National Park and Alto Purus. Starting in May 2019, we collected feline scats opportunistically while walking trails and beaches within a ~300 km^2 study area and will continue to do so throughout the dry season of 2020. Scats collected for both 2019 and 2020 will be pooled, as yearly sample sizes would not be sufficient (Sollmann et al. 2013). Most scat samples are collected during the dry season (May-September), due to heavy rainfall removing or destroying samples during the wet season (November-March). To date, scat samples have been processed by hand using circular scale imprints and cross sections that are then photographed and stored in a database for identification.

Known hair samples of potential prey were collected opportunistically from clearly identifiable, dead animals found within the jungle. We also took hair samples from the prey of an ocelot we rehabilitated and released, whose meals were possible to locate weekly. Hairs were taken from the back of the neck, between the shoulder blades when possible. For all possible species of prey in the study area, where hairs were collected for the reference collection, we created scale imprints and cross sections to be compared with hair samples extracted from scats. Along with our own reference collection, we used the reference collection from Quadros (2002), to identify prey remains. We also used remains of body parts including teeth, claws, hooves, bones and feathers in our reference collection, to aid with subsequent identification (Foster et al. 2010).

Ongoing Work

To date we have 41 samples, 34 ocelot scats and seven big cat scats. The majority of samples were collected during the dry season of 2019. Opportunistic scat collection, hence sample sizes, will increase when the dry season returns in 2020. Preliminary results show high peccary content in the big cat scat, as well as other medium to large mammals. Ocelot scat in this region shows higher reptile content, particularly of snakes, than found in previous studies. There is also a reasonable amount of peccary remains, suggesting that ocelots are hunting young peccary. The finer hairs from small mammals seem to make up about 50% of their diet, which aligns with other research.

Moving forward, scat samples will be divided with one half of each sample stored for analysis in a recently established genetics lab, and the other half processed in the field using the above-mentioned techniques. The genetics lab will be able to more effectively differentiate between jaguars, pumas, and ocelots, and provide more accurate prey descriptions. We will continue to build our reference collection for the region to promote further carnivore diet studies.

Hot sauce as a bobcat deterrent to prevent livestock depredation

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Livestock loss due to predators is a constant challenge in agricultural and conservation fields. Predators accounted for 24.3% of goat deaths during 2015 (USDA, 2015), 28.1% of sheep deaths during 2014 and 2.4% of cow death deaths during 2015 (USDA, 2015). The number of deaths can vary depending on state and kind of operation, but any deaths contribute to tension in the human-wildlife conflict. Bobcats(*Lynx rufus*) account for a small percentage of larger livestock deaths such as sheep, goats and cattle (Nealeet al. 1998) but can contribute to the death of lambs, goat kids, rabbits and chickens, as well as companion animals (Gese, Keenan and Kitchen, n.d.). Commonly used predator deterrents such as fox-lights, noise emitters and electric fencing will deter bobcats from predating on livestock, however, reports of home-made deterrents across the world remain untested. These include reports of using chili peppers or hot sauces to deter lions (*Panthera leo*) and mountain lions (*Puma concolor*). Therefore, a small-scale study, looking into the effect that hot sauces have on bobcat presence was conducted.

Methods

A 193-acre farm was chosen in the Western Sierra Nevada foothills. The farm includes interior California chaparral and woodland habitat as well as grassland. There are a few ephemeral streams and a few man-made water sources. The farm currently has a mixture of sheep, goat, rabbit and chicken pens. Apart from fencing and some herding dogs there were no other predator deterrents present and the owners reported approximately 10-12 predations in the year 2019, 7 of which were believed to be caused by bobcats.

Ten camera traps were placed along game trails and at water sources, at 100 m intervals. At the end of the third week, 5 randomized camera traps had scent applied on their location and 5 acted as untreated controls. The camera traps were left out for an additional 8 weeks where the scent was refreshed or changed every week. Once that treatment was completed the camera traps were left for another 3 weeks to see if activity returned to baseline.

Scent bomb lures saturated with hot sauces were placed above or as close as possible to the camera trap, out of reach of bobcats to prevent any accidental exposure to hot sauce and potential habituation. Four commercially available hot sauces were used in the following order: Sriracha, Tapatio Salsa Picante, 100% Pain Hot Sauce and Da Bomb, Beyond Insanity. The control camera traps had scent bomb lures with no scent.

Bobcat presence was counted as the total number of bobcat captures on a camera trap. Unless physical variations demonstrated differently, all bobcat captures that were within 5 minutes of each other were considered the same animal and therefore counted only once.

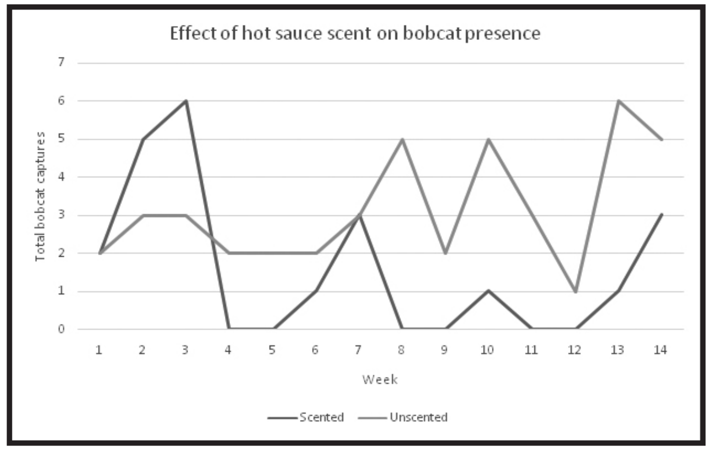

Figure 1. The effect of hot sauce scent on bobcat presence. Sriracha sauce was applied at Week 4, Tapatio Salsa Picante on week 6, 100% Pain on week 8 and Da Bomb on week 10 with scenting stopping at week 12.

Analysis and Results

This experiment examined whether hot sauce could influence bobcat presence and if so to what degree. Figure 1 shows the overall results of bobcat presence. After the application of hot sauce, total bobcat presence on scented cameras fluctuated between 0 and 1 with an odd week of 3 captures recorded. This was likely due to hot sauce Tapatio Salsa Picante not having as powerful of an odor as the rest. At the end of week 12, bobcat presence on the scented cameras began rising again, indicating that the presence of the hot sauce scent likely kept the bobcats away from those sites.

Future research

The experiment's results merit further research into how effective hot sauces can be in deterring bobcats. The hot sauces in the experiment were alternated to prevent habituation so the next steps include investigating the effectiveness of hot sauces across the Scoville Heat Units spectrum without alternating hot sauces, investigating the effectiveness of concentrated pepper essence as well as the time it takes for bobcats to become habituated to each smell.

Once that research concludes, further examination into the practical applications of hot sauces should be investigated such as whether hot sauces can act as a deterrent for other felid species, other mammal predators as well as whether they can work in a multi-predator landscape where some species such as American black bears (*Ursus americanus*) and Grizzly bears (*Ursus arctos horribilis*) have been recorded to be attracted to capsicum.

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Recent Publications

Conservation and Management

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Howard, A.L. et al. 2020. Estimating mountain lion abundance in Arizona using statistical population reconstruction. Journal of Wildlife Management. doi: 10.1002/jwmg.21769

Koehler, G. and K.A. Hobson. 2019. Tracking cats revisited: Placing terrestrial mammalian carnivores on delta H-2 and delta O-18 isoscapes. PLoS ONE 14: e0221876.

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Morin, D.J. et al. 2020. Comparing methods of estimating carnivore diets with uncertainty and imperfect detection. Wildlife Society Bulletin. doi: 10.1002/wsb.1021

Piaggio, A.J. et al. 2020. DNA persistence in predator saliva from multiple species and methods for optimal recovery from depredated carcasses. Journal of Mammalogy 101: 298-306.

Tellaeche, C.G. et al. 2020. Field chemical immobilization of Andean and pampas cats in the high-altitude Andes. Wildlife Society Bulletin 44: 214-220.

Research Highlights

A multi-scale, multi-species approach for assessing effectiveness of habitat and connectivity conservation for endangered felids.

Ashrafzadeh, M.R. et al. 2020. Biological Conservation 245: 108523.

Abstract - Habitat loss and fragmentation are major threats to global biodiversity. Felids, among the many taxa experiencing population declines and range contraction around the world, are known as ecologically and politically powerful levers in conservation programs. Many felids are wide-ranging, and therefore, identifying and conserving their core habitat patches and corridors is essential for developing an umbrella strategy for protecting co-existing species. We employed a multi-scale, multi-species approach to model habitat suitability and connectivity for six felids across Iran. We identified potential core habitats and corridors of movement. We also quantified the spatial niche overlap to estimate the most important variables of habitat selection within the guild. We evaluated the effectiveness of conservation areas in conserving habitats and connectivity. Our findings revealed that each species' habitat use was influenced in a scale-dependent manner by different sets of environmental variables. Core habitats of felids were mostly located in conservation areas. We identified a number of small core habitats for most felids outside conservation areas. Maintaining corridors and stepping stone habitat patches along corridors may be needed to facilitate movement of individuals, especially between habitat remnants in unprotected areas. Our study highlights the importance of considering multiple spatial scales in management and conservation of carnivores. Our analysis shows that habitat selection and connectivity predictions are both very sensitive to scale, and incorrect scale of analysis can result in incorrect inferences that may lead to dramatically inefficient or ineffective conservation actions.

A sociocultural perspective: human conflict with jaguars and pumas in Costa Rica.

Kelly, J.R. 2019. Conservation & Society 17: 355-365.

Abstract - This paper presents data about the sociocultural construction of conflict and the killing of jaguars and pumas in a part of the Mesoamerican Biological Corridor (MBC) of Costa Rica. Results from participant observation and 131 interviews revealed cultural differences between Ticos (non-Indigenous people) and Cabécar (Indigenous people) on four separate dimensions of conflict, where large felines were constructed as competitors, food, man-eaters, real and imagined. When compared to Ticos, Cabécar had more conflict, most likely because they live off the land and have frequent "real" encounters with felines. This study makes several contributions: 1) evidence suggests competition is not the only reason for killing large felines; motivations also include constructing them as man-eaters and as food, raising questions about the important role social and cultural factors play in solutions to conflict; 2) meanings from Cabécar are products of a traditional and modernised relationship with large felines; 3) Cabécar include jaguars as food, suggesting future research and conservation management must understand Indigenous Peoples' relations with large predators, including their diets and traditions; 4) potential for conflict may increase between Ticos and large felines as they repopulate; 5) culture is crucial to examine prior to management implementation.

The Elephant in the room: What can we learn from California regarding the use of sport hunting of pumas (*Puma concolor*) as a management tool?

Laundré, J.W., and C. Papouchis. 2020. PloSONE 15(2), e0224638.

Abstract - Puma management in the western United States is highly contentious, particularly with regard to the use of sport hunting as a management tool. Since the 1970s, puma in ten western states have been managed by state fish and game agencies through the use of a sport hunt. The rationale presented by wildlife managers is that sport hunting, in addition to providing recreational hunting opportunities, also reduces threats to human safety and livestock safety, and increases populations of the puma's ungulate prey, namely deer (*Odocoileus* sp.) and elk *(Cervus elephus)*. We evaluated these claims using the state of California as a control, which has prohibited sport hunting since 1972, and employing data obtained from state and federal agencies with authority and control over puma management. Specifically, we tested four hypotheses: 1) sport hunting will suppress puma populations, 2) sport hunting will reduce the number of problematic puma-human encounters; 3) sport hunting will reduce puma predation on domestic livestock, and 4) sport hunting will reduce the impact of puma predation on wild ungulate numbers, resulting in increased hunting opportunities for the sport hunt of ungulates. Our results indicated, respectively, that relative to the 10 states where puma are hunted, California had 1) similar puma densities, 2) the 3rd lowest per capita problematic puma-human encounters, 3) similar per capita loss of cattle ($P = 0.13$) and a significantly lower ($t = 5.7$, $P < 0.001$) per capita loss of sheep, and 4) similar average deer densities while changes in annual deer populations correlated with changes in other states ($F = 95.4$, $P < 0.001$, $R^2 = 0.68$). In sum, our analysis of the records obtained from state and federal wildlife agencies found no evidence that sport hunting of pumas has produced the management outcomes sought by wildlife managers aside from providing a sport hunting opportunity. Consequently, and particularly because other research suggests that sport hunting actually

exacerbate conflicts between pumas and humans, we recommend that state agencies re-assess the use of sport hunting as a management tool for pumas.

What makes a panther a panther? Genetics, human perceptions, and the complexity of species categorization.
Macdonald, C. and J. Wester. 2020. Nature + Culture 15: 19-31.
Abstract -Species categorizations can involve both scientific input and con¬servation questions about what should be preserved and how. We present a case study exploring the social construction of species categories using a real-life example of a cougar subspecies (*Puma concolor stanleyana*) purpose¬fully introduced into Florida to prevent the functional extinction of a related subspecies of panther (*P. c. coryi*). Participants in an online sample (n = 500) were asked to make categorization decisions and then reflect on those deci¬sions in an open format. Analysis of coded responses suggest people may experience "species" as both a social and biological construct, and that the question of what species people think an animal belongs to cannot be answered in isolation from questions about how that animal fits into larger social and biological systems.

Can school children influence adults' behavior toward jaguars? Evidence of intergenerational learning in education for conservation.
Marchini, S. and D.W. Macdonald. 2020. Ambio 49: 912-925
Abstract - A school-based experiment was conducted in the Brazilian Amazon examing the effects of passively-received information versus active elaboration on the 'perceptions' of jaguars (*Panthera onca*) among students, and the effects of information communicated via illustrated book on those perceptions among student's parents. Books distributed via school decreased fathers' perceptions of social acceptance of jaguar killing, but the same books distributed via a conservation organization did not. This suggests that fathers were influenced not only by the information conveyed in the content of books, but also by the implicit message that jaguar conservation was socially supported. Elaboration alone produced more persistent effects than information alone, but some negative attitudes were reinforced. Information and elaboration combined created more enduring effects than either intervention alone. These findings are important in designing interventions for our coexistence with jaguars and other charismatic species worldwide.

Fear of humans as apex predators has landscape-scale impacts from mountain lions to mice.
Suraci, J.P. et al. 2019. Ecology Letters 22: 1578-1586.
Abstract - Apex predators such as large carnivores can have cascading, landscape-scale impacts across wildlife communities, which could result largely from the fear they inspire, although this has yet to be experimentally demonstrated. Humans have supplanted large carnivores as apex predators in many systems, and similarly pervasive impacts may now result from fear of the human 'super predator'. We conducted a landscape-scale playback experiment demonstrating that the sound of humans speaking generates a landscape of fear with pervasive effects across wildlife communities. Large carnivores avoided human voices and moved more cautiously when hearing humans, while medium-sized carnivores became more elusive and reduced foraging. Small mammals evidently benefited, increasing habitat use and foraging. Thus, just the sound of a predator can have landscape-scale effects at multiple trophic levels. Our results indicate that many of the globally observed impacts on wildlife attributed to anthropogenic activity may be explained by fear of humans.

Urbanization impacts apex predator gene flow but not genetic diversity across an urban-rural divide.
Trumbo, D.R. et al. 2019. Molecular Ecology 28: 4926-4940.
Abstract - Apex predators are important indicators of intact natural ecosystems. They are also sensitive to urbanization because they require broad home ranges and extensive contiguous habitat to support their prey base. Pumas (*Puma concolor*) can persist near human developed areas, but urbanization may be detrimental to their movement ecology, population structure, and genetic diversity. To investigate potential effects of urbanization in population connectivity of pumas, we performed a landscape genomics study of 130 pumas on the rural Western Slope and more urbanized Front Range of Colorado, USA. Over 12,000 single nucleotide polymorphisms (SNPs) were genotyped using double-digest, restriction site-associated DNA sequencing (ddRAD-seq). We investigated patterns of gene flow and genetic diversity, and tested for correlations between key landscape variables and genetic distance to assess the effects of urbanization and other landscape factors on gene flow. Levels of genetic diversity were similar for the Western Slope and Front Range, but effective population sizes were smaller, genetic distances were higher, and there was more admixture in the more urbanized Front Range. Forest cover was strongly positively associated with puma gene flow on the Western Slope, while impervious surfaces restricted gene flow and more open, natural habitats enhanced gene flow on the Front Range. Landscape genomic analyses revealed differences in puma movement and gene flow patterns in rural versus urban settings. Our results highlight the utility of dense, genome-scale markers to document subtle impacts of urbanization on a wide-ranging carnivore living near a large urban center.

Extirpated, immigrated, genetically stratified-first demographic assessment of a recovering bobcat (Lynx rufus) population after a century of extinction.
Rose, C. et al. 2020. Mammal Research 65: 423-434.
Abstract - The bobcat is a widespread mesocarnivore that declined in the USA as settlement proceeded. It was considered extirpated in Ohio around 1850, and extinct for a century. Listed as state-endangered in 1974, verified reports increased in the 1990s. Genetically stratified clusters developed in 2 areas. The eastern population increased more rapidly, and the southern was part of a multistate population including West Virginia and Kentucky. To investigate the recovering bobcat's population ecology, Ohio collected carcasses of bobcats that died, mostly from vehicle collision. We processed specimens for demographic data, and supplemented the southern sample with western WV and eastern KY harvest data given genetic relatedness. We applied a vertical life table framework, interpreting our population cross-section as a recovery period. We estimated age structure, fecundity, and population status of eastern Ohio bobcats, and compared fecundity between areas. Life-table analyses indicated an eastern Ohio population hovering around zero growth. Juvenile females contained most reproductive value, and most males died as young adults. Fecundity in eastern Ohio surpassed that of the multistate population overall where comparable. Fecundity increased through several years of life as bobcats matured. Our results suggest, after a rapid recovery of eastern Ohio bobcats, population growth slowed as they began to saturate their environment. Ohio delisted bobcats in 2014 and proposed a harvest season in 2018. With loosening regulation, we recommend more robust sampling for improved population modeling after expansion of the recovered population's range.

Bobcat. Photo compliments of Susan Morse

About the Wild Felid Research and Management Association

The Wild Felid Research and Management Association is open to professional biologists, wildlife managers, and others dedicated to the conservation of wild felid species, with emphasis on those species in the Western Hemisphere. The Wild Felid Association acts in an advisory capacity to facilitate wild felid conservation, management, and research, public education about wild felids, and functions among various governments, agencies, councils, universities, and organizations responsible or interested in wild felids and their habitats.

Our intention is to:

1. Provide for and encourage the coordination and exchange of information on the ecology, management, and conservation of wild felids;
2. Provide liaison with other groups; and,
3. Provide a format for conducting workshops, panels, and conferences on research, management and conservation topics related to wild felids.

Our goal:

The goal of the Wild Felid Association is to promote the management, conservation and restoration of wild felids through science-based research, management, and education.

Our objectives:

1. Promote and foster well-designed research of the highest scientific and professional standards.
2. Support and promote sound stewardship of wild felids through scientifically based population and habitat management.
3. Promote opportunities for communication and collaboration across scientific disciplines and among wild felid research scientists and managers through conferences, workshops, and newsletters.
4. Increase public awareness and understanding of the ecology, conservation, and management of wild felids by encouraging the translation of technical information into popular literature and other media, and other educational forums.
5. Encourage the professional growth and development of our members.
6. Provide professional counsel and advice on issues of natural resource policy related to wild felid management, research, and conservation.
7. Maintain the highest standards of professional ethics and scientific integrity.

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