The Wild Felid Monitor

The Newsletter of the Wild Felid Research and Management Association

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Front cover: Patagonia puma. Photo credit Nicolas Lagos

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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Managing Editor: Harley Shaw, *wildfelidmonitor@gmail.com*

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

Life is unpredictable, and I'm fascinated by stories of other peoples' career paths. Some are fortunate enough to know what they want to do, then devise a plan and achieve their goal. I would feel better about myself if that wasn't generally considered the norm. I knew I wanted to work with wildlife, but that's about as far as my "plan" went. A senior class spring break senior at Fort Lauderdale, Florida, opened this Ohio-born boy's eyes to the world of palm trees and salty seas. Part one of my plan became clear; I knew where I wanted to live. I'd figure the rest out after I got there. While still in college in Ohio, I had done an internship in Naples, in southwest Florida. More trips--"classes" on sailing in the Bahamas--cemented my affinity to clear water and warm breezes. So right after graduation, I moved to Naples, a familiar place, to start my career. Wouldn't you know it, there were no wildlife jobs to be had, and "tropical depression" took on a new meaning for me. Looking back, it was probably one of the dumbest things I've done. However, with perseverance I landed a job at the Florida Panther National Wildlife Refuge. Not as a biologist, or bio-tech even, but as a wildland firefighter. But hey, I was in the system. Or so I thought. I never got that coveted federal job, but after returning from one of the large fires out West we increasingly were called for, I was advised of an opening on the panther program with the Florida Fish and Wildlife Conservation Commission. My work ethic definitely carried more weight than my experience, but I did have some rope-and-harness tree climbing experience and a stomach that wasn't fazed by tight circles at 500 feet in a small airplane. Little did I know that a job in fire would transition to saving the endangered Florida panther.

That was 27 years ago. In many ways, I've come to view fire as a metaphor for life. A little spark sputters and falters for a bit before really taking off. Then, the flames go where the winds blow them and where there's fuel to consume. They can rage big and hot or creep along gently. Either way, there is a transition. I would love to hear "fire stories" from our members.

Our Perspective in this piece addresses fire in a more literal sense, and its author, Dr. Winston Vickers, is no stranger to fires. California's 2020 fire season introduced us to a new term – gigafire, denoting fire complexes that burn over a million acres. Questions about impacts to wildlife inevitably arise after such conflagrations, and Winston touches on the complexities of addressing these questions. Because of the unprecedented fires in 2020, we will be delving deeper into this subject in our next issue as we look at the effects of fire and climate change on wild cats. We ask that you share your research or experiences with us. Please contact the editor to add your contribution on this important topic.

The Invited Article on sequencing the puma genome, by Melanie Culver, et. al., is fascinating as well. I'll admit, the things we can learn from whole genome sequencing seem like science fiction to my feeble tree-climbing, ergo monkey, brain. The ability to detect ancient hybridization events brings to mind the scenes in the movie *Underworld,* where a vampire drinks another's blood to learn its history. The authors' closing statement brings genomics to my back door.

I particularly appreciate our Notes From The Field and this issue is no different. I'm sure many of us are fascinated by what's happening in Patagonia. When you consider how much effort goes into simply detecting presence of Florda panthers, who would have expected viewing pumas similarly to being on an African car safari? And as the future looks bright for Patagonian pumas, so, too, are things improving in Florida with females venturing northward in the state into areas they've been absent from for decades. Back in my birth state, bobcats are making a comeback and more intensive studies are examining the factors affecting two populations to better inform management decisions. One of our 2019 Wild Felid Legacy Scholarship recipients updates us on testing solar lights to protect domestic animals from jaguars and pumas. And all the way from Sweden comes strategies for using cameras to monitor Eurasian lynx, tactics that are applicable wherever wild felids roam. Finally, genetic and genomic analysis continue to lend insights into population structures and species management.

If you or your colleagues are currently looking at such questions as they pertain to wild felids, please consider sharing your research with our WFA readership.

There are a few upcoming conferences to note. One we're all watching closely is the 13th Mountain Lion Workshop, currently scheduled to be held in Hood River, OR April 12-15. Keep an eye out for conference details in case it goes virtual. The International Urban Wildlife Conference will be held virtually on May 25-27 (see page 14). And The Wildlife Society is planning another virtual event for their upcoming conference in September (page 17). An upside to so many conferences being virtual at the moment is that attending them is easier and cheaper because there are no travel expenses involved. Now is a good opportunity to spread your wings and drink up some knowledge that you may not previously had access to. In closing, I want to bring attention to our 2021 Wild Felid Legacy Scholarship. Details are on page 6 and the deadline to submit applications is March 30, 2021. The scholarship offers an excellent opportunity for you to contribute to wild felid conservation.

"If you have knowledge, let others light their candles in it."

~ Margaret Fuller.

WFA Council

OFFICERS

President
Mark Lotz, 2020-2022
Panther Biologist
Florida Fish and Wildlife Conservation Commission
Naples, FL, USA 34114
(239) 417-6352 *marklotz.wfa@gmail.com*

Vice President – North America
Veronica Yovovich, 2020-2021
Ecologist & Post-Doc, UC Berkeley
vyovovich@gmail.com

Vice President – Latin America
Sandra Ortiz, 2016-2021
Alianza Nacional para la Conservación del Jaguar
Mexico City, Mexico
(+52) 15560881709 sandrafelidae@gmail.com

Secretary
Ron Thompson, 2019-2021
Exec. Director, Primero Conservation
Pinetop, AZ 85935
leoneroronatsulross@gmail.com
info@primeroconservation.org

Treasurer
Jennifer Timmer, 2020-2022
Bird Conservancy of the Rockies
Fort Collins, CO
timmerj3@gmail.com

COUNCILORS

Lisa Haynes, 2019-2021
Research Scientist
U of Arizona Wild Cat Research & Conservation Center
Tucson, AZ, USA 85721
lynx@email.arizona.edu

Brian Kertson, 2017-2022
Wildlife Research Scientist
Washington Dept Fish & Wildlife
Issaquah, WA, USA 98027
(425) 478-7501 brian.kertson@dfw.wa.gov

Mauro Lucherini, 2017-2022
GECM, Department of Biology,
Universidad Nacional del Sur - CONICET
Bahía Blanca, Argentina
lucherinima@yahoo.com

Yamel Rubio Rocha, 2019-2021
Professor / Researcher
Universidad Autónoma de Sinoloa (UAS)
Sinaloa, Mexico
yamel@uas.edu.mx

Toni Ruth, 2017-2022
Executive Director, Salmon Valley Stewardship
Salmon, ID, USA 83847
(208) 993-1680 truthinsalmon@gmail.com

Past President
Anthony Giordano, 2020-2022
Director, S.P.E.C.I.E.S.
Ventura, CA USA 93003
(516) 982-6554 species1@hotmail.com

WFA Committees and Coordinators

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A few weeks ago, I was cresting the top of the hill at UC Santa Cruz on my bike when I my collegue Ritchie called. A young puma had wandered into the town of Capitola and needed to be captured and relocated, and we had to mobilize quickly to deploy a GPS collar. I turned around, grabbed the capture supplies from our lab, and headed out. The puma was curled up under a bush next to a house in a suburban neighborhood, surrounded by California Department of Fish and Wildlife personnel and police officers. CDFW darted the subadult male. Our team fitted him with a collar and ear tag and took samples and measurements; CDFW relocated him to the Santa Cruz Mountains. Five hours after getting that call I was at campus, processing the puma's blood sample, pleased that the relocation had gone smoothly. That afternoon sums up what my life has been like as PhD student working on the Santa Cruz Puma Project. I live and conduct fieldwork in the same place, and since my puma research is inherently opportunistic, I have frequently been pulled from my normal day to assist with a puma who wandered into an urban area, investigate a potential litter of kittens, locate the body of a puma who died, or set and monitor a trap overnight. These opportunities are thrilling in their own right, but I also appreciate that they highlight how closely we live alongside these charismatic large carnivores, often without realizing it. Carnivore conservation outside of protected areas and in more human-dominated spaces is increasingly recognized as key to their persistence. For this to happen, we need to figure out how large carnivores can coexist alongside humans in landscapes that we share with them. This is the central goal of my dissertation research, and why I feel so lucky to live and work in the Santa Cruz Mountains. As the backyard of Silicon Valley and San Francisco, and home to approximately 60 adult pumas and hundreds of thousands of people, this fragmented area is an excellent laboratory to examine how carnivores and people coexist. My research focuses on puma movement ecology and population dynamics, and the interplay between the two. One of my dissertation chapters, for example, examines whether pumas can accurately perceive and avoid risk from people. My other projects involve modeling puma population dynamics, quantifying habitat quality, and describing how pumas respond to human disturbance. The goal of my work is to inform puma conservation in the Santa Cruz Mountains, while also being applicable to other large carnivore populations in human-dominated areas. As for that puma in Capitola we helped relocate, his data suggests he still has not found a permanent territory. I am crossing my fingers that he will soon find a good spot to settle, but no matter what happens I feel grateful to be able to observe.

STUDENT REPRESENTATIVES

Coordinator: Sarah Hegg 2015-
sarahjhegg@gmail.com

Arizona
Marianela Vilella 2020-
mvelilla@email.arizona.edu
UA, Tucson

California
Anna Nisi 2017-
anisi@ucsc.edu
UC, Santa Cruz

Ellie Bolas 2019 -
ebolas@ucdavis.edu
UC, Davis

Colorado
Annie Kellner 2018-
aekellner@gmail.com
CSU, Ft Collins

Idaho
Cameron Macias 2021-
maci2896@vandals.uidaho.edu
U of I, Moscow

New England
Meredith Palmer 2016-
palme516@umn.edu
U of Minnesota, Twin Cities

North Dakota & South Dakota
Marlin Dart 2019 -
Mdart90@gmail.com
SD State U, Brookings

Oklahoma
Nathan Proudman 2021-
nathanproudman@gmail.com
OK State U, Stillwater

Oregon
Joel Ruprecht 2020-
Joel.ruprecht@oregonstate.edu
OR State U, Corvallis

Utah
Claudia Stout 2018-
distractedbynature@hotmail.com
Utah State U., Logan

Washington
Samantha Zwicker 2021-
Samathajane.zwicker@gmail.com
U of Washington, Seattle

Montana & Wyoming
Jennifer Feltner 2020 -
jafeltner@gmail.com
U of M, Missoula

REGIONAL REPRESENTATIVES
Latin America Coordinator:
Sandra Ortiz, *sandrafelidae@gmail.com*

North American Coordinator:
Michael Cove, mvcove@ncsu.edu

Argentina / Chile
Nicolás Caruso 2013-
nccaruso@gmail.com
UNS, Bahía Blanca, Buenos Aires

Brazil
Henrique Concone 2014-
ohvbconcone@yahoo.com.br
Instituto Pró-Carnívoros

Fernanda Cavalcanti 2018-
cavalcantifer@yahoo.com
Federal University of Goiás

Costa Rica
Ronit Amit 2018-
Jaguar.rar@gmail.com
University of Costa Rica, San José

Mexico
Sandra Ortiz, MVZ MsC 2016-
sandrafelidae@gmail.com
Alianza Nacional para la Conservación del Jaguar

Paraguay
Diego Gilberto Baez
gimenezdiego89@gmail.com
Chief Prog Officer, Chaco Jaguar Cons Project, S.P.E.C.I.E.S.

Peru
Alvaro Garcia Olaechea 2018-
agarolae@yahoo.com
Universidade Estadual de Santa Cruz, Brazil
Co-founder BioS

Venezuela
Maria Puerto Carrillo 2016-
maripuerto@gmail.com
Venezuelan Inst. for Sci. Research (IVIC)

Western Canada
Mitchell Flowers
mitchelljflowers@gmail.com
Univ. of Alberta, Edmonton

Southeastern USA
Michael Cove 2013 –
mvcove@ncsu.edu
NCSU, Raleigh

Southwestern USA
Lisa Haynes
lynx@email.arizona.edu

We are pleased to announce ~

The 2021 Wild Felid Legacy Scholarship

The Wild Felid Research and Management Association began awarding the Wild Felid Legacy Scholarship in 2009 to encourage and support graduate level university students involved in wild felid research. To date, 32 scholarships totaling almost $39,000 have been awarded. The scholarship honors distinguished and dedicated biologists who lost their lives while seeking to understand and contribute to the conservation of wildlife: Dave Maehr, Ian Ross, Rocky Spencer, Eric York, Deanna Dawn, and Donna Krucki. More on these inspiring biologists can be found on the WFA's web site: *www.wildfelid.org*. Scholarships are made possible through grants and donations to WFA from The Summerlee Foundation, Deanna Dawn's family, Altria Group, WFA members, and other anonymous contributors.

PURPOSE OF THE FUND: The Wild Felid Legacy Scholarship provides financial aid to a graduate-level university student conducting research on one of the Western Hemisphere's wild felids. Up to three scholarships of $1000 to $1500 each will be awarded during summer 2021 and recipients will be recognized in the WFA's newsletter, the *Wild Felid Monitor*. Applications are evaluated based on: demonstrated need for financial aid; participation in a research project that aims to improve our understanding of wild felid biology, management and/or conservation; and recommendations by professors and supervisors. WFA will continue to offer the scholarship on an annual basis, contingent on funding.

SCHOLARSHIP FUND ADMINISTRATION: The WFA's Scholarship Committee (SC) administers the Wild Felid Legacy Scholarship and selects recipients, who are subject to approval by a majority of the WFA Board of Directors. The SC reserves the right not to award a scholarship or to award more than one scholarship during a calendar year, depending on the SC's opinion of the applicants' qualifications and the availability of funds. All SC decisions are final.

APPLICATION CRITERIA: Scholarship Applicants must be a student member of the Wild Felid Research and Management Association (if not currently a member, simply go to our website at *www.wildfelid.org* and sign up). As of July 1, 2021, applicants also must have completed a Bachelor's Degree and be enrolled in a graduate program in Wildlife Biology, Wildlife Management, or a related natural resource field, with a research focus that includes wild felids. Recipients agree to provide at least one update on their graduate work for inclusion in the *Wild Felid Monitor*.

APPLICATION DETAILS *(also see http://www.wildfelid.org/legacy.php)*: The application includes 5 parts:

1. Current résumé.
2. Transcript or diploma indicating completion of a Bachelor's Degree.
3. A copy of your acceptance letter into a graduate program in Wildlife Biology, Wildlife Management, or related field.
4. Two letters of reference (with phone numbers and email addresses): one from a professor familiar with your academic capabilities and accomplishments; the second from a supervisor whom you worked for in a natural resources related position (volunteer or internship work is acceptable).
5. A short essay (500-750 words) describing: (1) your interests in wild felid research; (2) your career goals; (3) how you would use the award to further your professional development; and (4) your demonstration of financial need. At the top of your essay, provide the following: name and email address; degree applying for; department and university attending; major advisor and their email address; thesis/dissertation title; research objectives; completion date.

To see how applications are scored, visit our scholarship page at *www.wildfelid.org/legacy.php* and click on "Evaluation form used to score applicants."

Emailed applications are preferred. Part 1 (essay) should be sent as a Word document. Clearly name files with your last name and subject (e.g., Smith WFLS Essay.doc). Emailed copies of your scanned transcripts, diploma and graduate acceptance letter are acceptable. References can also send their letters electronically.

All application materials must be received by the Scholarship Chairperson by **MARCH 30 2021**. Incomplete applications will not be considered.

Completed applications should be emailed to Dr. Marcella Kelly, Associate Professor at:
makelly2@vt.edu
Please put "Wild Felid Legacy Scholarship Application" in the subject line.

A perspective on wildfire and pumas (*Puma concolor*). What do we really know, what are the major questions that exist, and how can we communicate the story of pumas and wildfire in a more consistent way?

Winston Vickers, DVM, MPVM, Associate Veterinarian, UC Davis Wildlife Health Center, *twvickers@ucdavis.edu*

Whenever wildfire occurs, especially if injured wild animals are found afterward, questions are posed to researchers about wildfire impacts on wildlife. This is especially true when the animals involved are charismatic megafauna like pumas. This often gives researchers an opportunity to focus attention on these animals and conservation messaging. However, contradictory information sometimes reaches the public through journalistic license or overstatement, something most researchers are familiar with. Recent articles and headlines relating to wildfire and pumas have ranged from apocalyptic "California wildfires may have killed hundreds of cougars *(https://wildlife.org/california-wildfires-may-have-killed-hundreds-of-cougars)* to articles about fire being essential to fire-adapted landscapes and wildlife (numerous articles).

Female puma and kittens in Silverado Fire footprint 13 days after ignition. Photo courtesy of Irvine Ranch Conservancy

The basic question that pertains might be "Is a given wildfire, or a region's wildfire pattern in total, a disaster for pumas in the area, or a godsend, or somewhere in between?" Since it can be any of those, depending on whether one is referring to a large wildfire affecting a small isolated population, a large area of habitat affected by a mix of fire intensity, size, and local conditions, or long term changes to whole ecotones, answers are not easy or general. The ability of pumas to avoid serious effects of wildfire as a group or as individuals can vary tremendously, including effects such as human-puma interaction changes, and making general statements about these, either positive or negative, is rarely possible.

In 2003, when I had just begun working in puma research with Walter Boyce of the UC Davis Wildlife Health Center, the largest wildfire in California history up to that time (the 237,000 acre Cedar Fire) swept through our study area in southern California. That fire and others in southern California over the course of our study provided us with a natural experiment relating to wildfire and pumas that was rare until then, and that has occurred only occasionally since. A simultaneous mule deer study in the area gave us a chance to study the effects on prey as well.

Though one collared puma was lost in that fire (and an estimated 10-15% of the deer herd), other collared pumas in our study area that circulated during and after that fire and other fires in the region have continued to use their established home ranges. Post-fire use of burned areas has been higher than unburned areas overall up to 14 years post fire, especially in the first 9 years (Jennings et al. 2016). Only one other of our collared pumas has died in fire since 2001, and females with kittens have been documented immediately after fire on several occasions.

Over 4.2 million acres have burned in California as of early December 2020, with a late season wildfire burning in our study area in southern California as I write this. But remember that acreage burned is made up of 9,279 fires of vastly varying sizes and intensities (CALFIRE; *www.fire.ca.gov*). To my knowledge no collared pumas have succumbed in any of these fires in 2020 despite studies being underway in several of the wildfire areas, and to my knowledge only one confirmed and one suspected collared puma mortality has occurred in other puma study areas in California in the last couple of decades. All in all it appears that pumas and their primary prey of mule deer and elk are actually pretty good at getting away from most wildfire, with most animals surviving and populations remaining generally intact.

Pumas are compelling animals to humans, and fire effects on pumas can either be a good news story (improved deer/elk browse for several years after fire, and thus puma prey density increase), or a bad news story (long term potential for negative effects on total habitat). Having a charismatic animal to hang our messages on gives us tremendous opportunities to emphasize better management and policy prescriptions in areas such as controlled burns, climate change, and development planning that can benefit pumas and many other species.

Expanding research to better understand the impacts of wildfire on pumas on a more granular and local scale is essential, and this knowledge can have the most positive impact on policy and local decision-making to benefit this species and other wildlife. Developing consistent messaging can be helpful so that we collectively avoid oversimplification. We should not be hesitant to get into the weeds (so to speak) with journalists, policy makers, and the public. We need to clearly state that the answers are complex, depend on a lot of factors, and that there is a lot we are ignorant of at the moment (hard to admit). This approach gives us the opportunity to emphasize that we need to know more and to promote the idea of the need for more research, the goal we all have in order to give better answers than we can now.

Sequencing the puma genome: Why? And how is it beneficial for conservation and management?

Melanie Culver[1], Alexander Ochoa[2], Robert R. Fitak[2]
[1] U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit and School of Natural Resources and the Environment, University of Arizona, Tucson, AZ, USA.
[2] Department of Biology, Genomics and Bioinformatics Cluster, University of Central Florida, Orlando, FL, USA.

Since the 1990s genetic markers have played an important role in wildlife management and conservation, particularly for pumas. The applications include defining taxonomic units, quantifying inbreeding, characterizing population structure (i.e., current gene flow or modeling allele frequencies over time), and identifying forensic samples to detect illegal harvesting and trading activities. Over the last 30 years, the applications for genetic markers have subsequently grown to include many aspects of population demographics, evolution, history (e.g., population size estimation and monitoring, or relatedness tracking), ecology (e.g., measuring migration rates and dispersal distances), and behavior (e.g., ascertain reproductive strategies/success, migratory pathways, or prey choice). Biologists and wildlife managers have utilized these results in preventing the further loss of genetic diversity, reducing inbreeding in wild or captive populations, selecting individuals for translocation, and in setting harvest numbers.

So, with all these major achievements in Conservation Genetics, why are whole genomes needed? Genomic methods, in particular whole genome sequencing (WGS) and methods employing next generation sequencing (NGS) technologies, provide a higher-resolution perspective of questions than that examined with former and traditional genetic markers. They have opened questions in wildlife management and conservation previously not available. Genomic resources, originally developed for use in model species and human genetics, have been utilized extensively in wildlife and felid conservation in the past decade and include a variety of marker types. These markers cover regions of the genome shaped by specific, yet different, processes, such as regions (or genes) transcribed into proteins, non-protein-coding regions, regions under selection (i.e., directional, balancing), and neutrally evolving. Depending on the number and type of markers, they will provide approximately the same level of resolution as methods in prior decades (i.e., if using ~100 single nucleotide polymorphisms [SNPs]). Some common methods, such as those based on sequencing a large, albeit reduced, portion of the genome (Restriction-site Associated DNA sequencing, RADseq and Genotype by Sequence, GBS) will still provide a much higher resolution survey (i.e., those resulting in an average of 1,000 – 100,000 SNPs throughout the genome). Finally, WGS has the data and power to examine a new set of questions previously unattainable. WGS can examine selection across the genome (positive, negative, or neutral) including the search for diseases, genes contributing to inbreeding depression and adaptation to environmental changes, the accumulation of deleterious mutations or variants (genetic load) resulting from severe inbreeding and subsequent genetic drift, and the extent and timing of hybridization events. Detecting hybridization events using nuclear DNA haplotypes from genomic data is becoming increasingly important in felids such as in the tigrina which hybridizes with both Geoffroy's cat and Pampas cat (Trigo et al. 2008). Also, more ancient hybridization events can be examined as with the mixing of ancestors of the *Puma* and *Lynx* lineages, prior to their migration into North America. Without this ancient hybridization event, the puma lineage would actually appear most closely related to the Bay Cat lineage (Gang et al. 2016). Examples of examining genetic load in severely inbred species, using whole genome sequencing, can also be found in canid species. In California's endangered Channel Island Fox population, genomic analyses showed that instead of purging (eliminating deleterious alleles in homozygous state from a small population due to selection), they saw an increase in deleterious variants, amid a background almost devoid

Acinonyx jubatus	cheetah	*GCA_003709585.1*
Felis nigripes	black-footed cat	*GCA_004023925.1*
Lynx canadensis	Canada lynx	*GCA_007474595.2*
Lynx pardinus	Spanish lynx	*GCA_900661375.1*
Panthera leo	lion	*GCA_008795835.1*
Panthera onca	jaguar	*GCA_004023805.1*
Panthera pardus	leopard	*GCA_001857705.1*
Panthera tigris	tiger	*GCA_000464555.1*
Prionailurus bengalensis	leopard cat	*GCA_005406085.2*
Puma concolor	puma	*GCA_004123975.1*
Puma yagouaroundi	jaguarundi	*GCA_014898765.1*

Table 1. Latin name, common name, and GenBank accession number for the 11 wild felid genome sequences in the publicly accessible database.

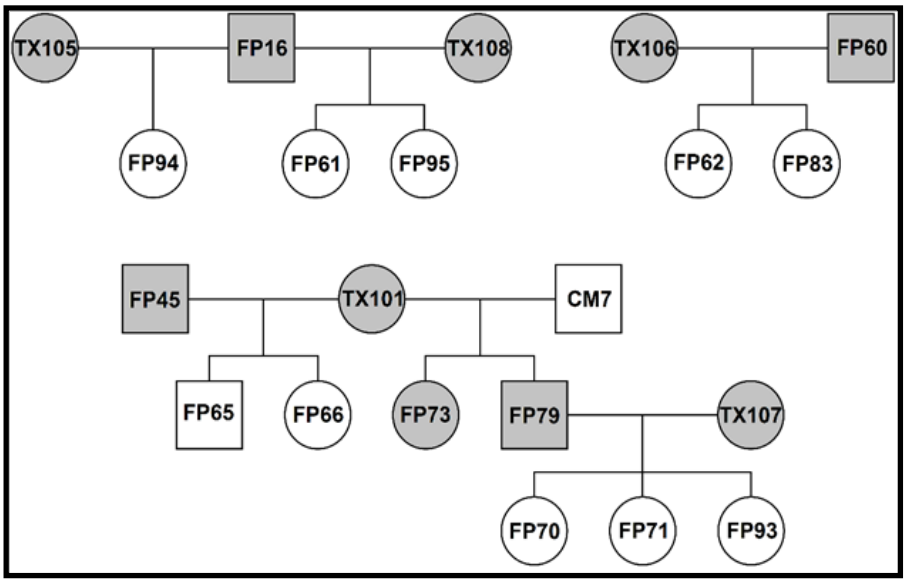


Fig. 1. Pedigree of the Florida-Texas-F1 trio individuals (highlighted in gray) used in Ochoa et al. (2019). Circles are females and squares are males. The five female Texas pumas that bred in Florida panther habitat as a result of an introduction in the mid-1990s are samples TX101, TX105, TX106, TX107, and TX108. Four Florida panthers that mated with these Texas pumas are represented as FP16, FP45, FP60, and FP79. An additional Florida panther (FP73) was sequenced to determine the genetic background of an unsampled Florida panther (CM7) that mated with a Texas puma (TX101). (Reproduced from Ochoa et al. 2019).

of genomic variation (Robinson et al. 2019).

The Isle Royale wolf population is an example of isolation followed by extreme inbreeding, and genomic analyses have found evidence of severe inbreeding depression due to strongly deleterious recessive mutations, with an overall homozygous genome for the population (Robinson et al. 2019). Regardless of the method, genomic techniques have already provided a boost to conservation of wild felids (and other species) by providing higher-resolution, landscape-level population genetics, kinship, paternity, and selection across the genome. In some instances,genomic methods have even shown better performance in degraded samples (i.e. scat or museum samples; Fitak et al. 2016).

WGS is becoming increasingly common. To date, complete or draft genomes exist for the domestic cat and 11 felid species. The puma genome is the most recently sequenced felid genome. Our study (Ochoa et al. 2019), which performed de novo genome assembly and annotation from 10 Florida-Texas-F1 trio individuals (Fig. 1) associated with the Florida panther genetic restoration program of the mid-1990s, had four main goals: i) develop bioinformatic resources (i.e., genomic databases) for the future exploration of genetic variants related to inbreeding depression traits (e.g., cryptorchidism, heart disease) in Florida panthers, ii) determine the genetic contribution of Texas pumas to the Florida panther gene pool, iii) detect genes under positive selection and assess gene expansion and contraction events (gain and loss of genes) in the puma lineage, and iv) describe the demographic history of North American pumas.

Our sample set included the five female Texas pumas that were introduced in Florida and that produced offspring with Florida panthers, four male Florida panthers that mated with these females, and another Florida panther that resulted from the mating of a Texas puma and an unsampled male Florida panther (Fig. 1). Specifically, two Florida panther samples (FP45 and FP60) had a 'pure' or canonical Florida origin, one Florida panther sample (FP16) had a hybrid Florida-Central America origin, and two Florida panther samples (FP73 and FP79) represented the F1 progeny of a Florida panther male and a Texas puma female (Fig. 1).

Approximately one quarter (24.2%) of the alleles contained across the ~6.2 million polymorphic sites found in our entire sample set were unique to the Texas pumas, while only 1.6% of these alleles were unique to the canonical Florida panthers (Fig. 2A). The Florida panther of mixed Florida-Central America origin (FP16) alone contributed8.7% unique alleles,

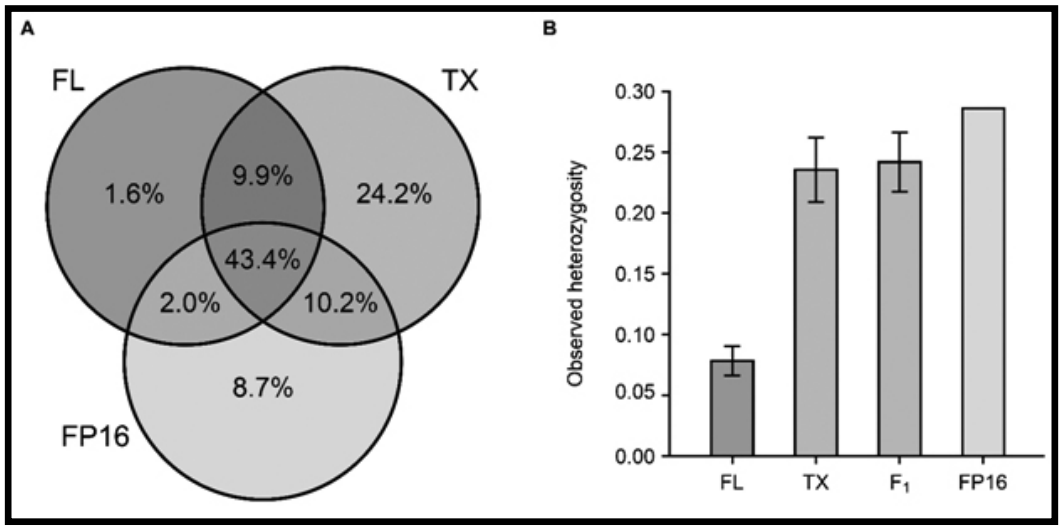


Fig. 2. Genetic contribution of Texas pumas to the Florida panther gene pool. A) Proportion of unique and shared alleles found across ~6.2 million polymorphic sites in canonical Florida panthers (FL: samples FP45, FP60, and CM7), a Florida-Central America hybrid Florida panther (sample FP16), and Texas pumas (TX: samples TX101, TX105, TX106, TX107, and TX108).B) Observed heterozygosity across ~6.2 million polymorphic sites in FL, TX, F1(samples FP73 and FP79), and FP16. (Reproduced from Ochoa et al. 2019)

many of which are hypothesized to reflect local adaptations from Central America. From the trios analyzed, F1 (Texas-Florida mixed lineage) panthers exhibited a three-fold increase in genetic variation (i.e. heterozygosity) relative to their pure Florida panther parents (Fig. 2B).

We identified 20,561 protein-coding genes present in the puma genome - a similar number to other felid genomes. Gene families were contracted for olfactory receptors and gene families were expanded for neuronal and embryological development.We also characterized 17 positively selected genes related to the refinement of sensory perceptions, in particular visual capabilities. Taken together - we speculated that this evidence from gene families and positive selection indicates senses were refined in pumas, such as vision, at the expense of others such as smell, and this might reflect the puma's keen hunting abilities. Positive selection also included genes associated with the vomeronasal organ, an auxiliary olfactory organ useful in detection of predators, prey, and sex pheromones. We also detected positive selection for genes related to transcribing virus DNA present in the puma genome which might be of interest for puma conservation. Pumas (and all wildlife) are continually exposed to an abundance of novel viruses due to environmental factors altering viral dynamics, some of which may be harmless and some may be associated with disease. Each novel virus is recognized as novel or not by the immune system, as the host samples and processes viral particles for recognition and potential elimination.

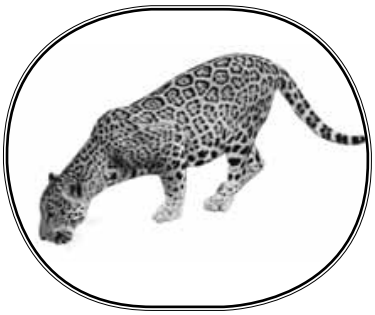
We also performed demographic modeling using the genome-wide SNPs in each individual puma. Results from the Texas and Florida individuals found that the North American population reached a maximum effective size of 40-60,000 during the late Pleistocene (30-60,000 years before present [ybp]) after which a sharp decline was observed. The demographic analyses were consistent with a recent colonization event in North America by a small number of founders, such as that first proposed by Culver et al. (2000) during the last glacial period.

A second puma genome paper was also published in 2019 which more broadly focused on the puma's range to include individuals from Florida, Wyoming, California, and Brazil (Saremi et al. 2019). They dated the divergence between North and South American pumas at approximately 200,000 ybp and the expansion for North American pumas also at approximately 21,000 ybp. Looking for population structure, three populations had the highest support: 1) South America plus Central American introgressed genes from Florida, 2) California and Wyoming, and 3) Florida. Finally, the authors analyzed long genomic stretches devoid of variation, called runs of homozygosity (ROH), to infer isolated populations and inbreeding. ROHs are inherited as a single block of genes unbroken by recombination, and, once formed , due to either inbreeding or hybridization/introgression, will take a long time to break apart (decay). In particular, inbred populations have exceptionally numerous, and long ROHs, because variation is required to break them apart. However, in outbred populations with lots of migration and mixing from other populations, ROHs will decay quickly. Their results indicated that Brazil had the fewest ROHs and highest heterozygosity, whereas pure Florida panthers had the most ROHs and lowest heterozygosity, with California and Wyoming falling in between. Florida panthers are known to be severely inbred and South American pumas generally the most outbred pumas (Culver et al. 2000) so these results were consistent with expectations.

Do managers find this puma genomic data useful? Here, two studies provided an extensive set of genomic resources for future studies of the puma, and have elucidated the genomic effects of genetic rescue on the Florida panther. Estimates from both studies are consistent witha recolonization of North America ~20,000 ybp after a decline during the Pleistocene. Population structure analyses continue to support the existence of only a single North American subspecies. Novel analyses, such as those using ROHs, are unique to genomic data and can inform managers of isolated populations. Saremi et al. (2019) demonstrated that more isolated populations had longer ROHs relative to more connected populations. Genomic data on pumas provided effective population size estimates for pumas, size of historical bottlenecks for pumas, timing of historical and current bottlenecks. Further characterization of the genetic rescue that occurred in Florida panthers by Texas pumas may be yet to come in future genomic studies but already selection for beneficial and negative alleles has been elucidated by Ochoa et al. (2019). We will continue to be interested in tracking whether Florida panthers had unique adaptations diluted, or confounded, by the Texas admixture or if the Texas alleles, when not neutral, had beneficial effects across the entire genome.

WFA Welcomes New Members

WFA welcomed 62 new members to our organization in 2020. A majority of those new members (40) joined during our "buy one year, get one year free" membership drive this past summer, including 15 at the student level, 14 at the standard level, and 11 at the newly offered "Latin American standard" level. We want to thank Pat Bumstead, Director of the International Society for Endangered Cats (ISEC), Canada, whose organization provided a donation to support 20 of those new members. New student members come from all over the USA as well as Mexico and Costa Rica. New Latin American members hail from Argentina (2), Bolivia (1), Brazil (5), Guatemala (1) and Mexico (2); many have been involved with jaguar, puma or small wild cats, on projects that examine habitat use and protection, conflict mitigation and coexistence, and diseases. We are looking forward to seeing articles on some of their research, management and conservation efforts in future issues of *The Wild Felid Monitor.*



Argentina

The Argentine Society for the Study of Mammals (SAREM, for its initials in Spanish) together with the Ministry of the Environment and Sustainable Development have completed a long process of revision of the conservation status of the 395 native mammals species that currently inhabit Argentina. Among them are 11 species of felids, 7 of which are under some level of threat. The jaguar (*Panthera onca*) and the Andean Mountain cat (*Leopardus jacobita*) are the felid species that have the most dire conservation status (CR and EN, respectively), followed by the *L. colocolo, L. guigna, L. guttulus, L. pardalis, L. tigrinus* and *L. wiedii,* all of which are listed as Vulnerable. The conservation status for *Puma concolor, L. geoffroyi,* and *Herpailurus yagouaroundi*, are all "Least Concern": *https://cma.sarem.org.ar/es.*

Dr. Alejandro Valenzuela and his group work in conservation and management of native and exotic carnivores in Southern Patagonia. Dr Valenzuela is the doctoral advisor of Ian Barbe, who just began his doctorate project to study puma populations in Santa Cruz province (southern Argentina) under three land use scenarios: livestock production ranches, touristic activity areas, and strict protected areas. The project adopts a socio-ecological framework where the main objectives are to: i) analyze the spatial, temporal and trophic niche of the species and its relation with other species, mainly with those with a high social, economic and/or tourist value (including sheep, penguins and deer); ii) study the social perceptions and attitudes of local people about the puma and their willingness to support conservation actions; and iii) integrate all the generated knowledge to promote the conservation of this species through informing the decision makers and managers. Dr. Valenzuela and his team are planning to install camera traps and complete interviews with local people around Monte Leon and Los Glaciares National Parks during the next year. For more information, please contact Dr. Valenzuela at: *avalenzuela@untdf.edu.ar*

~Nicolas Caruso

Brazil

Since the mid-1990's (Garcia-Perea 1994) there has been a debate on the validity of splitting the Pampas cat complex (*Leopardus colocola*) into distinct species. Using an integrative approach with evidence based on morphology, molecular data and environmental niche models, Nascimento et al. (2020) proposed a taxonomic revision that includes five species. Two of those (*L. munoai* and *L. braccatus*) occur in Brazil and are now accepted by the main federal agency that manages biodiversity in the country as well as the Brazilian Society of Mastozoology (Abreu et al. 2020). Main threats for both species are related to habitat loss and fragmentation, mostly due to the expansion of monocultures in Cerrado and Pampas biomes, but also caused by land management practices related to cattle ranching such as grassland fires. Projections of Brazil's Ministry of Agriculture, Livestock and Supply related to expansion of agribusiness show increasing threats to both species, and especially to *L. munoai* due to its limited distribution in the country. Another important threat is mortality from vehicle strikes on roads that criss-cross most of the cats' natural habitat. Therefore, it was urgent to revise the pampas cat's conservation status in Brazil, which in 2014 was listed as regionally Vulnerable (under IUCN criteria). During the first week of December 2020, Brazil's Chico Mendes Institute for the Conservation of Biodiversity (ICMBio) coordinated the Virtual Workshop for Evaluation of the Conservation Status of Pampas Cat, where 15 specialists, managers, and facilitators from 9 institutions worked on the evaluation of *L. munoai* and *L. braccatus* as two distinct species. The final status of both species is now under a validation process and will be published by ICMBio sometime during the first half of 2021. The evaluation process is the first, essential component of ICMBio's strategy for biodiversity conservation, providing a diagnosis to direct attention and effort toward species needing more urgent conservation actions, such as these two pampas cat species.

~Henrique Concone

California

In April 2020, the California Fish and Game Commission voted unanimously to consider listing several populations of pumas in southern California as an Evolutionary Significant Unit that is threatened or endangered under the California Endangered Species Act. This decision was in response to a petition filed by the Center for Biological Diversity and the Mountain Lion Foundation in June 2019, and begins a 1-year review period on the status of pumas by the California Department of Fish and Wildlife.

Several analyses have examined puma population dynamics, movement, and genomics across the broad spatial scales. At the statewide level, using population simulations alongside bounty, vehicle strike, and depredation permit data, Dellinger et al. (2020a) reconstructed historical population dynamics for pumas in California from 1906-2018 and found that the puma population decreased during periods when bounties were in effect and increased following their legal protection as a specially protected mammal. Looking at statewide patterns of puma habitat selection at two spatial scales, Dellinger et al. (2019) found that pumas select home range locations to meet energetic needs and within-home-range movements were governed by avoiding people. This analysis also quantified the amount of suitable puma habitat statewide and found that 50% of suitable puma habitat is currently unprotected. At the transcontinental scale, Saremi et al. (2019) used genomics approaches to reconstruct the history of pumas in North and South America and found that pumas likely originated in South America and dispersed northwards. Their work also examined current patterns of genetic diversity and shed light on genetic impacts of recent translocations as well.

There were several studies that specifically focused on connectivity in populations of wild felids in California. Dellinger et al. (2020b) found that large areas of suitable habitat for mountain lions are highly correlated with strong genetic diversity in distinct populations, and identified minimum habitat needs for distinct populations to maintain suitable effective population sizes. Five populations that are genetically at risk (Santa Cruz, Santa Monica Transverse Range, Eastern Peninsular, and Santa Ana populations) also have insufficient available habitat. However, increasing connectivity can help with persistence with these populations, and in the case of the Santa Cruz and Santa Monica populations, increased connectivity will also increase available suitable habitat to meet minimum thresholds (Dellinger et al.

2020b). Additionally, three studies examined connectivity in bobcats in southern California (Los Angeles, Orange County, and San Diego) both at the population level and across the region. Kozakiewicz et al. (2019) analyzed a data set of 13,520 SNP loci from 271 individuals and assessed gene flow across resistance surfaces using circuitscape. Smith et al. (2020) analyzed a data set of 11 microsatellite loci from 422 individuals (including individuals from northern California) and assessed genetic and geographic distances across resistance surfaces. Both Kozakiewicz et al. (2019) and Smith et al. (2020) found that freeways were a barrier to gene flow and created population structure (i.e., the 101-freeway north of Los Angeles and I-5 in Orange County created distinct populations). Combined, these two studies provide strong evidence that human development (including impervious surfaces, housing density, roads, and energy infrastructure) limit gene flow across the region and for specific populations (Kozakiewicz et al. 2019, Smith et al. 2020). Of note, Smith et al. (2020) also found evidence for gene flow between northern and southern California bobcat populations. A third test for connectivity of bobcats in southern California assessed the phylogenetic structure of feline immunodeficiency viruses in 292 individuals (Kozakiewicz et al. 2020). As in the landscape genetics studies, major freeways and dense urban development limit transmission of FIVs for bobcat populations, and each bobcat population that is genetically distinct hosts a strain of FIV that has a distinct evolutionary history that may have been shaped to human development (Kozakiewicz et al. 2020).

Management and conservation planning was a theme for several projects this year. Caldwell and Klip (2020) used occupancy models to look at wildlife use of highway underpasses. Predator-prey interactions drove corridor use for pumas and mule deer as well as coyotes and lagomorphs, and pumas, bobcats, and coyotes avoided human disturbance spatially and temporally in utilizing corridors. Laundre and Papouchis (2020) compared California, which does not allow sport hunting of pumas, to 10 western states that allow sport hunting to examine whether hunting achieves its motivating management goals of reducing puma populations, reducing encounters with people, reducing livestock depredation, and increasing ungulate abundance. They found that sport hunting is not effective at any of these four goals, suggesting that the use of sport hunting as a management tool should be rethought. Finally, Suraci et al. (2020) modeled puma movement across a high-priority corridor connecting the Santa Cruz Mountains with the neighboring Diablo Range across different revegetation scenarios, shedding light on the role of vegetation patch characteristics on puma movement requirements through a largely unsuitable matrix habitat.

Multiple studies examined the impacts of humans on various aspects of felid behavior, with two studies focussing on recreational impacts on wildlife. Townsend et al. (2020) monitored occupancy of pumas, bobcats, and several other species following trail openings, and while several species altered their use patterns following trail opening, these effects disappeared after 9 months. A similar study found that bobcat detections decreased by roughly 40% following opening of trails to hikers and bikers at a park in San Diego (Larson et al. 2020). Nickel et al. (2020) compared the effects of human presence (measured via camera traps on trails) and human footprint (building infrastructure) on occupancy of pumas, bobcats, and other species and found that human presence and footprints were non-equivalent and effects varied by species. Both pumas and bobcats avoided human footprint spatially but mainly avoided human presence via temporal partitioning. Yovovich et al. (2020) modeled habitat selection for pumas for reproductive behaviors in the Santa Cruz Mountains and found that projected human development in the area may eliminate substantial portions of suitable habitat. Finally, Hardesty-Moore et al. (2020) found that bobcats are less likely to use riparian habitats overrun with invasive arundo as compared to native habitats, although they still occur in arundo habitats, possibly because small mammal abundances remain constant across both habitat types.

Several studies shed light on various aspects of puma physiology. Dunford et al. (2020) found that steep terrain strongly drove puma energetic expenditure and that pumas alter movement behavior in steep areas to minimize these costs. Bleich et al. (2020) present hematological information for pumas in the Sierra Nevada, highlighting the impact of elevation on hematology. Finally, Weiss-Penzias et al. (2019) found that fog-borne monomethylmercury bioaccumulated through the coastal food chain resulting in much higher mercury levels in pumas in the Santa Cruz Mountains compared to pumas living inland.

There were also two studies on pathogen transmission in puma populations from Colorado, California, and Florida. A phylogenetic investigation of feline foamy virus (FFV) in both domestic cats and pumas found that FFV has two variants found in both felids, and transmission occurs from cats to pumas and between pumas (Kraberger et al. 2020). Transmission (force of infection) of feline immunodeficiency virus (FIV) in those same puma populations is constant with respect to age (Reynolds et al. 2019). There is a higher prevalence of FIV in males than females, and prevalence increases with age, however, there is no evidence of mortality associated with the disease (Reynolds et al. 2019).

~ Anna Nisi
~Ellie Bolas

Colorado

Human conflicts with mountain lions generate high-interest news stories, most recently seen in a viral video in which a hiker was escorted for several minutes by a female mountain lion boldly defending her cubs. Gauging the lasting impact of such incidents on public perception can be a time-consuming process, though understanding human attitudes towards wildlife is a critical component of carnivore management. Kerrick et al. (in prep) explored a novel means of investigating real-time public opinion of mountain lions before and after a high-profile incident in Colorado: the ambush of a hiker in February 2018 who ultimately killed a young mountain lion in self-defense. Kerrick et al. collected tweets nation-wide for three months before and after the event, classifying tweets by attitude (positive, negative, or neutral towards mountain lions). Prior to the attack, attitudes were divided roughly equally (48% positive; 51% negative), but after the attack attitudes shifted strongly negative (25% positive; 72% negative). However, the negative shift was short-lived, with a strong negative pulse in the month following the attack and a return to baseline thereafter. This pattern is reminiscent of other sensational events such as mass shootings, in which there is a sudden

pulse of sentiment followed by an abrupt decrease in interest. It is not known, however, whether an accumulation of such events will cause a gradual overall shift in attitudes towards a relatively well-tolerated predator. This study contributes to a contemporary understanding of attitudes towards mountain lions as well as methodology for future longitudinal studies on public perception of mountain lions and other carnivores.

~Annie Kellner

Idaho

In 2019, researchers at the University of Idaho and Idaho Department of Fish & Game (IDFG) began several five-year research projects known collectively as the Ecology of Everything Project. Focusing on large predators (cougars, black bears, wolves) and ungulates (white-tailed deer, mule deer, elk, moose) in northern Idaho, researchers are using literature and existing IDFG data to model predator-prey interactions and the influence of harvest on community dynamics; GPS data from collared ungulates for survival, cause-specific mortality, and reproduction data; and a combination of GPS data from collared predators, non-invasive genetic analysis of predator scat samples and remote cameras to estimate predator movement rates, predator density, and ungulate consumption by predators. The Ecology of Everything Project also encompasses several ungulate-focused research projects. The salient goals of these projects are to assess the population dynamics of Idaho's predator-prey community and to improve existing methodologies for big game monitoring and management.

~Cameron Macias

North Dakota

Tedd Darnell, a Ph.D. student from the University of North Dakota, surveyed 2,000 residents of North Dakota in the spring of 2019 to better understand their attitudes towards the state's extant mountain lion population. Darnell also attempted to determine if residents' decision to recreate in the Badlands regions of North Dakota is influenced by the presence of mountain lions. A K-means cluster analysis was used to create a binary response variable, either pro- or contra-lion attitude. Logistic regression analysis was used to identify factors that may explain or predict general attitudes towards mountain lions. The results suggested that slightly more North Dakota residents were pro-lion than contra-lion. A pro-lion attitude was associated with respondents being less worried about mountain lions, lower perceived risk associated with mountain lions, and a belief that human-lion encounters were decreasing. Darnell found little evidence that mountain lions influenced recreation in the Badlands region of North Dakota. The specific methods and results of this investigation are currently under review by the Wildlife Society Bulletin and hope to be made public soon.

North Dakota Game and Fish Department (NDGF) reports no significant changes in mountain lion harvest regulations. During the 2019/20 season, 17 mountain lions (7 female and 10 male) were legally harvested. From July 1, 2019 to June 30, 2020, NDGF recorded 53 mountain lion reports, of which 24 reports were verified through carcass, photograph or video, DNA analysis, tracks, scat, or a kill site confirmed by a qualified wildlife professional. Harvest and verified reports are consistent with recent years. Genetic analysis of mountain lion tissue samples from individuals harvested outside of the only known breeding population within North Dakota assigned 3 males to the Black Hills (South Dakota) population and 1 female to the Montana population. This year's bobcat report has yet to be completed, but NDGF reports that harvest and harvest regulations have been stable for years.

~Marlin Dart

South Dakota

Dr. Robert Lonsinger's Lab at South Dakota State University has two bobcat research projects in progress. Marlin Dart is evaluating the influence of landscape patterns, land-cover features, and intraguild interactions on the spatial and temporal ecology of bobcats in southeastern South Dakota. In two field seasons, 354 camera sets (n = 180 in 2019, n = 174 in 2020) collected 10,365 trap nights of data (mean = 29.3 trap nights ± 5.9 SD). Data from 2019 has been completely processed, finding 57 bobcat and 1 mountain lion detections. Preliminary estimates of bobcat occupancy (0.18, 95% CI = 0.12, 0.26) suggested space use is limited.

The second research project, conducted by Stuart Fetherston, is providing information on the population genetic structure of bobcats across South Dakota. The objectives are to (i) use harvested bobcat samples to identify the number and the spatial arrangement of distinct genetic populations, and (ii) create a statewide model of landscape connectivity for bobcats. Harvest samples from 2014-2019 (n = 1,225) have been genotyped at 17 microsatellite loci and a sex marker.

Erin Morrison, a West Virginia University (WVU) graduate student, is working with Dr. Christopher Rota (WVU Professor) and Dr. Chad Lehman from South Dakota Game Fish and Parks to investigate reproductive rates, kitten survival, and den site selection of bobcats in the Black Hills of South Dakota. During the 2020 season, ground triangulation for 27 adult female bobcats located 18 den sites from 14 bobcats. Thirty-one kittens were capture and 29 expandable VHF radio collars were deployed. Kitten capture occurred from May to July and the survival rate as of October 15, 2020 is 55.17%. Eighteen dens were surveyed along with paired random sites to evaluate den site selection.

The 2019/20 mountain lion season concluded with 51 mountain lions, including 27 females, harvested within the Black Hills Fire Protection District, falling short of the 60 total or 40 female harvest limit. These harvest estimates include 11 mountain lions (9 male and 2 female) that were harvested within Custer State Park. On the prairie outside of the Black Hills, 14 mountain lions (10 subadult males, 1 adult male, and 3 subadult females) were harvested from April 1, 2019 to April 30, 2020. The South Dakota bobcat report has been delayed due to the COVID-19 pandemic.

~Marlin Dart *marlin.dart@sdstate.edu*

Regional News

New Jersey

The bobcat (*Lynx rufus*) is New Jersey's only wild felid. This previously widespread carnivore was extirpated from New Jersey by the late 1970s due to habitat degradation and excessive harvest for pelts. The current New Jersey bobcat population is descended from 24 individuals that were reintroduced from Maine in the 1980s. The bobcat remains listed as endangered within the state of New Jersey and little is known about how this species navigates the high human footprint of the US's most densely populated state. The New Jersey Departments of Fisheries and Wildlife, Environmental Protection, and Endangered and Nongame Species have continuously monitored the nascent bobcat population since 2000. This year, Ria Matos of Montclair State University used these data to conduct the first investigation of bobcat home range size and habitat utilization in this part of the US. While bobcats in other parts of North America exhibit sexual and seasonal differences in home range size, data from 24 GPS collared bobcats monitored between 2002-2016 suggests that male and female New Jersey bobcats have similar sized territories and that territory size remains constant throughout the year, even as prey abundance and energetic demands fluctuate. Females were found to use forested landscapes more than males, while males utilized agricultural areas to a higher degree than females. These key differences between bobcat natural history in less densely populated areas compare to what has been found in NJ provide valuable information for shaping on-going conservation and anagement decisions in this recovering population. For more information, Rita Matos' M.Sc. thesis can be accessed online: *https://digitalcommons.montclair.edu/etd/505/.*

~Meredith Palmer

British Columbia

The Southern BC Cougar Project (*bccougarproject.weebly.com*) initiated by the University of British Columbia Okanagan (UBCO) and the Government of British Columbia completed its first year of the project in December 2020. This project is lead by Ph.D. student Siobhan Darlington in the WiRE and Hodges Labs at UBCO and provincial wildlife biologist T. J. Gooliaff and aims to address key knowledge gaps on cougar ecology in British Columbia's southern interior. Objectives of the study include 1) analyzing cougar kill rates and diet composition where mule deer and bighorn sheep are in decline 2) quantifying cougar population response to hunter harvest and 3) modelling cougar movement and habitat use in response to wildfire and forest harvest. To date, the team has GPS-collared 21 adult cougars, ear-tagged 2 litters, and has investigated 450 GPS cluster sites to collect predation data across three study areas (West Okanagan 5,800km^2, Boundary 5,200 km^2 and Kootenay 3,800 km^2). This multi-year study will inform management objectives for cougar and vulnerable prey populations in the province.

~Siobhan Darlington

2021 International Urban Wildlife Conference

Virtual Conference, May 25-27, 2021

Hosted by The Wildlife Society's Urban Wildlife Working Group

Abstracts for oral presentations, posters, organized symposia and workshops are due by January 22, 2021. Registration will open in early March.
The theme for this year's conference is **Changing Narratives**.

For more information go to *https://www.urban-wildlife.org/*

A brighter future for pumas at the south end of the world

Nicolás Lagos, Cerro Guido Conservación; Andean Cat Alliance, Chile; *nlagos@outlook.com*
Pía Vergara, Cerro Guido Conservación, Chile; *pia@cerroguidoconservacion.com*

At the southern tip of the American continent, in a place where Argentina and Chile converge towards the sea, lies Patagonia. It is characterized by vast landscapes with extreme weather conditions, making this place one of the most inhospitable on the continent. However, despite its challenging conditions, several species, including humans, managed to settle there and call the place home. And as usual, when humans and wildlife requirements clash, conflict is imminent. Sheep farming started in Chilean Patagonia towards the end of the 19th century, converting wild habitats formerly inhabited by local wildlife to domestic pastures. Such habitat reduction, intensified hunting of guanacos – the puma's natural prey- and the arrival of domestic livestock, led to a conflict that continues to this day. In only a couple of decades, sheep ranching became the main economic activity in Patagonia, encroaching on habitat where only wildlife inhabited before. With the arrival of a new source of food for pumas, it didn't take long for ranchers to perceive a substantial loss in livestock numbers. In retaliation, they began to persecute and hunt the cats. After more than a hundred years killing cats, ranchers are still waiting for help from the government. In the meantime, the methods of dealing with the conflict remain the same. Despite being legally protected in Chile since the 1970s, a single ranch may kill as many as a puma per a thousand hectares every year.

Unexpectedly, a solution has come from the pumas themselves. Over the last two decades, puma sightings became more frequent inside Torres del Paine, a National Park in Chile created in 1959, and since expanded to its current size by 1979. Protected from hunting inside the Park's 181,000 hectares, pumas began to habituate to human presence, therefore turning Torres del Paine into the best place in the world to observe pumas in their natural habitat and the epicenter of new big cat tourism in Patagonia. Today, hundreds of people travel every year from different corners of the world to observe and photograph pumas. This has prompted some of the ranches neighbouring the Park to host photographic tours with pumas, increasing tolerance towards pumas and turning persecution into protection.

Estancia Cerro Guido, encompassing more than 100,000 hectares, is a traditional Patagonian ranch located next to the Torres del Paine National Park. Founded at the end of the 19th century, its main economic activity is livestock. Cows and sheep roam in this vast landscape, and only a couple of years ago, pumas were considered only obstacles to successful ranching. But the owners decided to invest in a more sustainable way of doing things. They redesigned ranch practices to find a way to support coexistence with pumas and traditional livestock practices. These changes required protecting pumas inside the ranch, changes in their livestock management in order to minimize losses, and the diversification of their sources of income through tourism with pumas.

In January, 2019, Conservation Project in Cerro Guido was born (*www.cerroguidoconservacion.com*), with the goal to demonstrate that ranches can both host wildlife conservation and sustainable ranching. The goal is to protect pumas and other wildlife, while maintaining an important component of the cultural heritage of Patagonia: sheep ranching and *gaucha* culture. In such a big ranch, it's fairly easy to set apart some hectares for wildlife, and to maintain business as usual on the rest of it. But the goal here is to work collaboratively with ranchers and *gauchos* throughout the entire ranch. This is not easy, but we've already made important advances: seven guard dogs are now protecting sheep from puma and other carnivore attacks with good results; and we are planning to implement visual deterrents; and we want to implement changes in sheep management by avoiding high-risk zones, especially during lambing, when sheep are more vulnerable to attacks. In 2020, we established a collaboration with Panthera (*www.panthera.org*) to evaluate the effectiveness of mitigation strategies for livestock management within an experimental framework, including guard dogs and deterrents. Panthera is already working locally to support safe, sustainable tourism.

Now that pumas not being persecuted anymore on Cerro Guido, they are being seen more frequently, and their behaviour towards humans has slowly begun to change, as they feel more comfortable with our presence. Moreover, at least three different females have given birth within these two years of the project, with two of them now giving birth to their second litters. The idea for this 2020 was to begin receiving tourists, but the pandemic forced us to postpone the plan, waiting for safer conditions for everyone.

The development of big cat tourism in Chile is new, but growing fast. Global demand for wildlife tourism is also on the rise, and people are looking for places other than Africa and Asia to observe wildlife. Tourists wanting to see pumas eyes are looking towards Torres del Paine, so we expect a brighter future for pumas and local people in Patagonia, and a future of greater coexistence.

Mountain lion genomes provide insights into species management

Megan Supple, Research Specialist University of California, Santa Cruz *msupple@ucsc.edu*

Mountain lions are a wide ranging species, and as such are threatened by habitat loss and fragmentation. Increasing urban development is replacing natural environments, while the associated infrastructure, such as highways, divides the remaining habitat into small pieces. As a result, mountain lion populations are becoming smaller and more isolated. We conducted a genomic study to examine the consequences of habitat loss and fragmentation on mountain lion populations (Saremi et al. 2019).

Genomic analyses provide a powerful tool to identify populations at risk of extirpation and to predict the outcomes of management actions. The ancestry of an individual is written into its genome, and reading that information can provide us information about the individual and the history of the population from which that individual originates. For our genomic analyses of mountain lions, we sequenced complete genomes of ten mountain lions from South America (Brazil, n=2) and North America (Yellowstone National Park, n=1; California, n=4; and Florida, n=3).

Genetic diversity is the substrate that allows populations to adapt to changing environments. Quantifying the amount of genetic diversity in a population may provide an indication of the adaptive potential of the population. The mountain lion populations we examined varied in their overall genetic diversity. Individuals from small, isolated populations in California and Florida showed lower genetic diversity than the larger, more connected populations in Brazil and Yellowstone. This indicates that the California and Florida populations may require management interventions to remain viable.

Inbreeding substantially reduces an individual's genetic diversity, which can result in phenotypic defects that reduce the fitness of the population. To determine the level of inbreeding in each sample, we identified runs of homozygosity (ROH), which are regions of the individual's genome where the sequence inherited from the maternal parent is the same as the sequence inherited from the paternal parent due to a shared ancestor (Figure 1). We examined the lengths of ROH to determine how closely related the individual's parents were, with long runs indicating a closer relationship (such as siblings). We found high levels of inbreeding in the California and Florida populations, again indicating that these populations might require intervention.

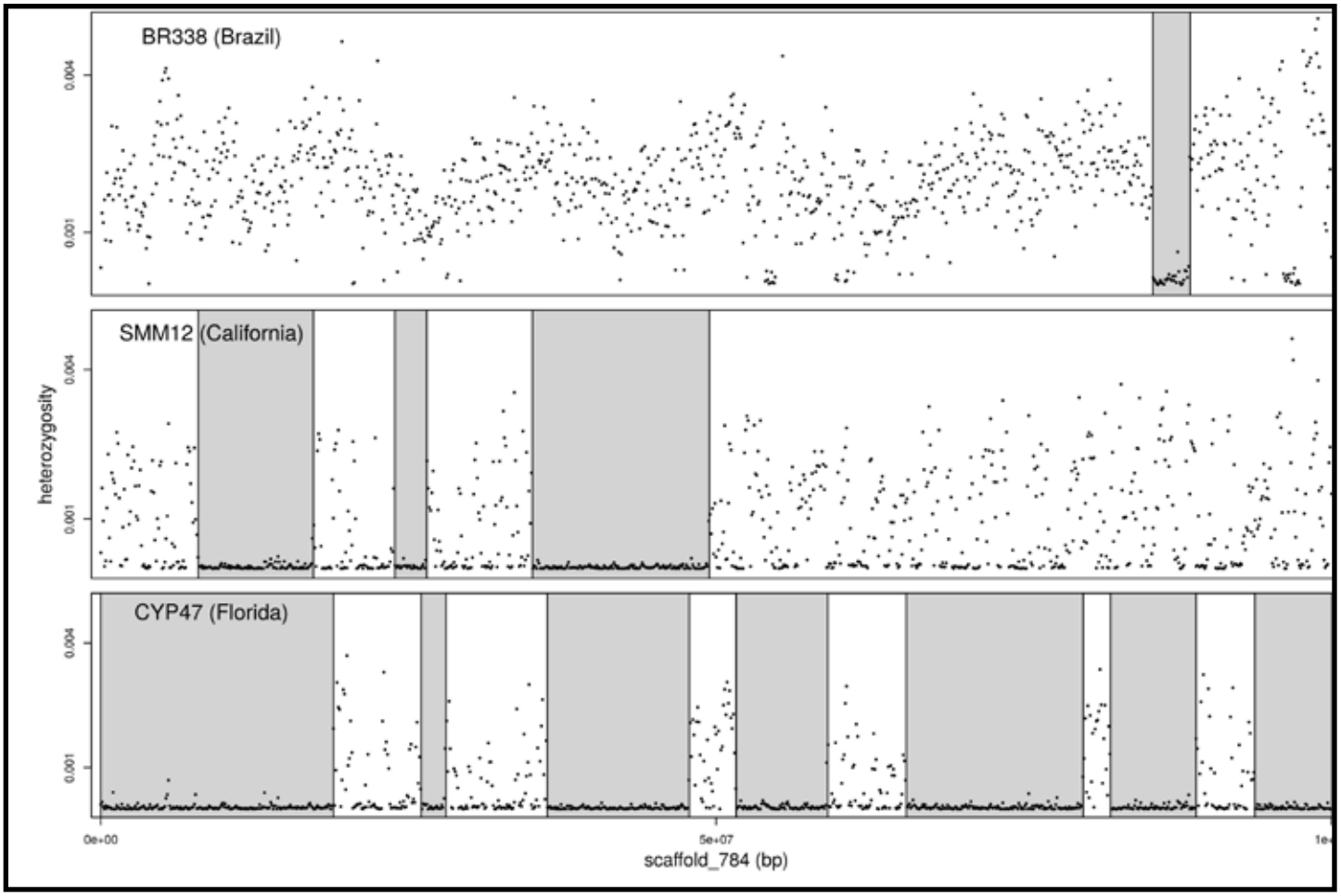


Fig. 1 Examples of ROH for three mountain lions from different populations shown across a region of the genome. Black dots represent heterozygosity measured in windows across the genome. Grey boxes represent ROH.

When vulnerable populations are identified, genetic rescue can be used to restore genetic diversity. Genetic rescue may take the form of translocations, where individuals are moved from a source population into the target population, or through landscape connectivity, where habitat corridors allow individuals from a neighboring population to move into the target population.

To examine the implications of possible genetic rescue strategies, we did pairwise genomic comparisons from our panel of ten mountain lions and quantified how many ROH were shared between each pair. Within the smaller populations, there was substantial sharing of ROH, indicating a lack of genetic diversity within those populations. However, between populations, ROH were generally not shared. This means that while each population may have lost genetic variation through inbreeding, there still exists substantial genetic variation in the populations as a whole. This suggests that restoring gene flow between populations would restore genetic diversity to at-risk populations.

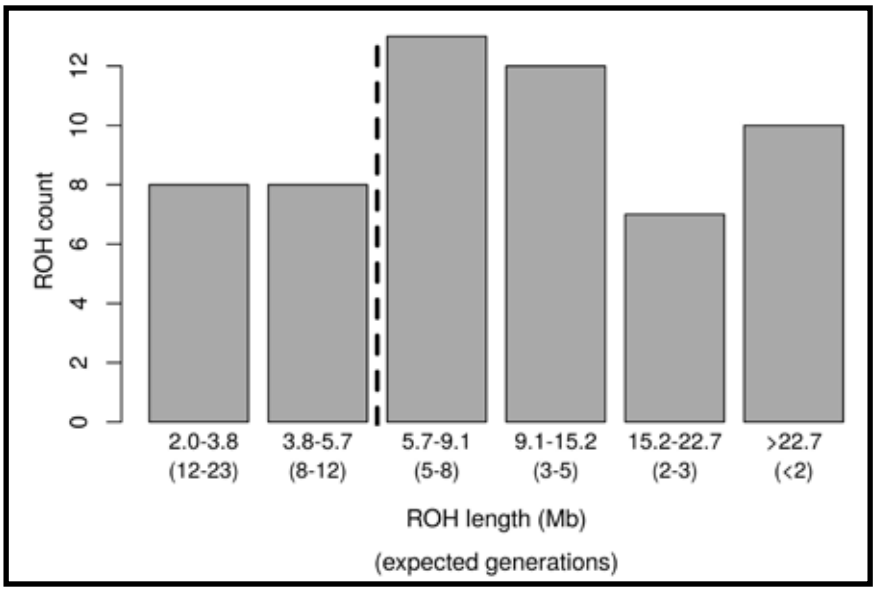


Fig. 2 Distribution of ROH for an individual that is a product of both genetic rescue and inbreeding. The x-axis indicates both the length of the ROH and the estimated number of generations back to the common ancestor. The vertical dashed line indicates the approximate time of the genetic rescue event. There are few ROH dating to prior to the event (left of the dashed line). The peak of the ROH distribution occurs immediately after the genetic rescue event (right of the dashed line).

To better understand the long term implications of genetic rescue, we examined the genome of an individual from a small and isolated population in Florida that experienced a genetic rescue event in the 1960's when captive individuals of mixed ancestry were released into the population. By converting the length of a ROH into an approximate number of generations back to a common ancestor, we can estimate the timing of key events in the population's history (Figure 2). In the distribution of ROH, we can see the signature of the genetic rescue event through the reduced number of inbred genomic regions dating to prior to the genetic rescue event. We can also see the signature of inbreeding, with the individual's maternal and paternal lines sharing ancestors from the time period immediately following the genetic rescue event to the present day. This indicates that the gains from genetic rescue may be quickly erased in small and isolated populations, suggesting that these populations need regular influxes of new genetic variation. This regular influx can be accomplished through repeated translocations or through landscape connectivity.

This study used genomic techniques to identify populations that are at risk of extirpation and to predict the consequences of management interventions. We found that genetic rescue would restore lost genetic diversity and that a sustained effort is likely needed to maintain the benefits of genetic rescue.

Central Florida panthers

Brian Kelly, Fish & Wildlife Research Institute, Florida Fish & Wildlife Conservation Commission. *brian.kelly@myfwc.com.*

By the mid 20th century, the cougar (*Puma concolor)* had been nearly extirpated from the eastern half of North America. Even its continued existence in southern Florida, where it was known colloquially as the Florida panther, was fodder for skeptics and steeped in lore. It is probably no coincidence that the last holdout of the panther was one of the least habitable and hospitable places for humans east of the Mississippi. Before in-home air conditioning and dichloro-diphenyl-trichloroethane became commonplace, the unrelentingly hot, humid, mosquito-infested swamps of southern Florida were inhabited by only the hardiest of humans and stealthiest of big cats. The latter's ability to survive was likely highly correlated with its ability to remain undetected by the former. Panther sightings must have been incredibly rare, and given the species' extraordinarily secretive nature, even the discovery of track and sign was a most noteworthy event. With solid evidence so hard to come by and motion-activated trail cameras still decades into the future, it is no wonder then that the question of whether panthers still existed was up for debate.

Legendary cougar hunter Roy McBride and his canine "professors" put an end to that debate when they arrived in Florida from Alpine, Texas. In 1973, Mr. McBride and his expert hounds treed a female panther in Gopher Gully, west of Lake Okeechobee and north of Fisheating Creek. Although this was proof that panthers still existed, he observed that this female was very old and had never bred, an ominous sign for the health of the population. Over the next 4 decades, Mr. McBride went on to tree hundreds more panthers further south and his capture efforts were instrumental to the recovery of the panther population. But for 43 years, the Gopher Gully panther remained the only documentation of a female north of the Caloosahatchee River. The Caloosahatchee, with the aid of much human engineering, connects Lake Okeechobee to the Gulf of Mexico, making a navigable waterway linking the inland towns of Moore Haven and Labelle to Ft. Myers and Cape Coral on the coast. It is by no means an insurmountable barrier to panther movement, but it nevertheless marked the northern extent of the panther's known breeding range until 2016, when Florida Fish & Wildlife Conservation Commission (FWC) biologists confirmed the presence of a female panther with trail camera photos and tracks on Babcock Ranch Preserve 13km north of the River.

The discovery of the Babcock female marked the beginning of a new era in panther conservation. Decades of isolation in the southern tip of Florida had deteriorated the genetic health of the population, pushing the panther to the brink of extinction. Genetic rescue, involving a one-time temporary introduction of female cougars from Texas in 1995, initiated a 20+ year period of population growth. But to be a self-sustaining population, the panther almost certainly would have to expand its breeding range across the Caloosahatchee and into Central Florida. The Babcock female provided hope that this expansion was underway. The next step for biologists and next milestone for panther recovery would be the documentation of successful breeding north of the River.

In March 2017, FWC trail cameras photographed the Babcock female with 2 kittens. Excitement was short-lived, however, as neither kitten is thought to have survived past 6 months-of-age. Their fate was substantiated by photographs of the female paired with an adult male in April 2017, leading to the birth of a new litter 3 months later, well before the first litter could have reached independence. Photographic evidence revealed that the second litter likely suffered the same fate. A third litter, documented via photos of the female exhibiting nursed teats, was never photographed and no more photos of the Babcock female were collected thereafter. Since it is unlikely a dam would dramatically shift home range while denning, it is presumed that the Babcock female died in May 2018, causing the third litter to fail. After consistent documentation of the female, mating events, and offspring over the previous 19 months, no evidence of females or breeding was collected during the remainder of 2018.

The FWC, in collaboration with U.S. Fish & Wildlife Service, ramped up trail camera monitoring efforts in Central Florida in March 2019. This involved expanding from 20 cameras in western Babcock Ranch to 100 cameras covering most public and some private lands within a 6000 km^2 area north of the Caloosahatchee River. This new 2-year study will systematically assess the distribution of panthers in Central Florida. In October 2019, fifteen months after the disappearance of the Babcock female, a new female was documented along a small tributary to the Caloosahatchee near the eastern boundary of Babcock Ranch. A month later an approximately 5-month old kitten was photographed without a dam and was never seen again. In March 2020, a new female was photographed in Fisheating Creek Wildlife Management Area, 25 km northeast of Babcock Ranch. Both of these females have since been photographed paired with males, most recently in August 2020.

Our efforts highlight the challenges that an expanding panther population faces. We are cautiously optimistic that we will soon document more offspring and successful recruitment north of the Caloosahatchee following this recent breeding activity. We're not surprised that these female panthers north of the River remain true to their nature and seem to be selecting the areas least accessible to humans. If their offspring's survival is indeed linked to their ability to remain undetected by humans, as it likely was for their forebears in the mid-1900's, our jobs as human biologists won't be easy. In time, it may necessitate making a call to the "professors."

Carnivore population structure across an urbanization gradient: A regional genetic analysis of bobcats in southern California

Julia G. Smith[1], Megan K. Jennings[1], Erin E. Boydston[2], Kevin R. Crooks[3], Holly B. Ernest[4], Seth P. D. Riley[5], Laurel E. K. Serieys[6,7], Shaelynn Sleater-Squires[8], & Rebecca L. Lewison[1]
[1]Biology Department, San Diego State University, San Diego, CA, USA
[2]Western Ecological Research Center, U.S. Geological Survey, Thousand Oaks, CA, USA
[3]Department of Fish, Wildlife, and Conservation Biology, Colorado State University, CO, USA
[4]Wildlife Genomics and Disease Ecology Lab, University of Wyoming, Laramie, WY, USA
[5]National Park Service, Santa Monica Mountains National Recreation Area, Thousand Oaks, CA, USA
[6]Department of Environmental Studies, University of California, Santa Cruz, Santa Cruz, CA, USA
[7]Institute for Communities and Wildlife in Africa, Biological Sciences, University of Cape Town, Cape Town, South Africa
[8]Department of Ecology and Evolutionary Biology, University of California, Los Angeles, Los Angeles, CA, USA

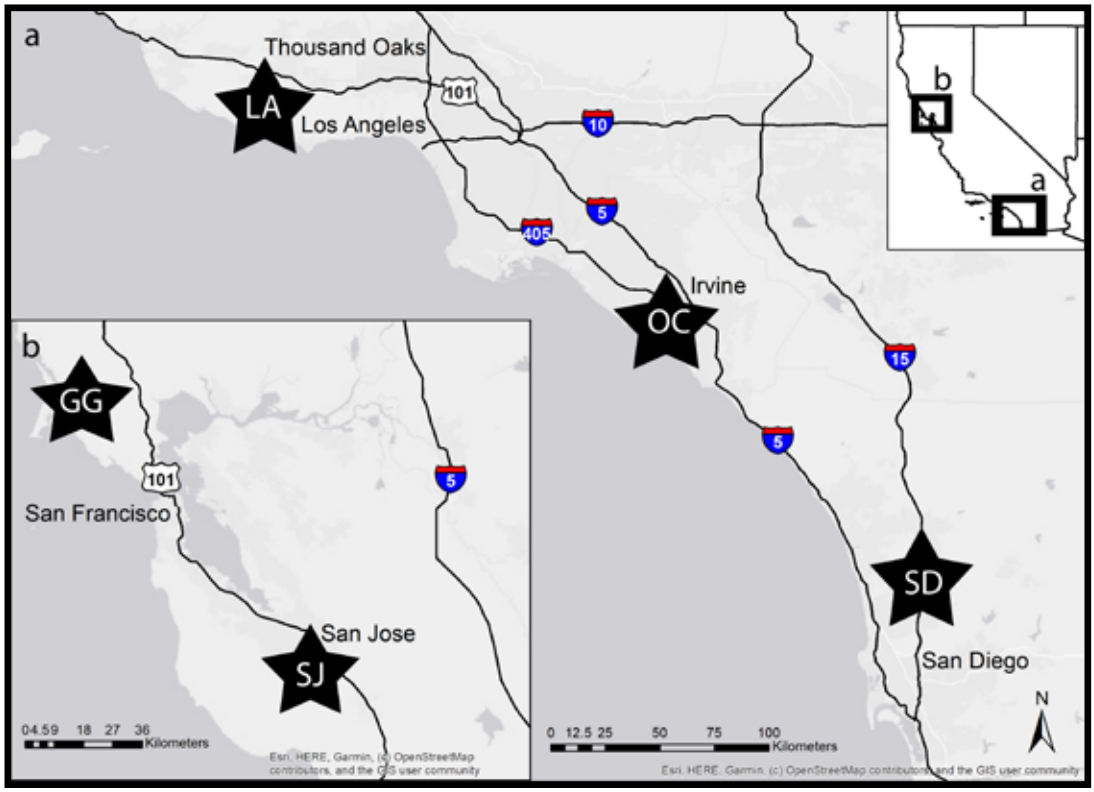


Figure 1. Map of study areas denoted by black stars with major roadways and city names for context. In northern California GG (Riley 2006) and SJ, and in southern California LA (Riley et al. 2006), Serieys et al. 2015, OC (Lee et al. 2012, and SD.

Bobcats (*Lynx rufus*) use a wide range of habitats including wetlands, forest, woodland, chaparral, desert, agricultural, and urban landscapes. Their capacity to exploit diverse environments, along with the capability to disperse long distances, make bobcats a model species for assessing importance of habitat connectivity in sustaining genetic diversity in mammalian populations.

Southern California encompasses a wide area of urbanization. The region is more urbanized and fragmented close to the coast and in the Los Angeles Basin, with fragmentation gradually decreasing to the south and east. In such human-dominated landscapes, habitat fragmentation and barriers to movement can interrupt gene flow in terrestrial species.

For this study, we incorporated genetic data from several studies to build a set of 11 loci from 422 bobcats from San Diego, Orange, Los Angeles, and Ventura counties (Fig. 1). We compared these individuals to two outgroups from northern California: the Golden Gate National Receation Area (GG) and Coyote Valley in San Jose (SJ) (Fig. 1, inset). To combine microsatellite data from multiple studies and facilitate inter-lab comparisons, we created a validation data set. We also created a smaller data set with nearly double the amount of markers (19 loci as opposed to 11) for 118 out of the 422 individuals from southern California.

To delineate populations, we used the program STRUCTURE (Earl and vonHoldt 2012), which employs a Bayesian clustering algorithm. We also employed a discriminate function analysis of principal components (DAPC), with a principal component analysis to find population structure while minimizing within-group variation (Dyer 2009).

From the STRUCTURE results of our larger dataset (422 bobcats at 11 loci), we found a distinct Los Angeles (LA) population and a split between the Orange County Coastal (OCC) population west of Interstate 5, and Orange County Inland (OCI) population east of Intestate 5. In our 19 loci data set, we found that the Orange County Coastal population was so genetically distinct from other populations that it obscured the signal of further differentiation across our study area. Only after removing OCC did we see the discrete populations of LA, GG, SJ, and the similarity between OCI and SD (figure 2).

In DAPC analyses, we found more differentiation between the outgroups GG and SJ, as well as between Los Angeles and the other

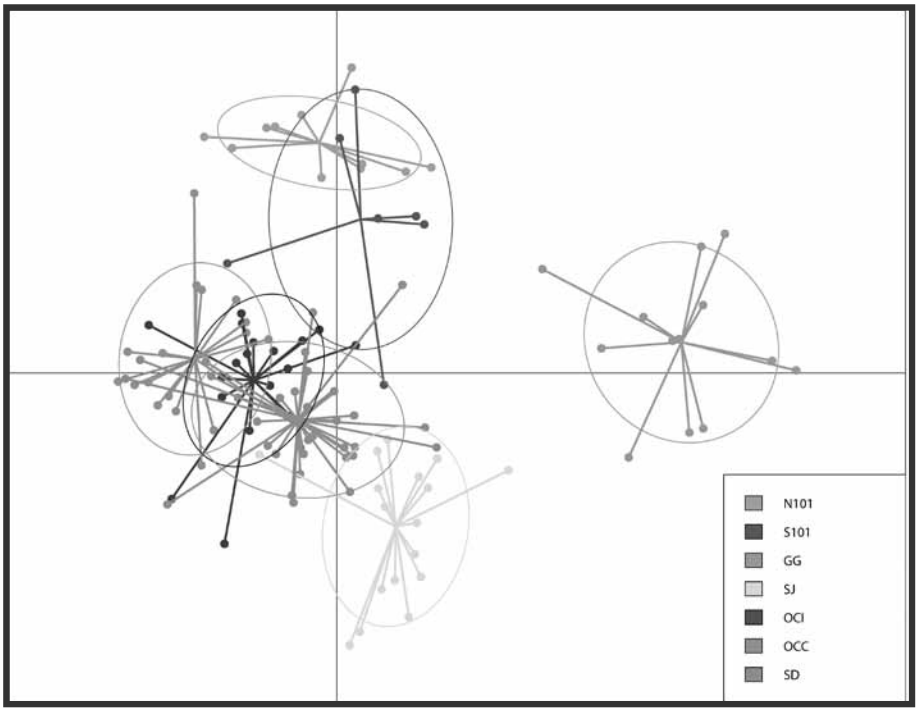


Fig. 2. Results of a priori population clustering of the 19 loci dataset in a discriminant function analysis of principal components (DAPC) scatterplot of population clusters. Each dot represents an individual within a labeled population. Ellipses summarize the cloud of points with bi-

southern California populations. We also compared populations
north and south of US101 (N101 and S101 respectively) for our 19 loci dataset, per previous studies (Fig. 3). We observed that OCC was less differentiated in DAPC analysis than in STRUCTURE but still not as similar as OCI and SD were to each other.

We hypothesized that these patterns resulted from fragmentation of man-made landscape features, so we conducted a landscape genetic resistance analysis for LA, OCC, OCI, and SD, using the 19 loci dataset (n=88). We tested five hierarchically-related landscape variables to see which variable best explained the patterns of genetic variance. Permeability was the strongest predictor of genetic differentiation across the landscape for bobcats. Permeability in this context incorporates built and natural features, suggesting that bobcats are more likely to be drawn to less developed, natural landscapes, and away from urbanization and roads. It is encouraging to know that in areas of high permeability and connectivity, gene flow and dispersal can be maintained, e.g., inland Orange County and San Diego. However, bobcats, like mountain lions (*Puma concolor*), may be susceptible to inbreeding, reduced genetic diversity, and increased susceptibility to diseases, including mange, because of habitat fragmentation. This suggests that even for a wide-ranging, habitat generalist, like bobcats, maintaining landscape permeability, through habitat reserves and corridors, is important for protecting gene flow and regional connectivity (Smith, J. G. et al. 2020).

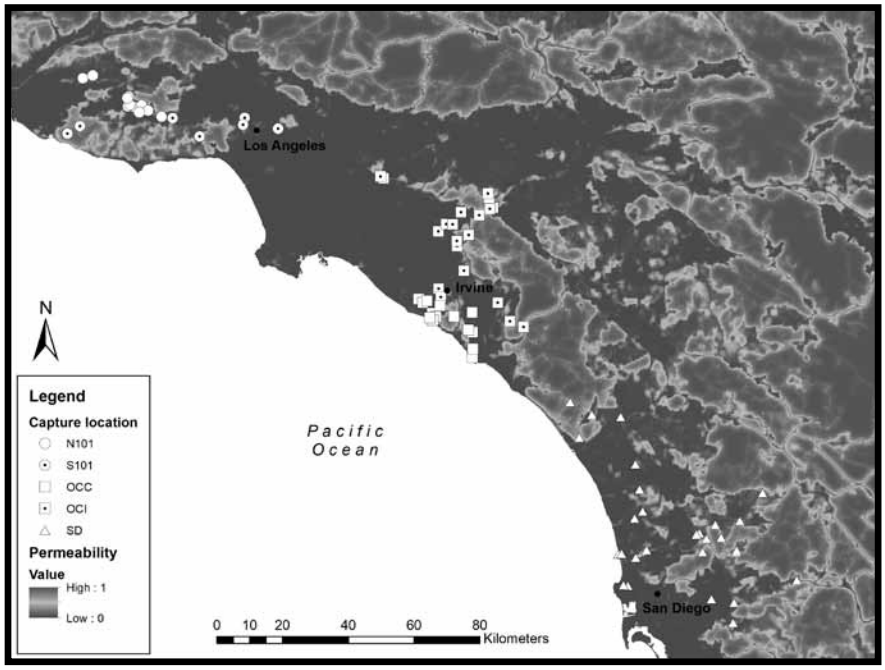


Fig. 3. Landscape resistance analysis results depicting permeability, which best explained the genetic distance of bobcat sampled in southern California at an inverse Ricker transformation at a 2000 m scale. Darker gray indicates areas of low permeability across the landscape and mid-gray, areas of high permeability. Southern California bobcats (n=88) sampling locations are partitioned by subpopulation; in LA, north (N101; circle) and south (S101; circle with dot) of US101,west (OCC; white square) and east (OCI; white square with dot) of the I-5 in OC, and SD (SD; triangle).

Uneven recovery of repatriated bobcats in a mined landscape

Suzanne Prange, Executive Director, Appalachian Wildlife Research Institute, Athens, Ohio. *IngerSuzanne@protomail.com.*

Ohio was originally 95% forested, but was reduced to 10% forest by the early 1900s. Bobcats (*Lynx rufus*) occurred throughout Ohio prior to European colonization but were extirpated by the 1850s, as forests were cleared for settlement and agriculture. Bobcats and other predators were lost because of habitat loss, overtrapping, and the general persecution of predators common at that time. Bobcats are the most widely distributed felid in North America. Nonetheless, they have long remained conspicuously absent from the upper Midwest in the United States, likely because of intensive agriculture. However, bobcat populations began to increase in number and range throughout this area in the late 1990s and have reoccupied areas in the Midwest where they were historically present, yet were extirpated for over 100 years.

Bobcat repatriation of the upper Midwest is likely the result of land use changes. Farms in the Allegheny Plateau of Ohio failed in the 1940s and 1950s because of poor farming and the loss of jobs to mechanization in the mining industry. Initial bobcat reestablishment occurred almost simultaneously in two spatially distinct areas, although growth was greater in the eastern than southern population. Understanding the reasons for the disparity in population growth rates and sustainability between the two populations is essential to bobcat management. The objectives of Ohio's bobcat study were to determine 1) relative density of bobcats, 2) annual home range and core area size for male and female bobcats, 3) the extent of home range and core area overlap, 4) habitat use of bobcats, and 5) body condition (CI), and to compare these factors between populations.

Relative density was higher in the eastern than the southern population, and body CI was higher for eastern bobcats. Annual home ranges and core areas of males and females were smaller for eastern than southern study animals. Smaller home ranges could be a consequence of higher density. In some studies, bobcats exhibited reduced home-range sizes in response to increased population density. If home-range size decreased primarily because of the pressure from increased density, a lower CI of animals would be expected because bobcats would be forced to subsist in smaller areas.

However, the CI of eastern bobcats was significantly greater for eastern than southern bobcats. This indicated that eastern bobcats had access to greater resources within a smaller area than did southern bobcats. The high energetic demands of females associated with parental care for polygynous mammals are well documented. Food resources are generally believed to be the main factor influencing spacing patterns of female carnivores, whereas spatial patterns of males are affected by the distribution of resources and females.Home range overlap did not differ, except for female-female pairs, which displayed very little overlap at the southern site, suggesting more limited resources. Habitat type based on broad vegetation categories was essentially equal between the two regions. However, significantly more mine land occurred in the eastern area.

At a national level, the Surface Mining Control and Reclamation Act (SMCRA) was enacted in 1977 in response to negative effects of coal mining and the growing number of abandoned mines. Despite the improvements, other issues became apparent. Grading equipment caused significant compaction of the soil, resulting in low soil porosity, permeability, and moisture-holding capacity. Although SMCRA required the site be restored, it did not require it to be restored to its original ecosystem. Consequently, most post-law surface-mined land in the Appalachian ecoregion was not reclaimed to forest and native forests were replaced with exotic grasslands.

Pre-law or legacy mines are typically classified as those mines that occurred prior to federal 1977 SMCRA. In general, pre-law mines could return to near native vegetation over time. These areas often have large rocks, boulders, and highwalls, which provide greater physical structure and diversity of habitats and may contribute to a higher density of small mammals. Studies comparing small mammal populations on pre-law mine lands with those on unmined areas found abundance to be greater on previously mined lands. The eastern area had a greater proportion of legacy mine land that might have provided increased small mammal density. Mined areas in eastern Ohio also had a higher density of gas wells surrounded by areas of thick grass that are maintained year-round to allow vehicular and personnel access. Although small, these areas may represent pockets of high densities of voles (*Microtus* spp.), which are a preferred prey item for bobcats. Thus, the results to date suggest a greater and more concentrated food base, which may result in higher reproductive output and better condition. Thus, an important interaction appeared to exist between landscape features of former surface mines and bobcat recovery.

Surface mines in the Ohio Appalachian Plateau region. Dashed line separates the eastern and southern bobcat population.

Strategies for camera use in monitoring of Eurasian lynx

Daniel Mallwitz, County administration board Västmanland, Sweden. *Daniel.mallwitz@lansstyrelsen.se*

In Sweden and Norway we perform a yearly winter monitoring of lynx. We try to find all the family groups in the country (females with kitten/kittens), but not necessarily every individual lynx. Our primary method for monitoring lynx in Sweden is snow tracking; and the method is standardized and performed by the county boards. During the last few years, use of trail cameras has increased in lynx monitoring. Trail cameras can be a good compliment to snow tracking, especially in areas with bad snow conditions or with high density of other game species that obliterate lynx tracks.

I work in the county Västmanland, one of the smallest counties (5000 km^2) and situated 100 km west of Stockholm. We employ over 70 cameras that complement our snow tracking. Randomly placing the cameras in the landscape is not a viable strategy, so we have identified seven key classes of positions for camera placement. In this article I will describe them and their pros and cons.

1. Spot for scent marking. Lynx scent mark regularly, often using the same spot over and over. Several lynxes may scent mark on the same spot. During the breeding season, such spots may yield photos of several different individuals at one camera site. Scent posts are easily detected during snow tracking. By placing the camera at scent marking spots where the landscape narrows the possible route (e.g. along a river or mountain side) you can increase the likelihood of getting lynx photos. By adding scent (e.g. beaver castor or valerian oil) you will increase the likelihood of photographing a lynx and increase the time the lynx will spend in front of the camera, thereby increasing numbers of photos of each animal (photograph 1).

Photograph 1

2. Passage over water. Lynx can swim but prefer not to, therefore placing cameras at small bridges, logs across streams, and beaver dams is effective. No lure or bait is needed. (photograph 2).

3. Game trails and roads. Lynx will use roads to travel, but Swedish law prohibits us from putting cameras on roads. However, a well-used game trail or an old logging road can be effective for finding lynx (photograph 3).

4. Artificial spot for scent marking. If natural scent marking spots aren't available, you can create one. We use a pallet (photograph 4) placed beside a logging road or trail. On the pallet we attach a pine tree branch. We drive two sticks into the ground on each side of the pallet, and place scent lure on the pine branch, the pallet and the sticks, in a way that causes the lynx to scent-mark on the side of the pallet and pause in front of the camera. Normally, the lynx will rotate in front of the camera and display gender. There are several brands

Photograph 2

Photograph 3

Photograph 4

of lure on the market, but making your own is cheaper and gives you control over what you put out in the environment.

5. Carcasses. A freshly killed roe deer (main prey) provides a good lynx attractant. If you can place the camera the first day after the kill, the lynx is likely to return that night. After the first night, the likelihood of the lynx returning drops rapidly. Bait pails have been suggested, but lynx do not normally scavenge, so an artificial bait pail would not be very effective. In our over 30,000 camera nights, we have one example of a lynx that is scavenging. (photograph 5).

6. Day beds. Lynx often reuse the same bed, spending a lot of time there and providing opportunity for multiple photographs. Such day beds are not easy to locate, but may at times be found while snow-tracking or by locating radio-collared lynx. Knowledge of lynx behavior, availability of good GIS information, and personal knowledge of the area help locate day beds. (photograph 6).

Photograph 5

7. Game calls. Sound systems or trail cameras with sound can be used to lure lynx. During the rut a mating call from a male lynx can be used. Our limited experience with using lynx calls shows that they work, but mainly aattract other males.

Effort and accuracy. During the monitoring period 2019-2020 we captured lynx on camera 119 times in 11,226 trap nights (1/94 trap nights). We photographed predominantly single adult lynx. However, 34 observations were of family groups or single kittens (photograph 7). These photographs, combined with the snow tracking data, yielded eight family groups, four completely residing in the county and four ranging into neighboring counties. To estimate numbers, lynx families in Sweden are grouped, based on distance between observations, time between observations, and prey density in the area. GPS

Photograph 6

data from the female and clear visual markers on the female can also be used to separate family groups (photograph 7). This approach yields a minimum population estimate.

Although Eurasian lynx do not exist in North America, there are several relatives, and I am confident that our methods are transferrable, completely or partly, to surveying wild cat species in North America.

Photograph 7

Testing solar lights to protect domestic animals from jaguars and pumas in San Luis, Colombia

Alexandra Pineda-Guerrero, Carnivore Coexistence Lab, University of Wisconsin-Madison. 2019 Wild Felid Legacy Scholarship recipient; *pinedaguerre@wisc.edu*

Adrian Treves, Carnivore Coexistence Lab, University of Wisconsin-Madison, *atreves@wisc.edu.*

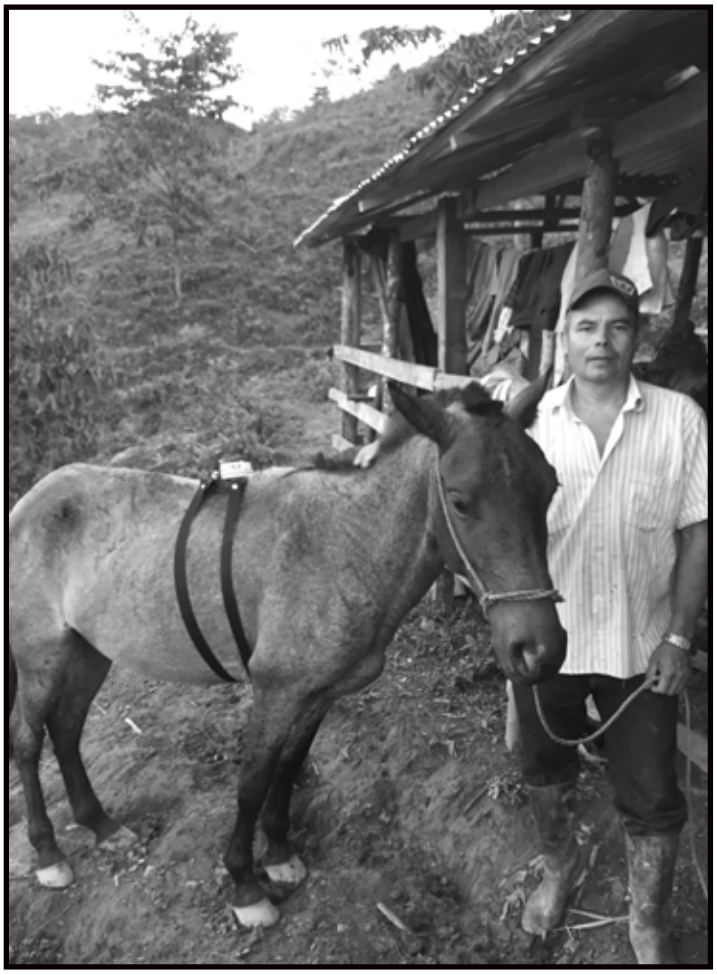
One of the major causes of mortality for carnivores is lethal control to reduce livestock predation (Inskip & Zimmermann 2009; Ripple et al. 2014). In response to domestic animal losses, many South American ranchers kill jaguars and pumas (Marchini & Crawshaw 2015). To avoid lethal control and increase local support for human–carnivore coexistence, mitigation of carnivore predation is essential. Information regarding the effectiveness of interventions to reduce livestock predation by jaguars and pumas in Colombia is currently insufficient.

Reviews of worldwide literature reveal that many methods for protecting domestic animals have not been rigorously evaluated for using controlled experiments (Moreira-Arce et al. 2018; Treves et al. 2016; van Eeden et al. 2018). Testing the effectiveness of interventions in the field requires governmental agencies and non-governmental organizations to invest adequate research resources (Ohrens et al. 2019). Rigorous experiments using random assignments and avoiding bias in treatment, sampling, measurement, and reporting are called the gold standard (Treves et al. 2016; Treves et al. 2019). However, only one study using gold standard experiments on predator control has been implemented in Latin America (Ohrens et al. 2019).

San Luis was occupied by armed groups, and rural inhabitants either abandoned their lands or were displaced during the civil war. Some of those inhabitants returned to their properties when the government began demobilizing the primary participants in the war. Most landowners in the study area own a few horses, mules, and cows. They rely upon horses or mules for transportation. Our objective is to evaluate the effectiveness of solar light deterrents (Foxlights®) for reducing jaguar and puma attacks on farms of San Luis, Antioquia, Colombia. We are testing portable solar light deterrents as a method to reduce livestock losses and resulting retaliation, using a randomized, controlled experiment with a cross-over design and blinding procedures to reduce bias.

In May, 2019 we conducted a pilot season in the San Luis Municipality, located in the Colombian Andes. With voluntary participation of livestock owners, we placed Foxlights on the backs of equids and cows. The environmental government agency (CORNARE) verified cause of mortality. A workshop was conducted to explain the project and recruit livestock owners to participate, and ten farms were randomly selected to participate in the project. Six of them had experienced attacks in the past.

Foxlights® were strapped to 10 animals. Two camera traps were installed per farm to confirm wild felid proximity. The solar lights were allocated by randomly assigning livestock owners to a treatment or a placebo control. During the pilot season, we experienced challenges to placing the Foxlights on the animal's back. Four domestic animals accepted the lights and 6 were not comfortable with the light. We decided to place one Foxlight on each animal's back, and six additional lights within the animals' sleeping areas. Owners were interviewed before the Foxlights were implemented to explore their attitudes towards felids and toward using the non-lethal method.



We have finished the first of two study phases, and no felid attacks have occurred, even though camera traps have recorded puma (*Puma concolor*) and jaguar (*Panthera onca*) nearby. Two individual pumas and one jaguar have been identified. Also, 3 species of small felids have been recorded in the study area: *Leopardus pardalis*, *Leopardus tigrinus* and *Herpailurus yagouaroundi*.

Given the conservation significance of large predators, non-lethal methods deserve more attention as feasible solutions livestock losses. Proven non-lethal methods for protecting domestic animals could reduce the rural communities' motivations to kill wild felids in retaliation for perceived livestock losses.

Acknowledgements

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Donations to our scholarship fund allow us to continue to provide support to students who are investigating ways to study, manage and conserve wild felids in a dramatically changing world.

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A stochastic model of jaguar abundance in the Peruvian Amazon under climate variation scenarios.

Burrage, K. et al. 2020. Ecology and Evolution 10:10829-10850.

Abstract – The jaguar (*Panthera onca*) is the dominant predator in Central and South America, but is now considered near-threatened. Estimating jaguar population size is difficult, due to uncertainty in the underlying dynamical processes as well as highly variable and sparse data. We develop a stochastic temporal model of jaguar abundance in the Peruvian Amazon, taking into account prey availability, under various climate change scenarios. The model is calibrated against existing data sets and an elicitation study in Pacaya Samiria. In order to account for uncertainty and variability, we construct a population of models over four key parameters, namely three scaling parameters for aquatic, small land, and large land animals and a hunting index. We then use this population of models to construct probabilistic evaluations of jaguar populations under various climate change scenarios characterized by increasingly severe flood and drought events and discuss the implications on jaguar numbers. Results imply that jaguar populations exhibit some robustness to extreme drought and flood, but that repeated exposure to these events over short periods can result in rapid decline. However, jaguar numbers could return to stability—albeit at lower numbers—if there are periods of benign climate patterns and other relevant factors are conducive.

Conserving predators across agricultural landscapes in Colombia: habitat use and space partitioning by jaguars, pumas, ocelots and jaguarondis.

Boron, V. et al. 2020. Oryx 54:554-563.

Abstract – Loss and degradation of natural habitats continue to increase across the tropics as a result of agricultural expansion. Consequently, there is an urgent need to understand their effects, and the distribution and habitat requirements of wildlife within human-modified landscapes, to support the conservation of threatened species, such as felids. We combined camera trapping and land cover data into occupancy models to study the habitat use and space partitioning by four sympatric felid species in an agricultural landscape in Colombia. Land use in the area includes cattle ranching and oil palm cultivation, the latter being an emerging land use type in the Neotropics. Factors determining species occupancy were the presence of wetlands for jaguars (positive effect); water proximity for pumas (positive effect); and presence of pastures for ocelots and jaguarundis (negative effect). Only ocelots were occasionally recorded in oil palm areas. Our results suggest that to align development with the conservation of top predators it is crucial to maintain areas of forest and wetland across agricultural landscapes and to restrict agricultural and oil palm expansion to modified areas such as pastures, which are of limited conservation value. Because there is no spatial segregation between the felid species we studied, conservation strategies that benefit all of them are possible even in modified landscapes.

Commentary: Five rules for evidence communication

Blastland, M. et al. 2020. Nature 587:362-364

Abstract – Researchers can be incentivized to sell their work and focus on a story rather than on full and neutral reporting of what they have done. We worry that the urge to persuade or to tell a simple story can damage credibility and trustworthiness. Instead, we propose another approach. We call it evidence communication. The five rules are: 1) Inform, not persuade; 2) Offer balance, not false balance; 3) Disclose uncertainties; 4) State evidence quality; 5) Inoculate against misinformation.

Quick tips for sharing evidence include:

- Address all the questions and concerns of the target audience.
- Anticipate misunderstandings; pre-emptively debunk or explain them.
- Don't cherry-pick findings.
- Present potential benefits and possible harms in the same way so that they can be compared fairly.
- Avoid the biases inherent in any presentation format (for example, use both 'positive' and 'negative' framing together).
- Use numbers alone, or both words and numbers.
- Demonstrate 'unapologetic uncertainty': be open about a range of possible outcomes.
- When you don't know, say so; say what you are going to do to find out, and by when.
- Highlight the quality and relevance of the underlying evidence (for example, describe the data set).
- Use a carefully designed layout in a clear order, and include sources.

Trust is crucial. Always aiming to 'sell the science' doesn't help the scientific process or the scientific community in the long run, just as it doesn't help people (patients, the public or policymakers) to make informed decisions in the short term. That requires good evidence communication. Ironically, we hope we've persuaded you of that.

Illegal trade in wild cats and its link to Chinese-led development in Central and South America.

Morcatty, T. et al. 2020. Conservation Biology 34:1525-1535.

Abstract – Seizures of hundreds of jaguar heads and canines in Central and South America from 2014 to 2018 resulted in worldwide media coverage suggesting that wildlife traffickers are trading jaguar body parts as substitutes for tiger parts to satisfy the demand for traditional Asian medicine. We compiled a data set of >1000 seized wild cats (jaguar [*Panthera onca*], puma [*Puma concolor*], and ocelot [*Leopardus pardalis*]) from 19 Central and South American countries and China. We ran generalized additive mixed models to detect trends in wild-cat seizures from 2012 to 2018 and assess the effects of socioeconomic factors of source countries and between those countries and China on the number of wild cats seized. Jaguar seizures increased over time, and most of the seized jaguar pieces were canines (1991 of 2117). Around 34% (32 of 93) of the jaguar-part seizure reports were linked with China, and these seizures contained 14-fold more individuals than those intended for domestic markets. Source countries with relatively high levels of corruption and Chinese private investment and low income per capita had 10–50 times more jaguar seizures than the remaining sampled countries. The number of Chinese residents in Central and South America was not significantly related to the number of jaguars seized. No socioeconomic factors influenced the seizures of puma and ocelots. Legal market chains may provide structure for the illegal chain; thus, the influx of illegal jaguar products is potentially a side effect of the economic partnership between Central and South American countries and China. Poverty and high levels of corruption in the source countries may motivate local people to

engage in illegal activities and contribute to the growth of this trade. Supply-side interventions to curb this threat to Neotropical wild cats may include improved training for officials and promotion of governance and the value of protecting these animals to local people.

Using spatial characteristics of apex carnivore communication and reproductive behaviors to predict responses to future human development

Yovovich, V. et al. 2020. Biodiversity Conservation 29:2589-2603.

Abstract – A growing body of evidence has documented how wildlife alter their behavior in response to human encroachment. For carnivores, behaviors related to reproduction and communication are particularly sensitive to human disturbance and can provide an early warning indicator of development's negative impacts. Despite the important role carnivores play in an ecosystem, few tools have been developed to anticipate how future human development impacts these behaviors. We developed a set of models to understand spatial relationships between anthropogenic development and puma (*Puma concolor*) habitat selection for two critical reproductive behaviors: nursery habitat for raising young, and sites for communication with mates. Using geospatial location data from the Santa Cruz Mountains in California, USA, we found that female pumas use small nursery home ranges (9 $km^2 \pm 1.72$ SE) of predominantly natural habitat, potentially with low levels of human development (< 1 housing unit per 40 acres), when supporting kittens < 8 weeks old. Areas immediately surrounding (≤ 600 m) puma communication sites were also almost entirely composed of undeveloped habitat or low-density development. When modeling projected human development compared to current land use, we found that increases in human development may eliminate 20% of current puma nursery habitat and nearly 50% of current communication site habitat. Future development will also increase the patchiness of suitable habitat, intensifying the difficulty of locating and accessing suitable areas for nurseries and communication. Focusing on the habitat needed to support reproductive and communication behaviors may be an effective way to prioritize conservation planning for pumas and other apex carnivores.

Minimum habitat thresholds required for conserving mountain lion genetic diversity.

Dellinger, J. et al. 2020. Ecology and Evolution 10:10687-10696.

Abstract – Jointly considering the ecology (e.g., habitat use) and genetics (e.g., population genetic structure and diversity) of a species can increase understanding of current conservation status and inform future management practices. Previous analyses indicate that mountain lion (*Puma concolor*) populations in California are genetically structured and exhibit extreme variation in population genetic diversity. Although human development may have fragmented gene flow, we hypothesized the quantity and quality of remaining habitat available would affect the genetic viability of each population. Our results indicate that area of suitable habitat, determined via a resource selection function derived using 843,500 location fixes from 263 radio-collared mountain lions, is strongly and positively associated with population genetic diversity and viability metrics, particularly with effective population size. Our results suggested that contiguous habitat of ≥10,000 km^2 may be sufficient to alleviate the negative effects of genetic drift and inbreeding, allowing mountain lion populations to maintain suitable effective population sizes. Areas occupied by five of the nine geographic–genetic mountain lion populations in California fell below this habitat threshold, and two (Santa Monica Area and Santa Ana) of those five populations lack connectivity to nearby populations. Enhancing ecological conditions by protection of greater areas of suitable habitat and facilitating positive evolutionary processes by increasing connectivity (e.g., road-crossing structures) might promote persistence of small or isolated populations. The conservation status of suitable habitat also appeared to influence genetic diversity of populations. Thus, our results demonstrate that both the area and status (i.e., protected or unprotected) of suitable habitat influence the genetic viability of mountain lion populations.

Large-scale assessment of genetic diversity and population connectivity of Amazonian jaguars (*Panthera onca*) provides a baseline for their conservation and monitoring in fragmented landscapes.

Lorenzana, G. et al. 2020. Biological Conservation 242:108417

Abstract – Jaguar population genetics has so far not been investigated on a broad scale in the Amazon rainforest, which constitutes the largest remaining block of continuous habitat for the species. Given its size, it serves not only as a stronghold but also as a reference for jaguar conservation genetics, against which fragmented landscapes can be compared. We assessed genetic diversity and population structure of Amazonian jaguars using 11 microsatellite loci and performed comparative analyses incorporating available data from two other South American biomes (Pantanal and Atlantic Forest) in which the species has faced different amounts of habitat loss and fragmentation. Using the largest genetic data set assembled to date for jaguars (n = 190), we observed that all diversity indices were consistently higher for the Amazonian population, with no genetic subdivision detected in that region, indicating large-scale connectivity across >3000 km. In contrast, we corroborate the inference of anthropic-driven genetic structure and bottlenecks for two Atlantic Forest populations. Our results indicate that the Amazon is a critically important stronghold for jaguars, comprising a highly diverse, panmictic population that allows a glimpse into the patterns of genetic connectivity that characterized this species prior to human intervention. In contrast, the Atlantic Forest populations jointly still retain considerable levels of genetic diversity, but this is currently partitioned among isolated fragments that are increasingly subjected to heavy anthropic disturbance. These results have important implications for jaguar conservation planning, highlighting the critical condition of Atlantic Forest populations and providing a genetic baseline to which they can be compared.

Identifying individual jaguars and ocelots via pattern-recognition software: comparing HotSpotter and Wild-ID.

Nipko, R. et al. 2020. Wildlife Society Bulletin 44:424-433.

Abstract – Camera-trapping is widespread in wildlife studies, especially for species with individually unique markings to which capture–recapture analytical techniques can be applied. The large volume of data such studies produce have encouraged researchers to increasingly look to computer-assisted pattern-recognition software to expedite individual identifications, but little work has been done to formally assess such software for camera-trap data. We used 2 sets of camera-trap images—359 images of jaguars (*Panthera onca*) and 332 images of ocelots (*Leopardus pardalis*) collected from camera traps

deployed in 4 study sites in Orange Walk District, Belize, in 2015 and 2016—to compare the accuracy of 2 such programs, HotSpotter and Wild-ID, and assess the effect of image quality on matching success. Overall, HotSpotter selected a correct match as its top rank 71–82% of the time, whereas the rate for Wild-ID was 58–73%. Positive matching rates for both programs were highest for high-quality images (85–99%) and lowest for low-quality images (28–52%). False match rates were very low for HotSpotter (0–2%) but these were greater in Wild-ID (6–28%). When lower ranks were also considered, both programs performed similarly (overall 22–24% nonmatches for HotSpotter, 17–26% nonmatches for Wild-ID). We found that in both programs, images more often matched to other images of the same quality; therefore, including multiple reference images of an individual, of different qualities, improves matching success. These programs do not provide fully automatic identification of individuals and human involvement is still required to confirm matches, but we found that they are effective tools to expedite processing of camera-trap data. We also offer usage recommendations for researchers to maximize the benefits of these tools.

Only the largest terrestrial carnivores increase their dietary breadth with increasing prey richness

Ferretti, F. 2020. Mammal Review 50:291-303. ISSN 0305-1838.

Abstract – 1. Animals should adapt their foraging habits, changing their dietary breadth in response to variation in the richness and availability of food resources. Understanding how species modify their dietary breadth according to variation in resource richness would support predictions of their responses to environmental changes that alter prey communities.

2. We evaluated relationships between the dietary breadth of large terrestrial carnivores and the local richness of large prey (defined as the number of species). We tested alternative predictions suggested by ecological and evolutionary theories: with increasing prey richness, species would (1) show a more diverse diet, thus broadening their dietary breadth, or (2) narrow their dietary breadth, indicating specialisation on a smaller number of prey. .

3. We collated data from 505 studies of the diets of 12 species of large terrestrial ammalian carnivores to model relationships between two indices of dietary breadth and local prey richness.

4. For the majority of species, we found no evidence for narrowing dietary breadth (i.e. increased specialisation) with increasing prey richness. Although the snow leopard and the dhole appeared to use a lower number of large prey species with increasing prey richness, larger sample sizes are needed to support this result.

5. With increasing prey richness, the five largest carnivores (puma Puma concolor, spotted hyaena Crocuta crocuta, jaguar Panthera onca, lion Panthera leo, and tiger Panthera tigris), plus the Eurasian lynx Lynx lynx and the grey wolf Canis lupus (which are usually top predators in the areas from which data were obtained), showed greater dietary breadth and/or used a greater number of large prey species (i.e. increased generalism).

6. We suggest that dominant large carnivores encounter little competition in expanding their dietary breadth with increasing prey richness; conversely, the dietary niche of subordinate large carnivores is limited by competition with larger, dominant predators. We suggest that, over evolutionary time, resource partitioning is more important in shaping the dietary niche of smaller, inferior competitors than the niche of dominant ones.

An ecological framework for contextualizing carnivore- livestock conflict.

Wilkinson, C. E. et al. 2020. Conservation Biology 34:854-867.

Abstract – Carnivore predation on livestock is a complex management and policy challenge, yet it is also intrinsically an ecological interaction between predators and prey. Human–wildlife interactions occur in socioecological systems in which human and environmental processes are closely linked. However, underlying human–wildlife conflict and key to unpacking its complexity are concrete and identifiable ecological mechanisms that lead to predation events. To better understand how ecological theory accords with interactions between wild predators and domestic prey, we developed a framework to describe ecological drivers of predation on livestock. We based this framework on foundational ecological theory and current research on interactions between predators and domestic prey. We used this framework to examine ecological mechanisms (e.g., density-mediated effects, behaviorally mediated effects, and optimal foraging theory) through which specific management interventions operate, and we analyzed the ecological determinants of failure and success of management interventions in 3 case studies: snow leopards (Panthera uncia), wolves (Canis lupus), and cougars (Puma concolor). The varied, context-dependent successes and failures of the management interventions in these case studies demonstrated the utility of using an ecological framework to ground research and management of carnivore–livestock conflict. Mitigation of human–wildlife conflict appears to require an understanding of how fundamental ecological theories work within domestic predator–prey systems.

People and jaguars: new insights into the role of social factors in an old conflict.

Caruso, F. et al. 2020. Oryx 54:678-686.

Abstract – Throughout its range in Latin America, the jaguar Panthera onca is threatened by habitat loss and fragmentation, and by conflict as a result of coexistence with people. This Near Threatened species is a top predator, and is often illegally hunted. Understanding people's attitudes and perceptions and the factors that could influence them is crucial for the conservation of this species. In this study we assess how knowledge, attitudes and perceptions among people in northern Argentina regarding jaguars vary depending on their level of education, age and occupation. We interviewed 810 people living in and around 10 protected areas in northern Argentina. Positive perceptions and attitudes towards the jaguar were associated with economic benefits that people may receive from the species' presence, such as income from tourism. Unexpectedly, higher levels of formal education were not associated with more positive attitudes and perceptions. Negative attitudes and perceptions towards the species were determined by fear; people see jaguars as a threat to their lives. This study shows that the socio-economic factors that affect the level of tolerance towards jaguars are not related only to economic losses. Our findings provide information for the design, implementation and evaluation of jaguar conservation projects in Argentina

Puma in recent wildfire area. Credit Wildlife Health Center, U. C. Davis.

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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