

Saving Species™

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SAN DIEGO ZOO GLOBAL

INSTITUTE FOR CONSERVATION RESEARCH

Climate Change

Addressing Challenges in Species Recovery

Stresses placed on animals and plants due to changing climate conditions are creating complex and emerging challenges in the fight against extinction.

NOW IT IS UP TO ALL OF US

\\ Allison Alberts, Ph.D., Chief Conservation and Research Officer

We all care about a healthy home—one that supplies us with fresh water, abundant food, and clean air to breathe. A thriving planet can give us all of these gifts, including a flourishing diversity of plant and animal species. It is because extreme changes in climate are threatening the very existence of many animal and plant species that we all need to do what we can for them. It would be easy to feel helpless in the face of such large and looming changes, yet there is reason for hope.

In this issue, you will learn about disease risk monitoring and why it is so important that we are acting now, while there is still time. We will share our multidisciplinary approach, which includes innovative management for species ranging from endangered Hawaiian forest birds to hoofstock on the African savanna, to frogs and other amphibians around the world.

You will see how an international network is coming together to protect polar bear denning habitat and find new ways to combat the effects of sea ice loss. Because there is no time to spare, we are reaching out to new partners, including engineers in the technology sector and zoos around the world.

Even as we work toward long-term solutions, we are using our animal care and science expertise to help rescue and rehabilitate climate refugees ranging from koalas to penguins. Knowing that plants will be among the most impacted, our seed banking strategy uses climate models to map future distributions and capture the full range of genetic variation.

Our most important partner in restoring ecosystems for wildlife is you. The small lifestyle changes we can each make to reduce our individual impact on the planet add up to a huge positive difference, when multiplied by the number of people who care. There is still time to address the worst effects of climate change on wildlife if we all commit to doing our part.

HOW YOU CAN HELP

Our field research teams all over the world rely on the generosity of donors like you to help achieve San Diego Zoo Global's vision to lead the fight against extinction. To learn ways you can help, please call Maggie Aleksic at 760-747-8702, ext. 5762, or email maleksic@sandiegozoo.org.

ON THE COVER:

Climate change adds a new and more challenging dimension to our ability to ensure a future for rare and endangered species. We are striving to create innovative tools that will help animals and plants thrive, in the face of devastating environmental impacts in the uncertain times ahead.

Hawaiian birds are threatened by deadly mosquito-borne diseases like avian malaria. Now that the birds' forest habitats are experiencing warmer temperatures and more rainfall, mosquitoes multiply at these higher elevations as never before.

UNDERSTANDING WILDLIFE HEALTH AND CLIMATE CHANGE: WHERE TO BEGIN?

\\ Bruce Rideout, D.V.M., Ph.D., Dipl. ACVP,
Director, Disease Investigations

One of the fascinating—and daunting—aspects of climate change that doesn't get much attention is the changing disease transmission dynamics we can expect as animals, pathogens, and disease vectors shift their distribution in response to changing climatic conditions. One of the ways we try to anticipate environmental change is through computer models developed by climate scientists, which can help predict large-scale processes, such as melting ice sheets and rising sea levels. But it is difficult or impossible to predict what will happen in specific disease transmission scenarios, because there are too many variables involved: even the most powerful computers can't handle the complexity. We know that changes in disease transmission patterns are coming, but we don't know exactly what they will be, or how they will impact us or the wildlife we care for—we are left in suspense.

But we cannot sit back idly and wait: we have to do our best to respond based on the evidence we currently have. What we do know is that most pathogens and disease vectors have relatively strict environmental requirements for optimum reproduction and development. As average temperatures increase, disease vectors such as mosquitoes will move into areas that were once too cold for them to develop.



“Rather than waiting in suspense to see what frightening scenarios play out, we’re working to minimize the impacts of climate change on wildlife and preparing for whatever responses might be necessary to lead the fight against climate-related extinction.”
—BRUCE RIDEOUT



HAWAIIAN BIRDS IN CRISIS

A classic example of this is the changing mosquito distribution in Hawai‘i. Mosquitoes were introduced to Hawai‘i by a whaling ship in 1826. Prior to that, Hawai‘i was an idyllic paradise, completely free of biting insects. The introduction of foreign avian pathogens, such as malaria and poxviruses, soon followed. Hawaiian forest birds had not co-evolved with these pathogens, so their immune systems were not equipped to respond to them, and their populations were decimated.

Today, fewer than a third of native Hawaiian forest bird species remain, and more than half of those are endangered or threatened with extinction. Those that survive are concentrated in high-elevation forests above 1,500 meters (4,921 feet), which was the line that historically marked the temperature break above which the larvae of the dominant mosquito species, *Culex quinquefasciatus*, could not develop. Now, these high-elevation forests are getting warmer and wetter because of climate change, and the mosquitoes are moving up in response, destroying the last refuge these birds have from these deadly introduced diseases.

As a result, our Recovery Ecology team has started an assurance population of ‘akikiki at our Kauai Bird Conservation Center by collecting eggs from the wild. ‘Akikiki are only found on Kauai, where the population is rapidly declining due to a lack of forest habitat without mosquitoes. We are also monitoring disease in a number of other native Hawaiian forest birds as the climate changes, and we already have mosquito-proof breeding facilities at our Endangered Bird Conservation Centers on Hawai‘i Island and Maui for maintaining reserve populations of many of these species as a hedge against extinction.

THE ARCTIC’S POLAR BEARS

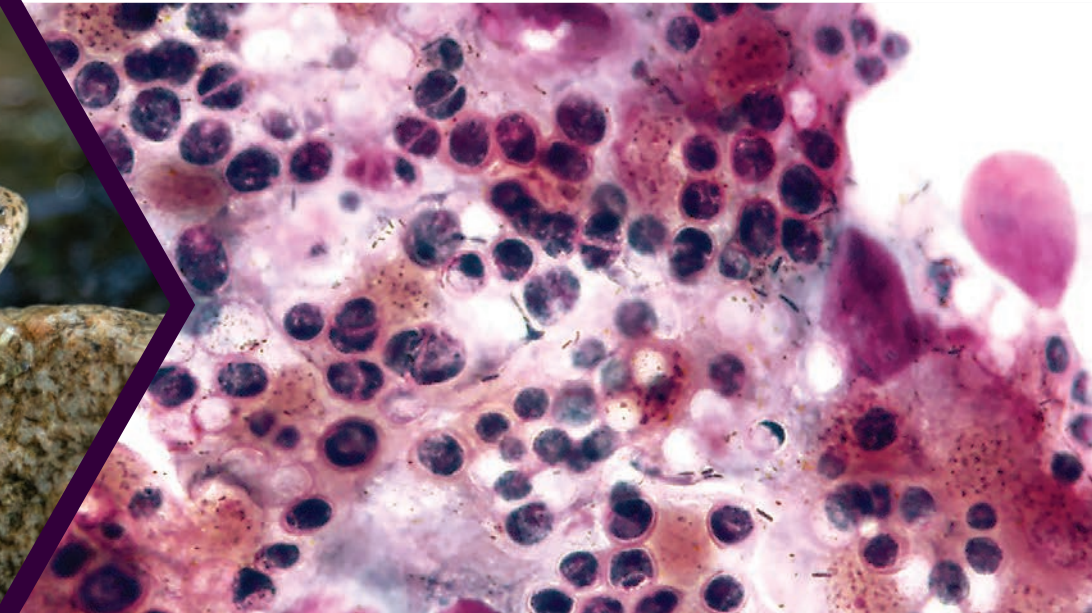
Much farther north, shrinking sea ice due to climate change and increasing human activities are causing some polar bear populations to gradually shift to more terrestrial food sources. These changes in foraging behavior are also changing the disease exposure dynamics for polar bears, resulting in an increasing prevalence of terrestrial diseases, such as those of domestic dogs. We are now collaborating with Environment Canada and our Population Sustainability team, looking at 30 years of disease exposure data in different polar bear populations. Understanding these changing disease dynamics will enable us to make management recommendations to better protect polar bears from terrestrial disease threats as a result of climate change.

KENYA’S WILDLIFE

Changes in animal behavior and disease resilience are also becoming evident in response to climate change. As native species decline in response to habitat loss and human development, they are at risk of going through a genetic bottleneck that results in increased susceptibility to disease. This is a concern for the critically endangered hirola antelope in Kenya, where drought and overgrazing by livestock add to the stress on the last remaining population, increasing their vulnerability to deadly livestock disease outbreaks. In response to these climate-related threats, we are developing the first integrated livestock-wildlife health management program for the region, which will protect the hirola from disease threats while simultaneously benefiting the local pastoralist communities whose livelihood and survival depend on their livestock.



Since starting our breeding program in 2005, San Diego Zoo Global has released and monitored thousands of critically endangered mountain yellow-legged frogs into local mountain streams, boosting species recovery.



Above: Tissue slide, chytrid fungus impression smear. This deadly fungus is threatening amphibian species worldwide.

AMPHIBIAN DISEASE LAB: URGENT SOLUTIONS

Our Amphibian Disease Laboratory was established under a grant from the Institute for Museum and Library Services to provide diagnostic and disease surveillance services for amphibian conservation programs. This is a pressing need: over 100 amphibian species have become extinct since 1980, and a third of the remaining 6,000 species are threatened with extinction because of the global spread of the deadly chytrid fungal disease.

We provide our services at cost, in order to facilitate the establishment of captive reserve populations as a hedge against extinction. Since the inception of the lab, we have provided support to over 100 zoos and conservation programs around the world. In addition to providing our laboratory diagnostic services, we provide expert consultations on disease surveillance strategies, and mitigation plans to control the spread of disease, which is exacerbated by climate change.

MINIMIZING IMPACTS

These climate impacts have the potential to create a self-perpetuating downward spiral in native species. Rather than waiting in suspense to see what frightening scenarios play out, we are working to minimize the impacts of climate change on wildlife and preparing for whatever responses might be necessary to lead the fight against climate-related extinction.

In Kenya, we work with local pastoralist communities to minimize the spread of deadly livestock diseases to the critically endangered hirola antelope that share this habitat with domestic herds.

San Diego Zoo polar bears have been featured in the following studies:

HEARING STUDY

Industrial activities in the Arctic can disturb denning mothers and cubs. Hearing study results from polar bears at the Zoo may strengthen protections for bears in the wild.

ENERGETICS/TREADMILL

Our animal care team and scientists worked with the Zoo's polar bears to provide critical data on energetic costs of their movements when swimming or walking.

SCENT COMMUNICATION

We compared behavioral responses of our Zoo polar bears and those from 10 AZA institutions to scent trails from Arctic bears, confirming that social communication is vulnerable to sea ice fragmentation impacts.

DRONES

Our Zoo research team collaborated with engineers to innovate approaches that image fine-scale characteristics of Arctic sea ice habitat.



“Sensitive and declining species like the polar bear are emblematic ‘canaries in the coal mine’—undeniable indicators that we can and must do more for our wildlife.”—MEGAN OWEN

CHANGING THE FUTURE FOR POLAR BEARS

\\ Megan Owen, Ph.D., Director, Population Sustainability, and
\\ Nicholas Pilfold, Ph.D., Scientist, Population Sustainability

THE POLAR BEARS' HOME IS MELTING AWAY

All threats to polar bears in the wild are dwarfed in comparison to the threat posed by the loss of sea ice in the Arctic as a result of increased ambient temperatures in the region. On average, polar bears spend 95 percent of their life on the sea ice and depend on it for all of their critical life functions: to hunt, travel, mate, and raise their young. Without sea ice, polar bears lose access to the fat-rich seals they require to meet their caloric needs. Equally problematic, it is clear that without sea ice, polar bears are coming ashore in larger numbers and spending more time there, finding themselves near human settlements. Conflicts with humans are dangerous for polar bears and the people living and working in the Arctic.

MEASURING THE IMPACTS OF CLIMATE CHANGE

Technological advances over the last 50 years have provided us with an unparalleled opportunity to regularly measure the Earth's dynamic systems and the impact of human activities. The challenge of measuring the Arctic sea ice is as great as they come, but satellite-mounted sensors have gathered daily measures of sea ice since the late 1970s. The data is startling: summer sea ice extent is reducing by 13 percent per decade—and in every region, in all seasons, sea ice extent is less now than it was in the 1980s and 1990s. Many polar bear populations are feeling the effects of this habitat change. Sea ice loss has caused changes in body conditioning, reproduction, and ultimately, population size. Because sea ice losses are expected to intensify in the coming decades, the International Union for Conservation of Nature (IUCN) Polar Bear Specialist Group recently estimated a further 30 percent decline in polar bear numbers by 2050. The Population Sustainability team and our partners are committed to studying the dramatic impacts of sea ice loss and industrial disturbances on polar bears, while encouraging change in behaviors we humans can make to become part of the solution.

ALL HANDS ON DECK

Our mission is focused on using science to save species from extinction. When it comes to polar bear conservation, we focus on research that will support biologically informed management strategies, effectively “buying time” for polar bears. Because of the rapid pace at which the Arctic is warming, we have made a point of working collaboratively to ensure that we are addressing management challenges as effectively as possible. We work with NGOs, most notably Polar Bears International, a longtime and critical collaborator on much of our work. We work with government agencies, including the United States Geological Survey in Alaska, the Norwegian Polar Institute, and Environment and Climate Change Canada. We work with academic institutions, particularly the University of Alberta, and we work with a large network of conservation-minded zoos around the world. These collaborations are critical to our efforts. There is no room for “first” or “only” in our work—we are all in this together.



PROTECTING MATERNAL DENS

One of the most critical phases in the polar bear life cycle is maternal denning. Pregnant females excavate dens in the fall and seclude themselves from the outside world until spring, when their young cubs are ready to test their legs out on the sea ice. Protecting denning habitat and the denning process from disturbance is vital. During the denning period, mothers do not eat, so the fat they have stored before going into the den must sustain them through pregnancy, cub birth, and months of

nursing hungry cubs. Any threat from the outside world—either real or perceived—may reduce a female’s capacity to successfully emerge from her den with healthy cubs. The delicate balance of maternal denning is part of our research focus. We are helping to understand how maternal behavior is impacted by both climate change and the increasing pressures from human commercial activities in the Arctic. Our goal is that our science is used to inform effective protections for mothers and cubs, to conserve future generations of polar bears.



CREATIVE APPROACHES TO CONSERVATION SCIENCE

The challenges of studying polar bears in the Arctic have also led us to take a creative approach to science, such as testing new technologies to study polar bears in the wild and including polar bears at zoos in critical conservation research. Both of these endeavors tap into the collaborative nature of the work we are doing. The technological needs of our research mean that we are reaching out for partners in the technology sector, hoping to capture the minds and imaginations of the best and the brightest in the world of engineering. At the same time, we are working with the Association of Zoos and Aquariums and the conservation-minded zoo community to study aspects of polar bear biology that simply cannot be done with free-ranging polar bears. Zoos working together also provide an important way to communicate the threats that polar bears face; the role of human activities in creating and resolving those threats; and, importantly, the various action steps that people can take to be a part of the solution.



DID YOU KNOW?

Polar bears are strong swimmers, covering up to 60 miles in a day. They also need sea ice that is stable enough to support their weight when they emerge from the ocean.

ACTION IS OUR ONLY OPTION

Research shows that if we can reduce our carbon emissions and reduce the amount of damaging greenhouse gasses we add to the environment, we can make a positive difference. Each day, every one of us can make choices that mitigate negative impacts on the environment. By making mindful, energy-efficient choices in our everyday lives and advocating, empowering, and inspiring others to do the same, we can help to reverse negative impacts on our planet. Sensitive and declining species like the polar bear are emblematic “canaries in the coal mine”—undeniable indicators that we can and must do more for our wildlife. They are not separate from us since we are inextricably linked through our shared ecosystems. We owe it to ourselves to take action—not only for our quality of life, but for our very existence, and for future generations.



RETETI ORPHANAGE

Many of the young elephants at the Reteti Elephant Sanctuary in Kenya were rescued after falling into wells, yet these wells are a necessity for local communities during drought. Climate change is driving more frequent and more intense drought conditions in already arid regions, challenging the survival of people, their livestock, and wildlife.

CHANGING ENERGY DEMANDS

\\ Anthony Pagano, Ph.D., Postdoctoral Fellow, Population Sustainability

Unlike humans who consume a reliable 2,000 to 2,500 calories per day, polar bears may spend up to two-thirds of the year fasting. In the spring, polar bears can more than double in mass, making this period critical for catching their seal prey. We are tracking the movements and energy demands of polar bears to understand the effects of climate change on overall energy balance. We are finding climate change-driven declines in Arctic sea ice—including increases in sea ice fragmentation and an increasing open water period—are increasing the movement rates and energy demands of polar bears. All this threatens their survival and their ability to successfully rear offspring.



LOOKING FOR SOLUTIONS

\\ Victoria Dunch, Senior Research Associate, Community Engagement

The Community Engagement team has a number of modules for middle and high school audiences that aim to emulate the science we are doing to better understand just how polar bears will be impacted by climate change-driven sea ice losses. Polar Bear Energetics immerses students in the science of metabolism, focusing on how a species' energy demands can change as a result of climate change. Polar Bear Bioacoustics focuses on our collaborative research program designed to address the impacts of noise disturbance on successful maternal denning. Members of our team are also going through National Network for Ocean and Climate Change Interpretation training, to learn best practices for communicating climate change to general audiences.



CHASING PLANT DIVERSITY IN SAN DIEGO

\\ Katherine Heineman, Ph.D., Data Scientist, Center for Plant Conservation, and Joyce Maschinski, Ph.D., Director, Plant Conservation, and CEO and President, Center for Plant Conservation

While it is tempting to think of plants as static bumps on the landscape—they are literally rooted in the ground, after all—plant species move and change in countless ways. Their seeds and pollen disperse through the air or with the help of animals, and their leaves, flowers, and fruits change throughout the seasons. The appearance and genetic composition of individuals in a plant population change from year to year. With increasing frequency, the geographic ranges of plant species are shifting as a changing climate makes some historical habitats too hot and dry for species survival.

In San Diego County, prolonged periods of drought coupled with increased temperatures have left majestic Torrey pines *Pinus torreyana* prone to bark beetle attacks, leading to high mortality of the population at Torrey Pines State Natural Reserve. High temperatures and drought have also made habitats that support rare plants susceptible to wildfire. For Tecate cypress *Hesperocyparis forbesii* the increased frequency of fires in the last decades threatens cone production. Because they require 40 to 50 years to reach prime seed production, fires in 1944, 1976, and in 2003—with spot fires in between and since then—severely threaten this population.

Seed banks are a fundamental safeguard that protect endangered plants from extinction. As part of our collaboration with California Plant Rescue (CaPR),

we collect seeds of California native plant species for long-term preservation in our Native Plant Seed Bank. Properly dried seeds can be reliably stored for years at low temperatures, and we can conserve large numbers of genetically diverse seeds. When we visit rare plant populations to collect seeds, we also record conservation status of the population and report this to the California Natural Heritage Database. We currently hold 128 accessions (collections on one date of a species growing at one location) of 47 endangered San Diego County plant species, and we are not finished collecting for the season!

San Diego thornmint *Acanthomintha ilicifolia* is a particularly dynamic and rare plant species that is vulnerable to changes predicted by future climate scenarios. This species has a long but narrow range, spanning from northern San Diego County to Baja California, Mexico, where it grows on a specific soil habitat known as clay lens. Because of its annual life cycle, thornmint populations swing dramatically in size from year to year, depending on rainfall that precedes the growing season, as well as temperature during the growing season. Climate forecasts predict that in 50 years, half of San Diego thornmint populations will experience annual temperatures hotter than current ones, so local extinction and range shifts farther north are extremely likely.

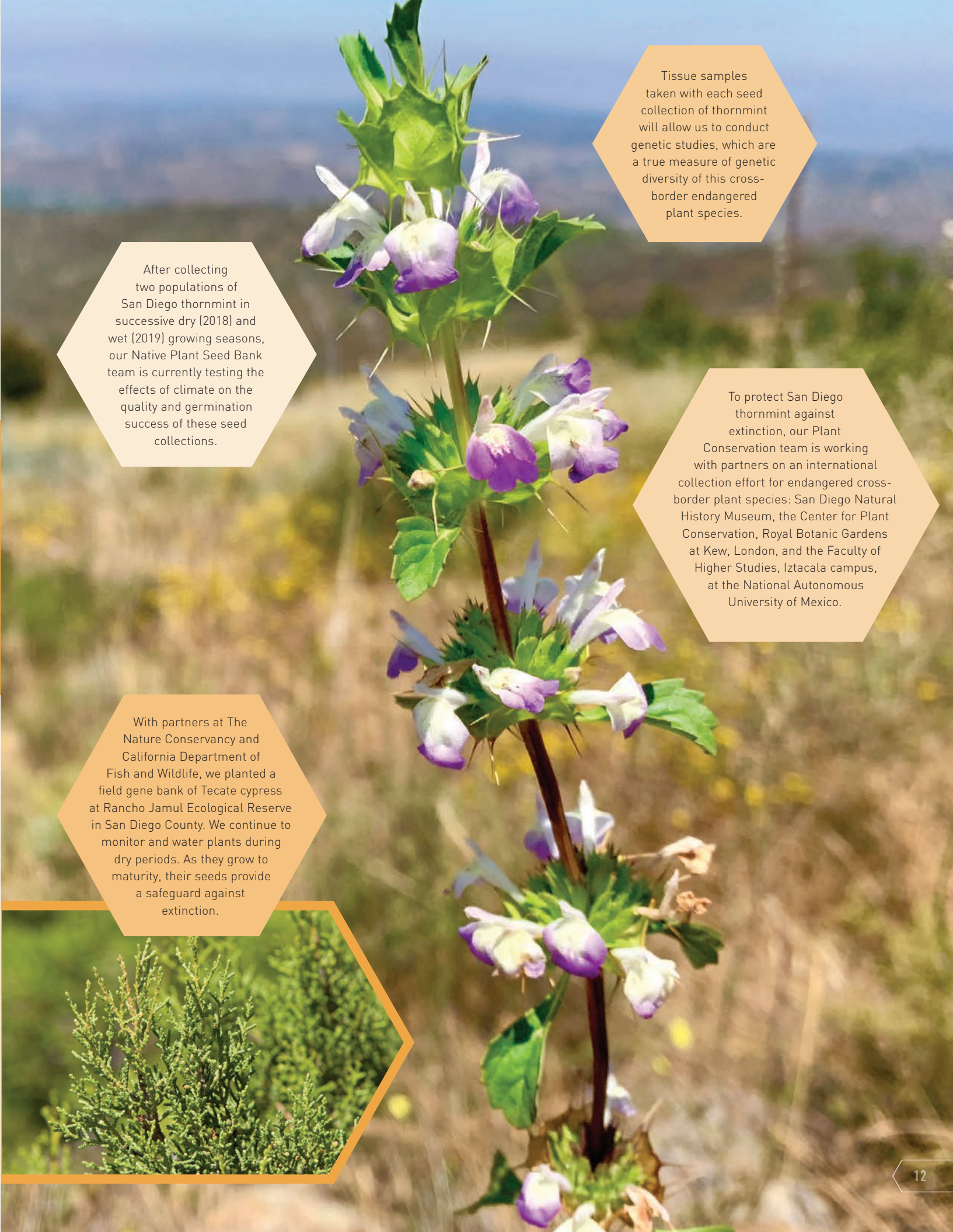
It is important to remember that a single seed collection from a plant species is only a partial snapshot of its diversity, because it is made on one day. The seeds that are available for collection on any day reflect expression of genetic diversity that is influenced by chance events, local adaptation, and growing season climate. To create a robust conservation collection, the Native Plant Seed Bank team has collected San Diego thornmint from 9 populations in San Diego County, ranging from Carlsbad in the north to 2.5 miles north of the Mexico border, as well as 5 populations in Baja California. Together, these conservation collections represent the full geographic range of San Diego thornmint and can serve as the basis for future wild reintroductions.

This is just one example of widespread collection and documentation of a rare plant species. Our Plant Conservation team is using the ecological data associated with hundreds of seed collections from many other species to model their possible future distribution as climate changes. Seed banks are an invaluable addition to plant conservation, giving us assurance that a healthy ecosystem can be preserved. As our team works to bank seeds today, they are also protecting tomorrow's plant biodiversity through propagation and restoration.



“Seed banks are a fundamental conservation safeguard that protect endangered plants from extinction...We currently hold 128 accessions (collections on one date of a species growing at one location) of 47 endangered San Diego County plant species, and we are not finished collecting for the season!” —JOYCE MASCHINSKI

Our Plant Conservation team is working to combat impacts of climate change in several ways. For Torrey pines, ongoing genetic studies seek key genes that may contribute to resistance to bark beetle attacks. If found, it may be possible to increase the number of trees with resistant genes into future reintroduced populations.

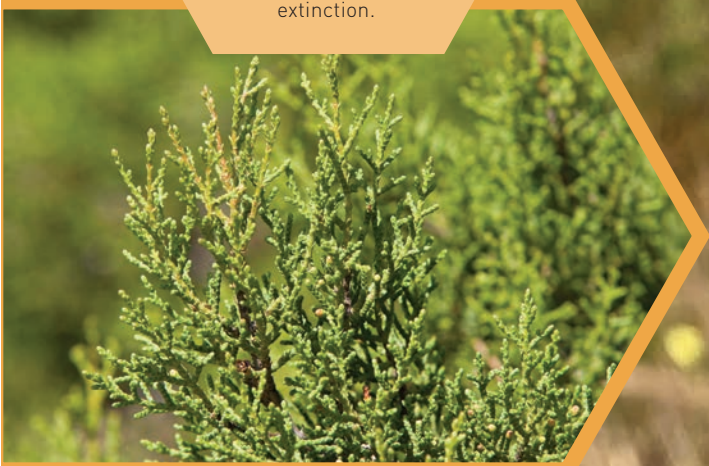


After collecting two populations of San Diego thornmint in successive dry (2018) and wet (2019) growing seasons, our Native Plant Seed Bank team is currently testing the effects of climate on the quality and germination success of these seed collections.

Tissue samples taken with each seed collection of thornmint will allow us to conduct genetic studies, which are a true measure of genetic diversity of this cross-border endangered plant species.

To protect San Diego thornmint against extinction, our Plant Conservation team is working with partners on an international collection effort for endangered cross-border plant species: San Diego Natural History Museum, the Center for Plant Conservation, Royal Botanic Gardens at Kew, London, and the Faculty of Higher Studies, Iztacala campus, at the National Autonomous University of Mexico.

With partners at The Nature Conservancy and California Department of Fish and Wildlife, we planted a field gene bank of Tecate cypress at Rancho Jamul Ecological Reserve in San Diego County. We continue to monitor and water plants during dry periods. As they grow to maturity, their seeds provide a safeguard against extinction.



CONSERVATION ACHIEVEMENTS

HONORS AND AWARDS

The **Hawaii Endangered Bird Conservation Program** and **San Diego Zoo Global** were recognized as 2018 Recovery Champions by the U.S. Fish and Wildlife Service for our four-year endeavor to successfully initiate a conservation breeding population for the critically endangered 'akikiki.

Jenny Glikman, Ph.D., was invited to join the editorial board of *Conservation Science and Practice*, a new open-access journal of the Society for Conservation Biology.

Symon Masiaine successfully defended his master's thesis at Michigan State University. Symon is the in-country lead for our *Twiga Walinzi* (Giraffe Guards) program in Kenya, and his thesis examined the effects of a large-scale incursion of livestock on space use by large herbivores at Loisaba Conservancy.

Our **San Diego Zoo Global campuses** received official accreditation as botanic gardens from Botanic Gardens Conservation International.

HIGHLIGHTED PUBLICATIONS

The fight to end extinction happens on a variety of fronts. Our conservation scientists and researchers work to lead this fight in every capacity, whether studying the smallest cells or working with the largest animals. From studying an African herb eaten by gorillas that is susceptible to climate change, to examining metabolic rates and body condition of polar bears when fewer marine mammal prey are available, to key aspects of polar bear metabolism that can make them vulnerable to extinction, here is what we've published lately:

Ley, A., P. Herzog, S. Lachmuth, **A. Abwe**, C. Mbella, P. Sesink Clee, **E. Abwe**, **B. Morgan**, and M. Gonder. 2018. Phenotypic variability along a climatic gradient in a perennial African tropical rain forest understory herb. *Basic and Applied Ecology* 28: 60-75.

This study examined variability in growth, physiology, productivity, and seasonality of a tropical African perennial herb eaten by gorillas. There was significant variation between plants grown under different climate conditions, suggesting that predicted increased dryness from human-induced climate change may be disadvantageous in the future.

Pagano, A. M., G. M. Durner, K. D. Rode, T. C. Atwood, S. N. Atkinson, E. Peacock, D. P. Costa, **M. A. Owen**, and T. M. Williams. 2018. High-energy, high-fat lifestyle challenges an Arctic apex predator, the polar bear. *Science* 359: 568-572.

By measuring field metabolic rates, daily activity patterns, body condition, and foraging success of polar bears moving on the spring sea ice, we found that high metabolic rates, coupled with low intake of fat-rich marine mammal prey, resulted in an energy deficit for more than half of the wild polar bears examined.

Whiteman, J. P. 2018. Out of balance in the Arctic. *Science* 359: 514-515.

In this Perspectives essay, San Diego Zoo Global Postdoctoral Fellow John Whiteman, Ph.D., provided an overview of the important role that polar bear metabolism plays in rendering the species vulnerable to extinction as a result of climate change-driven sea ice losses.

PHOTO CREDITS:

Pg. 2 mosquito doug4537/E+/Getty Images, pg. 2 iceberg Don Mennig/iStock/Getty Images Plus, pg. 2 fire Gilitukha/iStock/Getty Images Plus, pg. 3 mosquito Swarm Hans Verburg/iStock/Getty Images Plus, pg. 4 hirola by Juliet King, pg. 7 polar bear den KeithSzafranski/E+/Getty Images, pg. 9 polar bear SeppFriedhuber/E+/Getty Images, pg. 9 girls SDI Productions/E+/Getty Images, back cover seals wdj/iStock/Getty Images Plus.

WHAT'S News



RECOVERY ECOLOGY

Our Hawai'i Endangered Bird Conservation Program released six palila into the wild in an effort to establish a second population of this critically endangered honeycreeper species.



PLANT CONSERVATION

The team located and mapped a population of Campo clarkia *Clarkia delicata*—a California state-listed rare plant species—within the Safari Park Biodiversity Reserve.



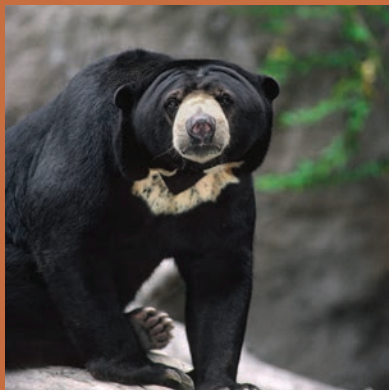
POPULATION SUSTAINABILITY

A new tablet-based survey for tracking seal abundance and distribution was designed and tested, and we deployed remote cameras to document feeding dynamics at seal kills by polar bears.



CONSERVATION GENETICS

We began a project to study the genomes of Pacific pocket mice that will help us explore trade-offs between beneficial and harmful genetic variation in species rescue efforts.



REPRODUCTIVE SCIENCES

Sperm and testicular tissue from a Malayan sun bear were frozen and stored so they may be used for assisted reproduction, which further safeguards the future of this vulnerable species.



DISEASE INVESTIGATIONS

We led a Disease Risk Analysis Workshop in the British Virgin Islands for the critically endangered Anegada iguana.



COMMUNITY ENGAGEMENT

Our team conducted community outreach for the Leopard Conservation Program in Loisaba Conservancy, Kenya, where predator deterrents at livestock pens were discussed.



BIODIVERSITY BANKING

We met with the South African National Biodiversity Institute as part of a binational collaboration to bank species' tissues and DNA, including samples from northern white rhinos, sungazer lizards, Cape mountain zebras, and bushbucks.

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