Saving Species with Science®

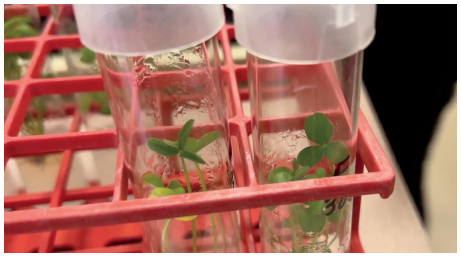
CREW ReView

Lindner Center for Conservation and Research of Endangered Wildlife

Cincinnati Zoo & Botanical Garden • Fall 2025

ROTH'S REMARKS

It Takes a Village to Save Species



CREW scientists often mention zoos, botanical gardens, universities, NGOs, and governmental agencies that collaborate with us and make our projects possible, stronger, and more impactful. However, that is just the tip of the much larger iceberg supporting CREW in its mission - Saving Species with Science®. Species are extremely difficult to save from impending extinction, and each progressive step we make towards that goal is achieved on the shoulders of many. Our donors and family foundations both local and across the U.S. are critical in providing financial support for our work, especially when grant funding becomes scarce (as occurred recently with the sudden termination of three of our federally-funded grants from the Institute of Museum and Library Services). To that end, the Zoo's Development Department plays a critical role assisting us. Similarly, net proceeds from the Toast to the Wild event series orchestrated by the Zoo's Marketing Department have been yielding a critical piece of the financial pie upon which CREW relies, and the Public Relations Department is always seeking opportunities to share our achievements with the community and beyond, giving people reason to hope as they read about our work's tangible impact on imperiled plants and animals. Beyond financial support, there is a plethora of ways our Cincinnati community contributes to CREW's work. Our dedicated volunteers help with biological sample processing, plant lab research, school group building tours, cat colony care, visitor engagement on Zoo grounds, overnight animal watches, and even serve as our receptionists. All of these contributions, and so many more, make us more efficient and stretch those valuable CREW dollars. Our model of teamwork and inclusivity has paid off over the decades with so many conservation science milestones we can point to with pride. A recent video captures just a few of those breakthroughs achieved over CREW's long, productive history, and we invite all of you, as valued members of our team, to watch it using the QR code.

Dr. Terri L. Roth
VP OF CONSERVATION & SCIENCE AND DIRECTOR OF CREW

Outstanding Outplanting:
20 Years of Sandwort Success

CREW has been working to restore the Cumberland sandwort for over 20 years, and our efforts have paid off in droves! CREW scientists and the U.S. Forest Service (USFS) originally targeted the federally endangered species due to its declining populations and lack of viable seed production. After USFS identified a potentially suitable habitat in Daniel Boone National Forest, the CREW Plant Research Division propagated over 60 plants from the original seven that were initiated into tissue culture and provided them for experimental outplanting. Nearly 20 years later, that little outplanting has grown to a self-sustaining population of over 300 individuals that regularly produce seedlings. To better understand how a population started with just a few individuals could grow to be so successful, CREW partnered with the Cincinnati Museum Center to do a population genetics study comparing the outplanting with the natural populations of the species. Former CREW graduate student and Zoology Collections Manager Rachel Bridgens teamed up with current CREW graduate student Ryan Brooks to collect and analyze samples last year, and the team found that although there is low genetic diversity in the species as a whole (common in many rare plant species), the outplanting is nearly genetically indistinguishable from the natural populations, indicating that the outplanting has been a genetic success too. All of our efforts seem to be paying off, as the Cumberland sandwort was delisted from the Endangered Species List in 2021 due to population recovery and our establishment of a successful restoration protocol. *This project was funded, in part, by the U.S. Forest Service and Botanic Gardens Conservation International.*

It Takes More than Luck to Save the Kentucky Clover

The CREW Plant Research Division teamed up with the Bowyer Farm Horticulture team and the Office of Kentucky Nature Preserves (OKNP) this spring to transplant nearly 1,000 Kentucky clover plants initiated in test tubes to their natural habitat. This rare species, related to our imperiled buffalo and running buffalo clovers, was first discovered in 2010 and is only found in two counties in Kentucky. CREW scientists first propagated the Kentucky clovers in test tubes, then transferred the plantlets to Bowyer Farm to harden them off and worked with OKNP to identify sites for their outplanting. In 2021, the first transplant from test tube to the field was tested with only 75 plants. After watching and managing the restoration for a few years, OKNP observed enough survival and even seed production from the transplanted species to commit to more (and larger!) restoration outplantings of the species. We completed our largest restoration so far in April 2025 and are on-track to deliver even more Kentucky clovers to their new forever homes next year. With a little teamwork and patience, we are hoping to see the species recover and re-colonize its original habitats. So far, the future is looking brighter for this little clover.

A New PAW-pulation of Pawpaws in Florida

Restoration of a species to the wild is the ultimate conservation goal, so we were thrilled that plants produced by CREW supported a project to help restore Rugel's pawpaw *(Asimina rugelii)* to its native slash-pine flatwoods habitat in Florida. Rugel's pawpaw is a federally endangered species also listed as critically imperiled by NatureServe and in need of restoration. It was discovered to science and described in the 1800s but has only ever been found in a few populations in Volusia County in northeast Florida. Propagation and cryopreservation protocols were developed for the species by CREW's Plant Lab in the early 2000s, but it wasn't until 2018 that it was possible to initiate an official restoration project. Shoots were collected from several populations of wild plants by collaborators from Bok Tower Gardens and sent to CREW for initiation into tissue culture and propagation. CREW staff and volunteers nurtured multiple tissue culture lines as the number of shoots increased. Shoots were then rooted, acclimatized to soil and sent to Bok Tower Gardens in 2019 for further growth in their greenhouse. By late 2024, 60 of the plants were big enough for transportation to Conservation Florida's DRanch Preserve in southern Volusia County where they were planted, starting a new population and moving the species one step closer to recovery. *Supported, in part, by funds from the U.S. Fish and Wildlife Service.*

Unbe-LEAF-able Results After Three Years of Oak Study

The CREW Plant Research Division has finally reached the end of our three-year IMLS-funded study on improving oak tissue culture initiation, and we uncovered some surprising results! By partnering with over 20 other botanic gardens and arboreta, we initiated nearly 3,000 tubes of eight oak species over the course of our study. We have been able to increase our survival rates nearly four-fold by testing several new sterilization methods, and we've established a protocol for producing somatic embryos using young leaf tissue of the endangered Georgia oak, allowing us to more easily cryopreserve this species for the future. Surprisingly, we found that the weather and environmental conditions the trees experience both short- and long-term before collection can have an impact on their survival in tissue culture, as higher humidity in the two weeks prior to collection leads to higher survival in tissue culture, and lower average winter precipitation over a 30-year period is associated with lower survival. Furthermore, different species tend to be more or less successful depending on the year, suggesting that a complex interaction between the environment and weather can lead to different results for each species. By comparing the observed environmental conditions with their desired species, researchers can now target the prime conditions for tissue culture success. Though our results are complex, they'll ultimately lead to more efficient oak conservation to preserve these majestic species for future generations. *This project was funded, in part, by the Institute of Museum and Library Services National Leadership Grant #MG-252118-OMS-22.*

When a Small Sample Size is Good News

Photo by: Grahm S. Jones, Columbus Zoo and Aquarium

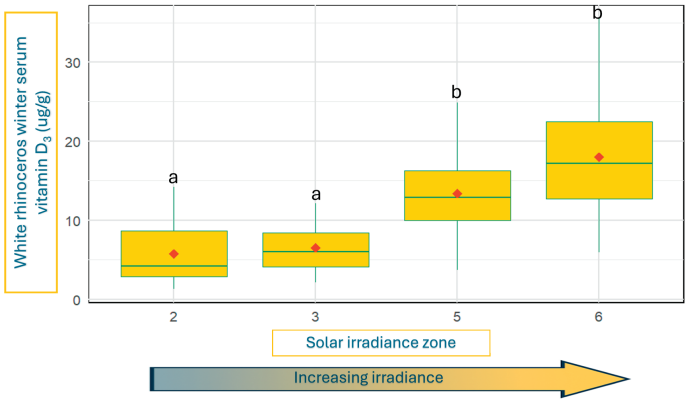
By definition, endangered species are rare, so scientists studying them are constantly plagued by small sample sizes that limit the power of their data. CREW's rhino scientists recently encountered that exact "problem" while analyzing hormone data as part of the AIRS project. One of the AIRS priorities was to identify factors causing reproductive dysfunction in rhinos, especially white rhinos that have a history of poor reproductive performance. However, our data revealed that all female black rhinos and ~75% of the white rhinos in our study were reproductively active, including 20 white rhinos that were even pregnant during AIRS. These findings are great news for the rhino community! Most female rhinos are contributing calves to the next generation which is essential for population sustainability. Although the small number of reproductively inactive females made it challenging to answer questions about dysfunction, we did identify just enough to address one potential concern. Hyperprolactinemia, a condition characterized by high serum prolactin concentrations, is associated with reproductive quiescence in elephants, and we wanted to know if this disorder also occurs in reproductively inactive female white rhinos. Despite the small sample size, AIRS data conclusively ruled it out. In fact, reproductively active white rhinos produce slightly higher prolactin concentrations than quiescent females, so hyperprolactinemia is one condition we probably don't need to worry about in rhinos. *This project was funded, in part, by the Institute of Museum and Library Services National Leadership Grant #MG-249011-OMS-21.*

The Rhino Horn–Human Health Disconnect

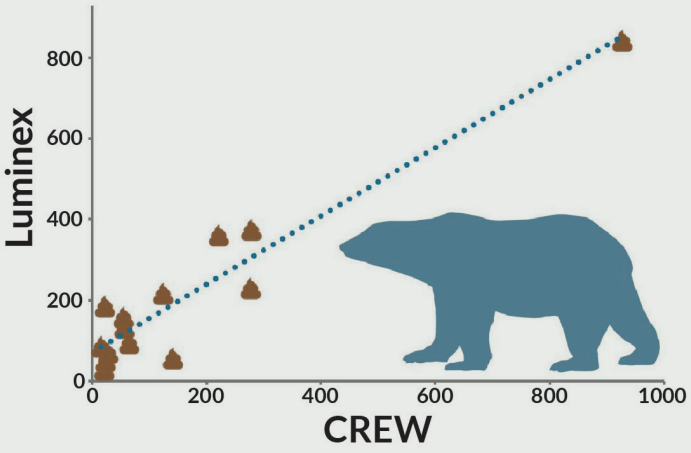
The world's wild rhinos continue to fight for survival as poaching ensues despite substantial efforts by conservationists and law enforcement to counter such threats. This crisis is fueled by the exorbitant price paid for rhino horn that is often consumed for its putative medicinal qualities. One of AIRS' studies focused on quantifying minerals in rhino horns as an indirect measure of liver concentrations. Our interest was driven by the challenges of monitoring iron overload disorder in susceptible black and Sumatran rhinos. Although our results revealed that only arsenic and selenium (not iron) concentrations in horn are correlated to those in livers, there was a very beneficial by-product of our research. We found that the numerous minerals we measured in horn keratin were present in such low concentrations that they could not possibly provide any human health benefits if ingested in feasibly consumable quantities. Furthermore, horn products are often illegal and unregulated, so the environmental contamination we documented in horn is likely adding risk to an otherwise ineffective "medicine". Humans are better off simply taking a daily vitamin/mineral supplement that is inexpensive, readily available, and safe. Although scientific data about its composition is unlikely to stop rhino horn demand, even a slight reduction in the illegal market would be a welcomed reprieve from the current merciless slaughter of wild rhinos. *This project was funded, in part, by the Institute of Museum and Library Services National Leadership Grant #MG-249011-OMS-21.*

Basking in the Sun: Reduced Ultraviolet Irradiation Impacts Vitamin D but not Reproduction in White and Black Rhinos

Black and white rhinos in managed care, particularly those in Europe and North America, experience substantially less ultraviolet (UV) exposure than their wild counterparts. In many zoo-managed species, reduced UV availability can limit cutaneous production of vitamin D, a key regulator of calcium and phosphorus absorption, bone health, and other physiological processes including reproduction. Because reproductive challenges remain a concern in some managed rhino populations, we investigated whether reduced UV exposure and associated vitamin D status might be a contributing factor. As part of AIRS, we measured serum concentrations of vitamin D2 and D3 in black and white rhinos across North America and assessed their correlation to reproductive parameters. Neither vitamin D2 nor D3 were significantly associated with reproductive status, pregnancy, or lactation, and no effects of age or species were observed. However, clear differences emerged between the two vitamin D forms. Plant-derived vitamin D2 was consistently low, often falling below detectable limits, and showed no seasonal variation. In contrast, vitamin D3, primarily synthesized in the skin following UV exposure, declined significantly during winter months and was positively correlated with regional UV irradiation levels. These findings demonstrate that black and white rhinos likely rely on endogenous vitamin D synthesis rather than dietary plant sources, and although UV exposure is reduced in managed care, diminished vitamin D is not associated with reproductive challenges. *This project was funded, in part, by the Institute of Museum and Library Services National Leadership Grant #MG-249011-OMS-21.*



Making the Most of Every Fecal Sample: The "Doing More with Less" Approach



Fecal samples are goldmines of information. They're easy to collect, available daily, and packed with clues about health, reproduction, and stress. However, labor intensive processing is required to access that valuable biological data within them, and traditional hormone assays measure only one hormone at a time. That means multiple rounds of preparation, reagents, plastics, and staff time are required to obtain all the desired data. Enter Luminex technology, an innovative tool designed for blood samples that can measure up to 100 hormones in a single round. We asked a simple but important question: if serum isn't available, can this same efficient approach work with feces, urine, or saliva? This past year, our team put the technology to the test using samples from polar bear, black and white rhino, okapi, aye-aye, domestic cat, caracal, Amur leopard, Andean bear, and sloth bear. The specific assay we used focused on six hormones tied to reproduction, stress, and metabolism — all measured at once. Across rhinos, polar bears, and several cat species, the Luminex results closely mirrored our trusted in-house assay results, and even urine from aye-ayes and saliva from rhinos produced reliable hormone patterns. These findings show that one test can now reveal multiple layers of information from a single non-invasively collected sample. By reducing time, consumables, and the number of separate tests needed, we can maximize the data gathered across many species — helping CREW do more with less. *This project was made possible by funding from the Basis Foundation.*

It's Complicated: AMH and Polar Bear Fertility

With only a limited number of polar bears in zoos, strategic breeding recommendations are essential to ensure a sustainable population. Yet it is often difficult to know which individuals have the best chance of producing cubs. Scientists at CREW are exploring new ways to assess fertility and recently turned their attention to a hormone called Anti-Müllerian hormone (AMH), long used in humans and domestic animals as a fertility marker, but never before studied in bears. By analyzing 165 blood samples from 48 zoo-housed polar bears, the team uncovered several intriguing findings. Unlike results in humans and most domestic animals, AMH concentrations in polar bears are not stable throughout the year but rather fluctuate with the seasons. However, in females, AMH does decline with age as expected, offering a potential tool for identifying those nearing the end of their reproductive lifespan. In males, AMH was inversely related to testosterone, suggesting a role in suppressing sperm production during the non-breeding season. Although too much overlap between fertile and infertile groups means AMH cannot serve as a stand-alone test of fertility, it represents a promising addition to our toolbox for investigating reproductive potential (and reproductive biology) in this species, thereby facilitating the sustainability of polar bear populations under human care while advancing efforts to secure the species' long-term future. *This study was funded, in part, by the Institute of Museum and Library Services Grant #MA-249327-OMS-21 and the Charlotte Schmidlapp Foundation.*

From Freezer to Field Science

Studying polar bear health in the wild is extraordinarily difficult - field researchers often can reach bears only by helicopter, under sub-zero degree conditions, with a single chance to collect samples. Fieldwork often takes place during breeding season and, although females may be observed near males, whether they are truly in estrus is unknown. CREW scientists previously validated a method to determine estrous status in anesthetized zoo polar bears by collecting vaginal cells with a long swab, rolling them onto glass slides so that they adhere, and then spraying the slide with a fixative to preserve the delicate cells until they can be examined microscopically. While effective in the zoo setting, this approach was doomed to fail in the Arctic where freezing temperatures would instantly freeze slides, preventing cells from sticking. To overcome this challenge, CREW intern Maya Beumer spent long hours in CREW's -20°C walk-in freezer to mimic Arctic conditions and experimented with many different iterations until she developed a field-friendly protocol that involved submerging the swabs directly into fixative solution rather than rolling them on slides. With this method in hand, field researchers successfully collected samples from wild polar bears this past spring, and CREW scientists are now using those samples to determine estrous stage in free-ranging females. This collaboration demonstrates how zoos and field programs complement one another: controlled zoo settings enable method development and training, while fieldwork puts those methods to the test under real-world conditions. *This study was funded, in part, by the Institute of Museum and Library Services Grant #MG-253001-OMS-23 and the Ellen and Richard Berghamer Foundation.*

Decades of Endocrine Data from Zoo Polar Bears

Understanding polar bear physiology is key to improving their care and conservation. Whereas fecal hormone analysis is commonly used in zoo and wildlife studies, some hormones, like estradiol, thyroid-derived triiodothyronine (T3) and thyroxine (T4), are not reliably detected in polar bear feces. Measuring hormones in blood provides access to a broader range of biomarkers but is often not feasible in zoo populations due to limited sample volume, particularly when multiple hormones are of interest. To overcome this limitation, CREW scientists used a multiplex assay to simultaneously measure six hormones in 400 banked polar bear blood samples, some collected more than 40 years ago. Metabolic hormones, such as cortisol, T3, and T4, varied across months and ages, while sex steroid hormones, such as testosterone and estradiol, differed between sexes and across life stages, following previously reported trends. We also observed sex-specific seasonal patterns that coincide with key reproductive events. Measuring multiple hormones allows scientists to characterize subtle shifts in individual hormone concentrations across time and how they work together to regulate physiological responses to the environment, offering a more integrated view of polar bear physiology that has not been captured in previous studies. *This project was funded, in part, by the Institute of Museum and Library Services grant #MA-249327- OMS-21.*

CREW would like to thank our generous sponsors, the best volunteers and the Cincinnati community for their support of another WILDLY successful Toast to the Wild event series. Each event in the series helps CREW to further its mission of Saving Species with Science®.

Soft Drink Sponsor: PEPSI

Designated Driver Sponsor: CELSIUS LIVE FIT

Presenting Sponsor: CAVALIER DISTRIBUTING

Welcome Drink Sponsor: Terrex DEVELOPMENT & CONSTRUCTION

Photo Experience Sponsor: Windows DIRECT USA — WINDOWS • BATHS • DOORS

And thanks to many beer and liquor partners!

On the Fast Track to the Future

Accurate assessment of sperm motility is fundamental to evaluating male fertility. Historically, this task relied on scientists visually estimating sperm movement under a microscope and assigning a subjective score. However, manual evaluation is imprecise, limiting the reliability of fertility assessments and complicating comparisons across institutions. Computer-assisted sperm analysis (CASA) provides an automated, objective alternative that generates precise measurements of motility, concentration, viability, and morphology. These metrics not only improve accuracy but also allow identification of sperm subpopulations with the highest fertilization potential. Because sperm size, shape, and movement can vary across species, CASA systems for each taxon must be validated. However, to date, no system had been validated for any felid species. To address this gap, CREW scientists collaborated with the manufacturer of the Hamilton-Thorne IVOS II CASA Analyzer to optimize system parameters for felids. Validation included manual review of more than 500 domestic cat sperm tracks, demonstrating 96% agreement between optimized CASA outputs and expert human evaluation. The same parameters also performed effectively in Amur leopards, jaguars, and caracals, confirming broad applicability across felids. This study establishes the first validated CASA protocol for felids, providing a reliable and standardized approach to semen evaluation. This powerful new tool will help strengthen CREW's CryoBioBank® and support the continued development of effective assisted reproduction technologies. *This work was funded by the Arthur L. and Elaine V. Johnson Foundation.*

Scan the QR code to watch sperm on the fast track with CASA.

Community Service:
Evidence-Based Solutions for Free-Roaming Cats

CREW was awarded a $450,000 grant from the Joanie Bernard Foundation to launch a two-year project focused on innovative, humane solutions for community cats (i.e., outdoor, unowned domestic cats). Entitled Innovative Solutions for Community Cat Care: Bridging Trap-Neuter-Vaccinate-Return (TNVR) Knowledge Gaps and Advancing Non-Surgical Sterilization, the project addresses the critical need for effective management strategies that benefit cats, communities, and wildlife alike. Key initiatives include a rabies protection study to evaluate vaccine effectiveness in younger kittens, a dietary study using stable isotope analysis to assess predation impacts, a systematic review of TNVR literature to synthesize current knowledge and identify gaps, and refinement of a single-dose, permanent sterilization method with the long-term goal of FDA approval. The award also expanded CREW's capacity by funding two new full-time keeper positions in the Cat Colony, filled by Reagan Steele and Haylie Kinman. Using positive reinforcement techniques, they are training cats to voluntarily participate in essential husbandry and medical procedures such as blood collection, which reduces stress, improves welfare, and allows for more frequent and reliable health monitoring. In addition, grant support for a postdoctoral scientist position ensures advanced training for the next generation of animal welfare researchers. Together, these initiatives represent a transformative opportunity for CREW to lead the way in innovative, evidence-based approaches to community cat management.

FRIENDS OF CREW

Thanks to the following for supporting CREW in Fiscal Year 2025

(April 1, 2024–March 31, 2025)

$100,000+

The Joanie Bernard Foundation
Mr. and Mrs. Roger W. Gross
Institute of Museum & Library Services
Arthur L. and Elaine V. Johnson Foundation
The Michelson Found Animals Foundation, Inc
University of British Columbia

$20,000 - $99,999

Anonymous
Ellen and Richard Berghamer Foundation
Cavalier Distributing
Mary Elizabeth Dodson Trust
Reuben Herzfeld Fund
Dave and Debbie Horn
Sandra Houck
Mr. Robert A. Johnston
Stephen Rogers
Texas A&M Research Foundation
The John K and Janice L Howie Foundation
G. Richard and Jane S. Thomas Foundation
United States Geological Survey
The Vista Foundation
Karen Wachs
Ginger Warner
Botanic Gardens Conservation International

$10,000 - $19,999

Ms. Sheryl Grouse and Mr. Alan Cockell
Bill and Pat Haynes Family Charitable Fund
Julia Roth*
Craig and Mary Beth Young and Family

$5,000 - $9,999

American Association of Zoo Veterinarians
Eileen and John Barrett
Dallas W. and Helen B. Bowyer Charitable Trust
Dr. and Mrs. William B. Camm
Ms. Alison M. Chase
Cincinnati Business Courier
Coombe Family Fund
Lucile and Richard Durrell Special Fund II of GCF
Hard Rock Casino Cincinnati
Janet Mott
Margie Nordlund
Mr. and Mrs. Charles Strebel
Debra Williamson

$1,000 - $4,999

Anonymous (8)
Archbold Biological Station
Augusta Distillery
Dr. Diane S. Babcock
Bardstown Bourbon Company
Bob and Janice Bechtel
Dr. and Mrs. Thomas E. Bell
Mr. and Mrs. Joe Bobbey, Jr.
Boone County Distilling Company
Kelly and Tim Brown
Angie and Gary* Butterbaugh
Jaime and Mike Carle
Candace Carson and Jennifer Dickey
Mr. and Mrs. John J. Curley
Jacquelyn Dieckman and Michael Camery
Dynegy
Enterprise Holdings Foundation
Erie Zoological Society
Mary Ann Fieler and Bob Faelten
Amy Roy Ferneding
S. Gallagher
Mr. and Mrs. Thomas Gard
Stew and Linda Hall
Brenda and Joe Harry
Heaven Hill Inc.
William G. & Mary Jane Helms Trust
Mr. and Mrs. James J. Hodos
Lou-Ann and Mick Holtzleiter
Carol Ann Horn
Donald and Lucia Hudson
Debbie Huffman
Innovative Cryo Enterprises LLC
Nathan and Vanesa Jenkin
Jeffrey Kapela
Mr. and Mrs. Stephen M. Kralovic
MaasMeyer Household
Magnified Giving
Sybil and Richard McFadden
Dee Ellingwood and Kaycee McGinley
Mr. Robert Medsger
Metro Parks, Serving Summit County
Michter's Distillery
New Riff Distilling LLC
Ohio Eagle Distributing
Mr. Michael A. Paul
Dr. Marilyn Pugh*
Mrs. Jane A. Rahn
John and Jenifer Ray
RNDC General, LLC
Dr. Terri L. Roth and Dr. William F. Swanson
Stuart and Roselyn Schloss
Peggy Schmidt
Paul and Jeanne Schneider
Angela and Matthew Schroeder
Karen and Eugene Schunk
Lois Shadix
Dennis and Tammy Shuler
Adam and Laura Schmucker
Kathleen Kemper and Gary Smith
Steve and Linda Smith
Society for Theriogenology
Mr. Stephen W. South and Ms. Sue Van Patten
Ken and Carol Stecher
David and Linda Stentz
Ms. Judith H. Stewart
Mr. Bruce G. Strawn
The Tavares Family
Watershed Distillery
Mr. Robert Werdman
Terrie A. Wiedenheft
Mr. and Mrs. Donald Wolnik
Linnea Bowling Woodward
Betty A. Wuest
Susan and Drausin Wulsin
Mary Lou Zins

$500 - $999

Anonymous
Ron and Cheryl Allari
Mr. and Mrs. Pete Ayers
Laura and George Babcock
Tom* and Bev Barden
Glenn and Donna Boutilier
Jarrod and Judy Bradford
Jordan Campbell and Donald Hopster
Mr. and Mrs. William Cox
The Patel-Curran Family
Josh and Melissa Earley
Dave and Claire Ehrlinger
Tricia Fetters and Matt Puthoff
Fretboard Brewing Company
Miss Anna Gearhart
Dr. Joanne Goodman and Mr. James Goodman
Hill Family
Mr. and Mrs. Daniel L. Holden
Beth Jackson
Mrs. Sandy Keller
John Liddil
Listermann Brewing
James and Jennifer Losch
Abby Marcus and Qui Nguyen
Ms. Nancy Mitchell
Dr. Ryan and Michelle Moore
MPH Brewing
Keith A.Murrell DVM
Ms. Kathleen O'Connell and Mr. H. Kenneth Peterson
Jeanne Z. Olsen
The Irene and Daniel Randolph Donor Advised Fund of the Cambridge Charitable Foundation
Mary and Brian Rhame
Mr. and Mrs. Thomas Ritter
Bob and Sue Roenker
Laurie Jo Ryan
Trevor R Schnedl
Mary D. Schweitzer
Mr. Eli E. Shupe, Jr. and Ms. Toby Ruben
Gayle and Samuel Smith
Mark and Anna Stecher
Mr. James J. Stewart
Rebecca Young

$100 - $499

Anonymous
Drs. Frank and Mary Albers
W. Terry Averbeck and Theresa T. Averbeck
Mr. Kenneth A. Ayer
Beth and Bob Baer
Michele and Carl Bamford
Mr. Robert Barbella
William and Deborah Barnett
Mr. and Mrs. Timothy A. Baxter
Mr. and Mrs. Frederick J. Bazeley
Adam Bissonnette
Lynn and Gary Blattman
Mr. and Mrs. Michael E. Boehm
Ms. Marylynne Bradley
Milo Brown
Mr. and Mrs. Ralph E. Collins III
Ms. Laura J. Condo
Mrs. Mary L. Corley
Theresa Culley
Ms. Christa E. Curtis
Dr. Rick Dalessandro
Mr. Robert C. Dehner
Mr. William DeTalvo
Emilie and David Dressler Family Fund of Greater Cincinnati Foundation
Michael Ehrlinger
Dr. Emily Eilers
Dr. Nancy H. Eisenberg*
Amanda Epperson
Mr. and Mrs. Randy C. Gardner
Mr. and Ms. James L. Girbert
Mr. and Mrs. Mark X. Glassmeyer
Laura Guggenheim
Michael James and Debra Hartsell
Mr. and Ms. Joseph H. Head III
Mr. and Mrs. Jeremy S. Hilton and Family
Aileen Hodges
Mrs. Judy A. Hoffmann
Judy and John Houston
Barbara Hurley and Charlene Campbell
Mr. and Mrs. Jonathan Iverson
Katherine Jacobs
Mr. and Mrs. Michael D. Jones
Mrs. Pamela Malanchuk
Mrs. Donna Mancini
Ms. Sherri Margraf
Mr. and Mrs. William D. Martin
Deborah and Anthony Maruffi
David Mason
Mike McNeely
Mrs. Christine J. Moore and Dr. Robert G. Bartolo
Drs. Eric and Tanya Mullins
TheMusicMinions
Mrs. Cathi Nagel
Mary and Hale Newman
Ms. Kathleen L. Patton
Phil and Susan Price
Mr. and Mrs. Robert D. Rece
Janis Schmidt DVM and David Pariseau
Mr. and Mrs. Ronald Schmiedeker
Mr. and Mrs. Hugh Shipley
Somi Shrive
Grant Shuler
Mr. and Mrs. Robert E. Singer, Jr.
Meghan and Mark Smith
Mrs. Julia A. Sprong
Ms. Lois A. Taylor
Ms. Judy A. Tessel
James L. Thompson
Morley and Brenda Thompson
Mr. and Mrs. George E. Toft
Mr. and Mrs. Terrence L. Tucker
Mr. Raymond J. Ulrich II
Mr. Thomas C. Vogelsang
Reid and Karen Wells
Isabella Willms

* Deceased

DONATE TO CREW TODAY!

Help us in our mission of Saving Species with Science!

SCIENTIFIC HIGHLIGHTS

Names in bold are CREW staff.

BOOK CHAPTERS

Ballesteros D, JL Canón-Prieto, A Nebot, HW Pritchard, Y Tu, H Chen, R Folgado, **M Winkeljohn, M Philpott, VC Pence,** AM López Peralta, L Prieto and J Foster. 2025. Conserving the Genetic Resources of Exceptional Plant Species Through Pollen Banking. In: Gantait S and P Chmielarz (eds.), Conservation of Plant Genetic Resources, Springer Nature Singapore Pte Ltd, https://doi.org/10.1007/978-981-96-8331-4_4.

Herrick J, H Bateman, **E Curry,** JB Nagashima and N Songsasen. 2024. Chapter 18: Hormones and Reproductive Cycles in Carnivores. In: Norris DO and KH Lopez (eds.), Hormones and Reproductive Cycles in Vertebrates, 2nd Ed. Elsevier, Amsterdam, Netherlands, Pp. 415-456, https://doi:10.1016/B978-0-443-15986-2.00007-1.

Nardelli F, E Dierenfeld, RW Havmøller, N Schaffer and **T Roth.** 2025. Sumatran Rhinoceros *Dicerorhinus sumatrensis* (Fischer, 1814). In: Melletti M, B Talukdar and D Balfour. (eds.), Rhinos of the World - Fascinating Life Sciences, Springer, Cham, Switzerland, Pp. 153-183, https://doi.org/10.1007/978-3-031-67169-2_7.

PEER-REVIEWED PUBLICATIONS

Ballesteros D, RM Davies, JL Peach and **VC Pence.** 2025. Longevity, cryopreservation and propagation of carnivorous plants seeds: insights from 13 species in long-term *ex situ* collections. Annals of Botany 136(1):111-128, mcaf058, https://doi.org/10.1093/aob/mcaf058.

Barnes J and **L Vansandt.** 2025. Estrous cycle manipulation in cats. Clinical Theriogenology 17:67-81, https://doi.org/10.58292/CT.v17.11649.

Chen DM, SS Lampert, LD Chen, IJ Burger, CK Kouba, PJ Allen, N Songsasen, **TL Roth** and AJ Kouba. 2025. Production of live tiger salamander offspring using cryopreserved sperm. Scientific Reports 15:15702, https://doi.org/10.1038/s41598-025-99052-2.

Metrione LC, **TL Roth,** Y Rodriguez and EW Freeman. 2024. Pilot investigation of socio-spatial relationships in an *ex situ* white rhino *(Ceratotherium simum simum)* bachelor group. Journal of Zoological and Botanical Gardens 5(4):774-87, https://www.mdpi.com/2673-5636/5/4/51.

Pence VC and **M Philpott.** 2025. Adventitious bud clusters can increase tissue cryopreservation efficiency: A case study of Gesneriads. Acta Horticulturae 1421:77-86.

Philpott M, A-C Vanhove, M Chaiken and **VC Pence.** 2025. Long-term survival after cryopreservation of the endangered exceptional species *Crotalaria avonensis.* Cryobiology 119:105249, https://doi-org.uc.idm.oclc.org/10.1016/j.cryobiol.2025.105249.

Philpott M and **VC Pence.** 2025. Cryopreservation of the endangered Hawaiian fern *Asplenium peruvianum* var. *insulare* using green globular bodies. Acta Horticulturae 1421:87-94, https://doi.org/10.17660/actahortic.2025.1421.12.

Ree JF, C Powell, R Folgado, **VC Pence,** C Walters and J Maschinski. 2025. Establishing tissue culture lines from mature Nuttall's scrub oak *(Quercus dumosa Nutt.)* for *ex situ* conservation. In Vitro Cellular & Developmental Biology - Plant 61:102–116, https://doi.org/10.1007/s11627-024-10475-4.

Ree JF, C Powell, R Folgado, **VC Pence,** C Walters and J Maschinski. 2024. Development of a micropropagation protocol for the *ex situ* conservation of Nuttall's scrub oak *(Quercus dumosa).* Plants 13:1148, https://doi.org/10.3390/plants13081148.

Rispoli LA, E Donelan, PM Pennington, PH Joyner and **TL Roth.** 2025. Evaluating alternatives to flow cytometry for sex-sorting rhinoceros sperm. Theriogenology Wild 7:100135, https://doi.org/10.1016/j.therwi.2025.100135.

Teman SJ, TC Atwood, KL Laidre, **EE Virgin,** KD Rode, **LA Rispoli** and **E Curry.** 2025. Hemoglobin A1c is a retrospective indicator of denning in polar bears *(Ursus maritimus).* Journal of Mammalogy, gyaf033, https://doi.org/10.1093/jmammal/gyaf033.

SCIENTIFIC PRESENTATIONS

Arbogast D, K Chimpen Mac Leod, E Back, **P Pennington,** A Richardson, J Rivera, L Metrione and E Freeman. 2025. A comparison of affiliative and agonistic behaviors among ex situ white and black rhinos. Animal Behavior Society 2025 Annual Meeting, Baltimore, MD. Oral presentation.

Arbogast D, K Chimpen Mac Leod, **L Rispoli,** L Metrione, **T Roth** and E Freeman. 2025. Is oxytocin a relevant indicator of prosocial behavior in ex situ rhinos? 4th International Symposium on Zoo Animal Welfare (ISZAW), Chicago, IL. Poster Presentation.

Ballesteros D, JL Canon-Prieto, HW Pritchard, Y Tu, H Chen, R Folgado, **M Winkeljohn** and **VC Pence.** 2024. Effects of desiccation and low temperature storage on oak *(Quercus* sp) pollen. Society for Cryobiology Conference, Washington, D.C. Oral presentation.

Bach EM, SR Lavin, MW Schook, AC Alba, GM Ferrie, CJ Wheaton, J Rivera, AT Richardson, **P Pennington, L Rispoli, E Donelan,** K Chimpen Mac Leod, D Arbogast, M Miller, M Jones and LK Warren. 2025. Investigation of body condition and metabolic health and their role in the reproductive success of managed Southern white rhinoceros. American Society of Animal Science (ASAS) – Canadian Society of Animal Science (CSAS) Annual Meeting, Hollywood, FL. Poster Presentation.

Barnes J. 2025. Reproductive endoscopic assessment and therapeutic interventions enhance diagnostic capabilities across taxa. American Association of Zoo Veterinarians Annual Conference, Kansas City, MO. Oral presentation.

Brandhuber M, S Atkinson DeMaster, K Rode, T Atwood, T Wilson and **E Curry.** 2024. Hormonal indicators of reproductive status and confirmation of lactational anestrous in wild female polar bears. Biennial Society for Marine Mammalogy, Perth, Australia. Poster presentation.

Brooks RJ, M Philpott, VC Pence and TM Culley. 2025. Identification of Somatic Variation in Cryopreserved Oak Tissues. Botanical Society of America Conference, Palm Springs, CA. Oral presentation.

Curry E, E Virgin, A Tompros and J Wojtusik. 2024. Species-specific validation of commercial immunoassays for accurate hormone quantification in polar bear serum. International Conference on Bear Research and Management. Edmonton, Alberta, Canada. Oral presentation.

Godin P, N Sicher, **LM Vansandt,** MC Meinsohn, **JL Barnes, C Bunner,** J Cleverdon, R Hasan, N Davidsohn, G Gao, D Wang, **WF Swanson,** T Conlon and D Pepin. 2025. Directed evolution-engineered muscle-tropic AAVs for feline anti-Mullerian hormone (AMH)-based contraception. 56th Annual Meeting of the Society for the Study of Reproduction, Washington, D.C. Oral presentation.

King E, M Dublin, M Cozzini, G Kalin, W Robinson, J Knox, R Tomas, M Patterson, D Bandara, **A Miller, L Vansandt, L Lam** and A Byun. 2024. Calling for love: Using vocalizations to estimate sexual receptivity and track reproductive patterns in Amur leopards. Association of Zoos and Aquariums Annual Conference, Calgary, Canada. Poster presentation.

King T, M Wenninger, J Heinz, J Nollman, C Premanandan and **J Barnes.** 2025. Twin pregnancy in a southern tamandua *(Tamandua tetradactyla).* Society for Theriogenology Conference, Sacramento, CA. Poster Presentation.

Mac Leod KC, M Jones, D Arbogast, E Back, **P Pennington,** A Richardson, J Rivera, L Metrione and E Freeman. 2025. Temperament assessment using novel object tests to understand mental states of rhinos in human care. Animal Behavior Society 2025 Annual Meeting, Baltimore, MD. Oral presentation.

Miller A, JL Barnes and **LM Vansandt.** 2025. Investigation of semen collection and cryopreservation techniques in the caracal *(Caracal caracal).* Reproduction, Fertility and Development 37:1. International Embryo Technology Society 51st Annual Conference, Fort Worth, TX. Poster presentation.

Pence VC and **M Philpott.** 2025. Improving efficiencies in the *in vitro* technologies supporting the cryobanking of exceptional plants. Society for In Vitro Biology Annual Meeting, Richmond, VA. Poster and short oral presentation (virtual).

Pence VC. 2025. Low(er) hanging fruit for cryobanking *in vitro* tissues. Conserving Exceptional Plants Symposium, Virtual. Oral presentation.

SCIENTIFIC PRESENTATIONS *(cont'd)*

Pence VC. 2025. The global working list of exceptional plants. Conserving Exceptional Plants Symposium, Virtual. Oral presentation.

Philpott M. 2025. Tools for exceptional plant researchers. Conserving Exceptional Plants Symposium, Virtual. Oral presentation.

Philpott M. 2025. Streamlining protocol development for exceptional plant conservation. Center for Plant Conservation Annual Meeting, St. Louis, MO. Oral presentation.

Roth TL. 2025. American Institute of Rhinoceros Science – A Model for Saving Species with Science *Ex Situ*. The Wild's Hosted 2025 Conservation Science Symposium, Muskingum University, New Concord, OH. Keynote presentation.

Roth TL, EW Freeman, MA Miller, LC Metrione, **PM Pennington,** MW Schook, AC Alba, DM Arbogast, E Bach, **EM Donelan,** GM Ferrie, M Jones, PH Joyner, SR Lavin, KC Mac Leod, A Richardson, **LA Rispoli,** J Rivera and **S Windle.** 2025. Early reveal by the American Institute of Rhinoceros Science (AIRS). American Association of Zoo Veterinarians Annual Conference, Kansas City, MO. Oral presentation.

Shellabarger W, N Hendriks, T Bechshoft, A Pagano, SD Petersen, S Teman, **E Curry,** MA Owen and A Cutting. 2024. Engaging the zoo and aquarium population of polar bears in scientific studies. International Conference on Bear Research and Management, Edmonton, Alberta, Canada. Poster presentation.

Swanson WF. 2025. Biosafety considerations for gene therapy studies in domestic cats. Midwest Area Biosafety Network Symposium, Cincinnati, OH. Oral presentation.

Teman S, **E Curry,** T Atwood, **E Virgin,** K Rode, **L Rispoli, V Hope** and KL Laidre. 2024. Evaluating hemoglobin A1c for use as a nutritional and reproductive biomarker for free-ranging polar bears *(Ursus maritimus).* International Conference on Bear Research and Management, Edmonton, Alberta, Canada. Oral presentation.

Vansandt LM. 2024. Michelson Prize & Grants-funded research in AAV-MIS single-dose, non-surgical sterilant for female cats: Update & plans. Alliance for Contraception in Cats and Dogs Council of Stakeholder's Briefing, Crystal Beach, FL. Oral presentation.

Windle S, M Miller, M Duncan, D Agnew, J Buchweitz, H West, M Jones and **T Roth.** 2025. Exploring liver mineral profiles in rhinos: Comparative analyses of species, management and individual characteristics. 2025 International Rhino Keeper Association Workshop, Omaha, NE. Poster presentation.

Windle S, D Beetem, C Cseplo, **E Donelan, K Krupp, C Consago** and **TL Roth.** 2025. Bull presence influences fecal progesterone values in managed female white rhinos *(Ceratotherium simum):* Insights from behavioral and hormonal monitoring at The Wilds. 2025 International Rhino Keeper Association Workshop, Omaha, NE. Oral presentation.

Winkeljohn M, VC Pence, TM Culley and **M Philpott.** 2025. Investigating the impact of vitrification on shoot tip survival in threatened oak species. Botanical Society of America Conference, Palm Springs, CA. Oral presentation.

GRANTS AWARDED

Funding Source: The Joanie Bernard Foundation. Project: Innovative solutions for community cat care: Bridging trap-neuter-vaccinate-return knowledge gaps and advancing non-surgical sterilization. Role: Principal Investigator. Duration: 1/1/25 – 12/31/26. **Amount: $450,000**

Funding Source: Michelson Found Animals Foundation. Project: Vectored contraception of prepubertal domestic cats. Role: Principal Investigator. Duration: 1/1/25 – 12/31/29. **Amount: $167,791**

Funding Source: Association of Zoos and Aquariums. Project: Genetically-informed biobanking of the federally endangered exceptional Florida species, *Deeringothamnus pulchellus* and *D. rugelii.* Role: Principal Investigator. Duration: 9/1/2025 – 8/31/2027. **Amount: $128,321**

Funding Source: The Arthur L. and Elaine V. Johnson Foundation. Project: Creating a functional genome resource bank for imperiled felids. Role: Principal Investigator. Duration: 1/1/25 – 12/31/25. **Amount: $100,000**

Funding Source: United States Geological Survey. Project: Using comprehensive veterinary records in tandem with serum cytokine data to identify indicators of fitness in polar bears. Role: Principal Investigator. Duration: 9/27/24-9/27/25. **Amount: $71,500**

Funding Source: Wild Animal Health Fund – American Association of Zoo Veterinarians (AAZV). Project: Enhancing reproductive monitoring of white rhinoceroses: The role of prolactin. Role: Principal Investigator. Duration: 5/21/2025 – 12/1/2026. **Amount: $17,175**

Funding Source: International Association for Bear Research and Management. Project: Characterizing hemoglobin A1c (HbA1c) in relation to season, fasting, and reproduction in polar bears (Ursus maritimus). Role: Co-supervisor. Duration: 4/1/25-3/31/26. **Amount: $8,850**

Funding Source: International Oak Society. Project: Identification of somatic variation in cryopreserved oak tissues. Role: Principal Investigator. Duration: 2/1/2025-12/31/2026. **Amount: $7,675**

Funding Source: Garden Club of America and Center for Plant Conservation. Project: Identification of somatic variation in cryopreserved oak tissues. Role: Principal Investigator. Duration: 5/1/2025-5/1/2026. **Amount: $5,000**

CREW WISH LIST

EXTERNAL HARD DRIVE – So much valuable scientific information is stored on CREW computers/servers, and back-ups provide insurance. **Cost: $120**

SHOWER TESTING FUNNEL – Emergency showers need testing regularly without splattering all over the lab. **Cost: $250**

DIGITAL DIFFERENTIAL CELL COUNTER - To replace our failing manual model, used by all three animal teams during the evaluation of reproductive cell samples. **Cost: $300**

pH PROBE - Essential in the media making process, and we cannot go a day without one! **Cost: $365**

AUTOCLAVABLE BINS - Used to sterilize soil for test-tube plants which is necessary for healthy growth in vitro. **Cost: $388**

CRYO-GLOVES – For handling all of those irreplaceable samples in the CryoBioBank and -80°C freezer. **Cost: $472 for two pair**

µHANDY SCIENCE KIT + DARK FIELD STAGE - One each for plant and animal teams to share microscope views with students/guests, and for field work - no power or lab required. **Cost: $500 total**

MINI GEL ELECTROPHORESIS SYSTEM - Would reduce waste and allow us to more efficiently analyze the size of DNA fragments before sequencing them. **Cost: $642**

COREDX BIOPSY FORCEPS – These ultra-fine biopsy forceps are used to collect tiny uterine samples from cats, giving CREW scientists a microscopic view of feline reproductive health. **Cost: $1,025**

SMALL AND LARGE STIRRING HOTPLATES - After a decade of daily use, our secondhand stirring hotplates used to make media are breaking down. **Cost: $1,025 for both**

LARGE HOT WATER BATH - Need to replace our current, worn bath used for genetics work that requires highly specific temperatures. **Cost: $1,200**

CAT COLONY FURNITURE – CREW cats are in need of new running wheels, climbing towers, and lounging furniture to replace their well-loved (but worn) pieces. **Cost: $1,800**

MDS-VET™ SEMI-FLEXIBLE MICRO-ENDOSCOPE – This delicate scope makes reproductive exams possible in species too tiny for traditional equipment. **Cost: $2,180**

PIPETTES AND MORE PIPETTES – Used daily and constantly, and we are always looking for more upgrades that will make our work a bit easier and more accurate. This year, there are three different types on our wish list. **Total cost of all: $2,400**

SEMEN COLLECTION PROBES – Three specialized probes are essential for collecting and banking sperm in Amur leopards, jaguars, and lions for CREW's CryoBioBank®. **Cost: $1,000 each, total $3,000**

CREW "CASTLE" FURNISHINGS – A home was recently restored on Beldare Avenue (behind CREW) that will provide housing for CREW's visiting scientists/interns/scholars as soon as we can furnish it. **Cost: $15,000 (smaller gifts help too)**

Cincinnati Zoo & Botanical Garden
Center for Conservation and Research of Endangered Wildlife
3400 Vine Street
Cincinnati, Ohio 45220

HONORS AND AWARDS

Dr. Valerie Pence Receives Prestigious International Award

Dr. Pence was named the 2025 winner of the prestigious Ulysses S. Seal Award for Innovation in Conservation by the Conservation Planning Specialist Group (CPSG) of the International Union for Conservation of Nature (IUCN). This significant international honor is awarded every other year to a candidate who exemplifies innovation in the application of science to conservation and whose work reflects CPSG values of creative thinking that results in improved conservation actions. Valerie focused her life's work on developing successful tissue culture and cryopreservation protocols for many of our nation's imperiled plants. She coined the term "exceptional plants" to call attention to those species that cannot be seed-banked and were being overlooked during conventional plant seed conservation efforts. Today, both the term and the need are recognized by conservationists worldwide, embraced by botanical gardens, and included in global plant conservation strategies, all of which create a brighter future for thousands of Earth's rare floral species.

Raising the Bar in Reproductive Medicine

Marking her six-year anniversary at CREW, Dr. Julie Barnes became an official Diplomate of the American College of Theriogenologists (DACT). This board certification in veterinary reproduction is not only a personal milestone—it's a first for the zoo and aquarium community. Dr. Barnes is the only board-certified theriogenologist working within an AZA-accredited institution, setting a new standard of excellence in wildlife conservation. The rigorous two-year program included training at multiple facilities, blended independent research, and intensive coursework, culminating in a grueling 14-hour board exam with a pass rate of just 40%. Julie's achievement highlights CREW's growing leadership in reproductive science and her research into the reproductive health of felids, bears, and a variety of other wildlife species demonstrates how investing in expertise can directly translate into benefits for endangered species. *This work was funded, in part, by Institute of Museum and Library Services National Leadership Grant #MG-256221-OMS-24.*