Turner Endangered Species Fund

&

Turner Biodiversity Divisions

Annual Report

2019

TURNER ENDANGERED SPECIES FUND

TURNER BIODIVERSITY

TURNER ENTERPRISES, INC.

Magnus McCaffery, Val Asher, Cassidi Cobos, Levi Fettig, Cheney Gardner, Carter Kruse, Eric Leinonen, Dustin Long, Hunter Prude, Grace Ray, Chris Wiese, and Mike Phillips

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Conservation and restoration of native species on Turner properties helps to maintain healthy, functional landscapes… and their essential ecological processes.

Annual Report

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All photos not otherwise marked are TESF/TBD photos.

Cover Photo: *White-Nose Syndrome (WNS) has infected bat populations across North America and Canada, killing millions. At TESF, we monitor our cave systems for signs of WNS and foster innovative bat research on Turner properties. The Armendaris Ranch in New Mexico (pictured here) is home to the lava tubes of Jornada and supports one of the largest aggregations of Mexican free-tailed bats in North America.*

Mexican free-tailed bats on the Armendaris Ranch

Executive Summary

Every year tens of thousands of species and attendant ecological actions, fine-tuned by time and place, disappear at the hand of man. These losses strip away the redundancy and certainty of nature and diminish the lives of millions of people. If these trends continue, the world will become a dismal place indeed, with silent springs and hot summers and little left to excite the senses except the weeds. Without doubt, the extinction crisis looms as one of humanity's most pressing problems.

In response to this crisis, Ted Turner and Mike Phillips along with Turner's family established the Turner Endangered Species Fund (TESF) and Turner Biodiversity Divisions (TBD) in 1997 to conserve biological diversity by ensuring the survival of imperiled species and their habitats, with an emphasis on private actions and private land.

TESF focuses on species protected under state or federal endangered species laws and is recognized by the U.S. Internal Revenue Service as a non-profit, private operational charity. To complement TESF, TBD operates under the auspices of the for-profit Turner Enterprises, Inc. (TEI), and focuses on vulnerable species that are at slightly less risk. Both organizations work on diverse ecological issues aimed at restoring individual species and their habitats. TEI oversees management of Turner properties in an ecologically sensitive and economically sustainably manner while promoting the conservation of native species.

TESF and TBD implement projects that are multidisciplinary, collaborative, and guided by the principles of conservation biology. These projects routinely employ cutting-edge theory and techniques, and draw from the disciplines of community ecology, population biology, molecular genetics, and evolutionary biology. Success requires working closely with state and federal agencies, universities, other conservation organizations, and zoological institutions. From the beginning, TESF and TBD have believed that wrapping many minds around problems leads to durable solutions. That belief notwithstanding, given the high profile and legal status of the species targeted, working closely with state and federal agencies has been a requisite. From receiving permits to technical advice and support, our relationships with government agencies have been supremely important.

Whether managing extant populations or restoring extirpated populations, the ultimate goal for both TESF and TBD is the restoration of viable populations of imperiled species. Self-sustaining populations of native species are the hallmarks of healthy or at least recovering landscapes.

TESF and TBD have made full use of those provisions of the Endangered Species Act (ESA), and related policies, which promote the involvement of private land in species recovery efforts. For example, we have executed candidate conservation agreements, safe harbor agreements, critical habitat exclusions, and innovative ESA section 10(a)(1)(A) permits. Through such administrative approaches we have advanced novel restoration projects without burdening other land management activities practiced on Turner properties.

Since inception, TESF and TBD have been involved in successful restoration projects for imperiled plants, birds, fishes, mammals, reptiles, an amphibian, and invertebrates. The projects have been of sufficient scope to promote the range-wide security of several species and make important intellectual contributions that advance conservation science and restoration ecology by offering new approaches to fieldwork and novel answers to cardinal questions such as: Restore to what? How does one justify the selection of one species over another? What is the role of research in restoration projects?

Additionally, we are involved in worldwide conservation efforts including Half Earth, Nature Needs Half and the IUCN Private Protected Areas Specialist Group. In addition to advancing successful imperiled species restoration projects, including controversial efforts involving highly interactive species, our work has highlighted the value of strategically located tracts of private land to large scale conservation initiatives that transcend the boundaries of any single property. For example, our work has dovetailed nicely with well-known large-scale reserve design initiatives, including the Yellowstone to Yukon Reserve Design, Southern Rockies Ecosystem Project, and the Sky Islands Wildlands Network.

American alligator at the Avalon Plantation

About Us

Turner Family, TESF Board of Trustees

The Turner family is committed to environmental efforts that promote the health and integrity of the planet. Ensuring the persistence of species and their habitats is one such effort that is critical for advancing worldwide peace, prosperity, and justice. The Turner family are acutely aware of and keenly supportive of the work of TESF and TBD.

Beau Turner

Chairman of the Board of Trustees for TESF; Vice Chairman of TEI

Beau oversees wildlife projects, is a Trustee for the Turner Foundation, Inc., and serves on the board of the Jane Smith Turner Foundation. He is passionate about getting youngsters outdoors and excited about nature. To achieve this, he founded the Beau Turner Youth Conservation Center in Florida.

Mike Phillips

Executive Director, TESF; Coordinator, TBD

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Mike co-founded TESF and TBD with Ted Turner in 1997. He received a M.Sc. in Wildlife Ecology from the University of Alaska in 1986. Mike's career focuses on imperiled species, integrating private land and conservation, ecological economics, and socio-political aspects of natural resource use. He was elected to the Montana legislature in 2006 and will hold his state senate seat through 2020.

Carter Kruse

Director of Conservation Management, Research and Education, TEI; Senior Aquatics Biologist, TBD

carter.kruse@retranches.com

Carter joined TBD in 2000. He has a Ph.D. in Zoology from the University of Wyoming. Carter developed the TBD Native Cutthroat Trout Conservation Initiative and administers a variety of projects that include water rights issues, native species conservation, and species management.

Val Asher
Field Biologist, TESF

val.asher@retranches.com

Val has served as wolf biologist since 2000. She worked closely with state and federal agencies as a wolf specialist from 2000-2009, and in 2010 began investigating how wolves affect ranched bison and wild elk populations on the Flying D Ranch. Val was part of the capture team in Canada during the Yellowstone/Idaho wolf reintroductions.

Magnus McCaffery
Senior Biologist, TESF

magnus.mccaffery@retranches.com

Magnus joined TESF in 2010. He is involved in efforts to conserve and restore Chiricahua leopard frogs in the Southwest, gopher tortoises and red-cockaded woodpeckers in the Southeast, and American burying beetles in the Midwest. He is a native of Scotland, where he graduated with a MSc in Wildlife Biology. A passion for ecology and wild places brought him to Montana, where he gained a PhD in Wildlife and Fisheries Biology from the University of Montana.

Eric Leinonen
Senior Biological Technician, TBD

eric.leinonen@retranches.com

Eric joined TBD in 2011 as a seasonal member of the Native Cutthroat Trout Conservation Initiative. In 2015 he became a full-time employee, where he works with cutthroat trout and provides support to other projects. Eric received a B.A. in Environmental Science and Geography from The University of Montana.

Cassidi Cobos,
Field Biologist, TESF

cassidi.cobos@tedturner.com

Cassidi joined TESF in 2014 and serves as a field biologist on the Chiricahua leopard frog project. She received a B.A. in Wildlife Science from New Mexico State University and is initiating a MS program in Wildlife Management at NM state university.

Chris Wiese
Senior Biologist, TESF

chris.wiese@retranches.com

Chris joined TESF in 2012. She oversees the bolson tortoise and Mexican gray wolf projects on the Ladder and Armendaris ranches in New Mexico. Chris received her PhD in Cell Biology from the Johns Hopkins Medical School in 1996.

Cheney Gardner
Media Director, TESF

cheney.gardner@tedturner.com

Cheney joined TESF in 2016 as the media/ outreach coordinator for an education project to advance wolf recovery to Colorado. She attended UNC-Chapel Hill, where she received a degree in journalism after being awarded the prestigious Morehead-Cain scholarship.

Levi Fettig,
Senior Biological Technician, TBD

levi.fettig@retranches.com

Levi joined TESF in 2015 as a seasonal technician working with prairie dogs and black-footed ferrets. In 2018, Levi began working full time with TBD on a variety of projects, including black-footed ferrets, prairie dogs, prairie chickens, fish and amphibians. Levi received a B.S. in Wildlife and Fisheries Science from Valley City State University.

Hunter Prude
Senior Biological Technician, TBD

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Hunter began working for TBD on the Armendaris Ranch in New Mexico in 2012, where he collaborates with New Mexico Department of Game and Fish to manage desert bighorn sheep in the Fra Cristobal Mountains. Hunter obtained a B.S. in Natural Resource Management; Wildlife Management from Sul Ross State University in 2011.

Grace Ray
Rangeland Ecologist, TEI

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Grace started her position as the Rangeland Ecologist for TEI in 2016. She develops and manages various habitat and species-based conservation projects on the western Turner properties and helps to oversee grazing and rangeland management across 16 key bison properties. She received her M.Sc. in Rangeland Sciences from Oregon State University in 2015.

Barb Killoren
Office Administrator, TEI

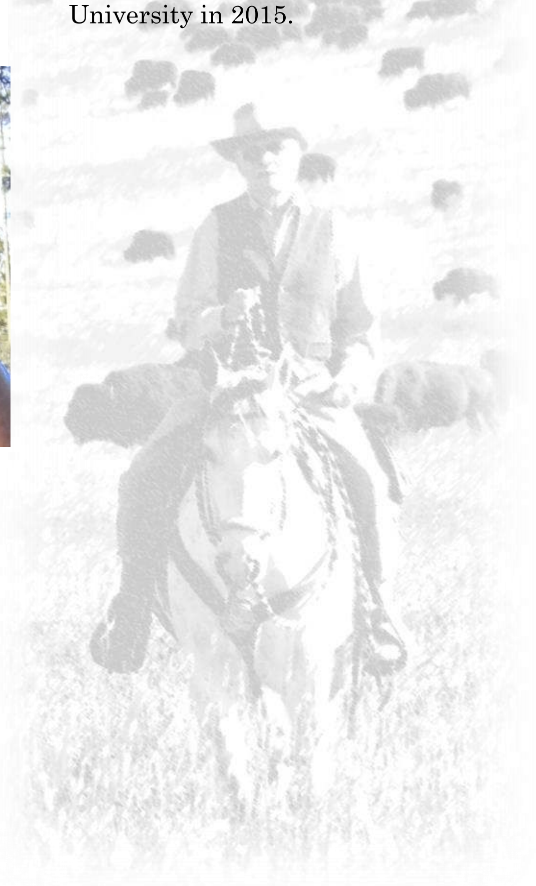
barb.killoren@retranches.com

Barb joined TEI in 2001 and assists TESF as office administrator. She manages office operations and provides support to the Executive Director, project managers and field personnel. Barb has a B.S. from the University of Wisconsin, Eau Claire.

Dustin Long
Senior Biologist, TESF

dustin.long@retranches.com

Dustin joined TESF in 1998, and led the black-footed ferret, bat, monarch butterfly, and lesser prairie-chicken projects into 2019 before becoming manager of the Ladder Ranch. Dustin has a M.Sc. in Life Science from New Mexico Highlands University.



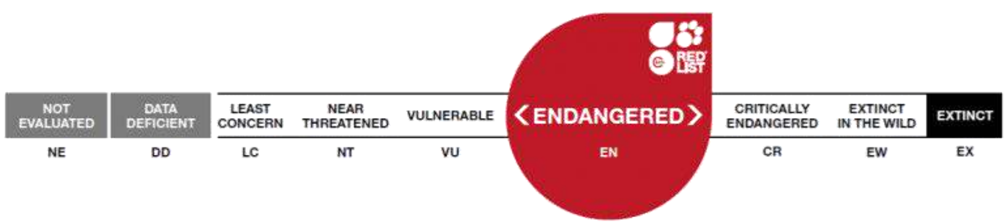
Acknowledgements

The work of TESF and TBD would be impossible without the support, assistance, and partnerships of numerous individuals and organizations. We would like to thank the TESF Board of Trustees and Turner Foundation for their deep commitment to the conservation of biodiversity; the ranch and plantation administrators, managers, and staff who go beyond their daily duties to make our projects a success; and our state and federal partners whose collaboration and support of our conservation and restoration programs help to enrich the biodiversity on Turner properties, and give us the opportunity to contribute to broader recovery goals for numerous at-risk species.

Inclusion of ICUN Red List Category

This year, in additional to using federal and state listing designations for project species, we will also be including **the International Union for Conservation of Nature's (IUCN) Red List status**, when applicable. The IUCN's Red List of Threatened Species is the world's most comprehensive information source on the global conservation status of animal, fungi and plant species, as well as a critical indicator of the health of the world's biodiversity. It uses detailed criteria, including "the range, population size, habitat and ecology, use and/or trade and threats" to evaluate the degree of risk of extinction facing a species.

Red List designations encompass nine categories: Not Evaluated, Data Deficient, Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild and Extinct.



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1. BATS

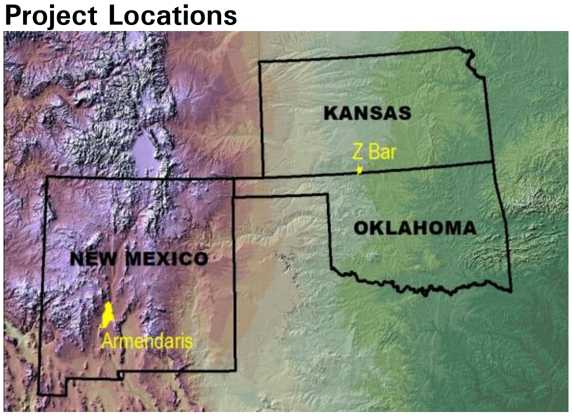
- USFWS threatened: Northern long-eared bat (*Myotis septentrionalis*)
- USFWS Species of Concern: Big brown bat (*Eptesicus fuscus*); Cave myotis (*M. velifer*); Allen's big-eared bat (*Idionycteris phyllotis*)
- NMDGF Species of Greatest Conservation Need: Allen's big-eared bat (*I. phyllotis*); Spotted bat (*Euderma maculatum*)
- KDWPT Species of Greatest Conservation Need: Townsend's big-eared bat (*Corynorhinus townsendii*);
- ODWC Species of Greatest Conservation Need: Mexican free-tailed bat (*Tadarida brasiliensis*)

Project Biologists

Dustin Long

Carter Kruse

Project Locations



Goal – To track the dynamics and disease status of bat populations at the Z Bar and Armendaris Ranches.

Objective – TESF and its partners will perform summer and winter surveys of bat populations at the Armendaris and Z Bar Ranches. TESF personnel will collaborate with bat biologist and remain current on bat ecology and through these contacts and information advise and assist ranch managers in improving bat habitat and alleviating threats.

Project Partners

Funding *Monitoring*

Strategies – Population surveys, WNS monitoring, and habitat management and improvement will be implemented in collaboration with state, federal, and NGO partners. In addition, access to caves used by bats will be regulated to limit the potential for the human-caused spread of WNS.

Project Background – WNS, an epizootic disease caused by the fungus, *Pseudogymnoascus destructans* (Pd), was first observed at Howes Cave, west of Albany, New York, in February 2006, when a caver photographed a powdery white substance on the muzzle of a hibernating bat. Bats with the disease symptoms of WNS are found in 33 US states and 7 Canadian provinces (Fig. 1.1). In addition, the fungus (Pd) that causes WNS has been found in three more US states at the frontier of its spread across North America.

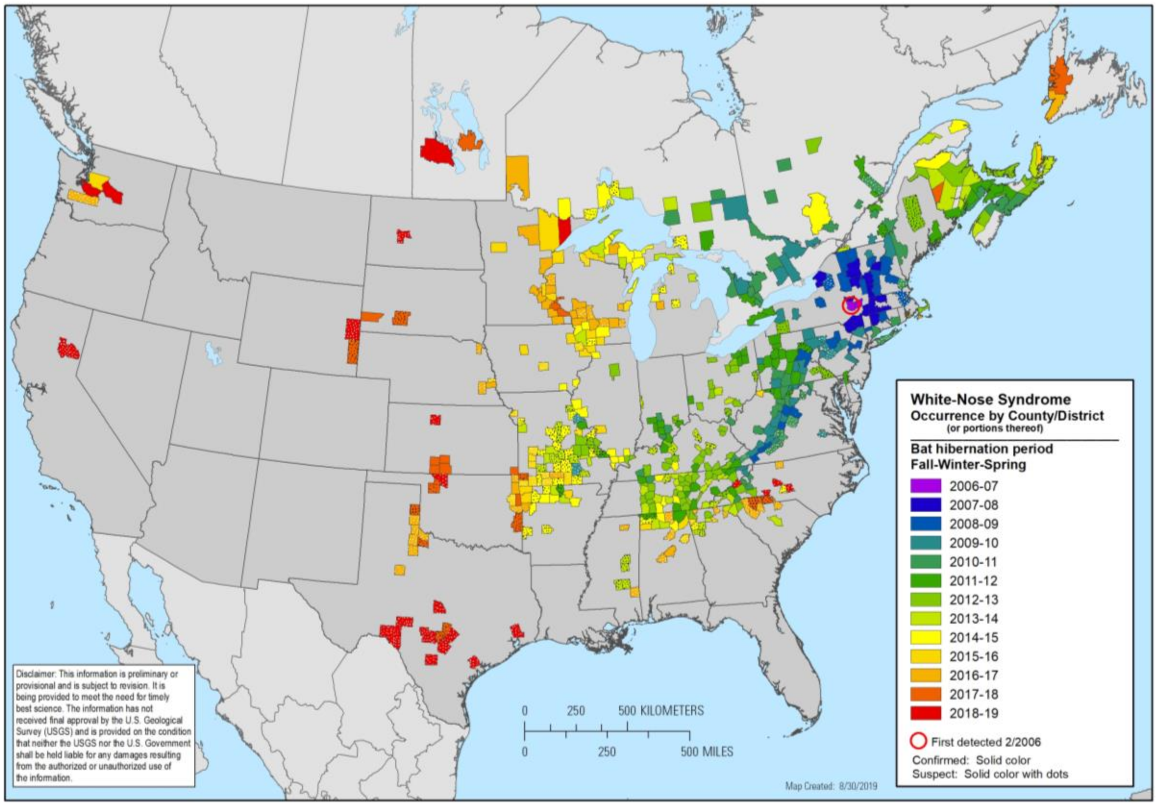


Fig. 1.1. White-nose syndrome occurrence map (2006-2019). Data last updated: 8/30/2019. Available at: https://www.whitenosesyndrome.org/static-page/wns-spread-maps

WNS is currently the only known disease of concern for bats on Turner properties. Most bat species are relatively long lived (10-15 years) and produce one offspring a year; consequently, bat population growth depends on high rates of adult survival. Bat populations affected by WNS often experience a 95% loss of the adult population. Documenting the arrival of WNS and its impacts on bat populations on Turner properties will play an important role in a larger nationwide effort to track, study, and ultimately minimize the impacts of the disease.

Mexican free-tailed bats make up the majority of bats on Turner properties. While they may not be susceptible to WNS because they migrate rather than hibernate, much remains unknown about the species and its seasonal use of caves on Turner properties. In collaboration with bat researchers, we will begin to fill in those basic ecological information gaps and offer insight into how best to manage bat populations on Turner lands.

The Jornada caves at the Armendaris Ranch are the second largest lava tubes in North America and provide habitat for eight bat species: Mexican free-tailed bat, Pallid bat (*Antrozous pallidus*), Allen's big-eared bat, Yuma myotis (*M. yumanensis*), Townsend's big-eared bat, spotted bat, California myotis (*M. californicus*), and fringed myotis (*M. thysanodes*). The migratory population of Mexican free-tailed bats at Jornada is the largest in New Mexico, and the fifth largest in North America.

The Merrihew, Rattlesnake, and Skunk caves (gypsum cave) at the Z Bar are occupied by at least five bat species: Mexican free-tailed bat, Townsend's big-eared bat, big brown bat, cave myotis, and tricolored bat (*Perimyotis subflavus*). Four of these hibernate, and all are either federally or state listed. Four caves in the Oklahoma-Kansas Red Hills region were tested for WNS in 2014 and 2016 and all tests returned negative for the disease.

Project Activities in 2019

Armendaris – No surveys were implemented at the Jornada caves in 2019.

Z Bar – Kansas Department of Wildlife, Parks, and Tourism collected samples at Merrihew Cave on 4/11/19 for *P. destructans* (Pd) surveillance. Combined wing/muzzle swabs from 10 of 25 bats sampled at this location tested inconclusive for Pd, the causative agent of WNS, by real-time PCR. However, because multiple field signs consistent with WNS, such as wing scarring (Fig. 1.2), were observed in species known to be susceptible to the disease and the location is within the recognized range of WNS, Merrihew cave was classified as "Suspect for WNS" (Fig. 1.3). The presence of WNS field signs together with multiple inconclusive Pd PCR results from samples collected at this site suggest that Pd was truly present in the bat population at this location.

Fig. 1.2. Wing scarring on a tri-colored bat surveyed at Merrihew Cave in 2019

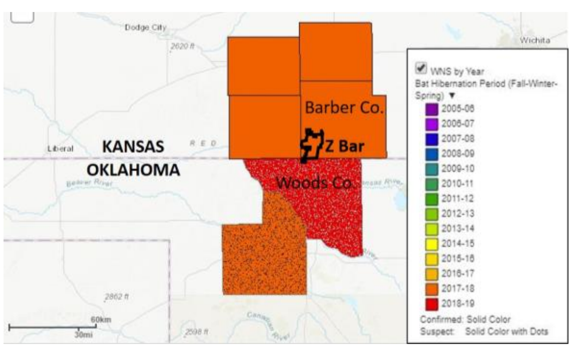
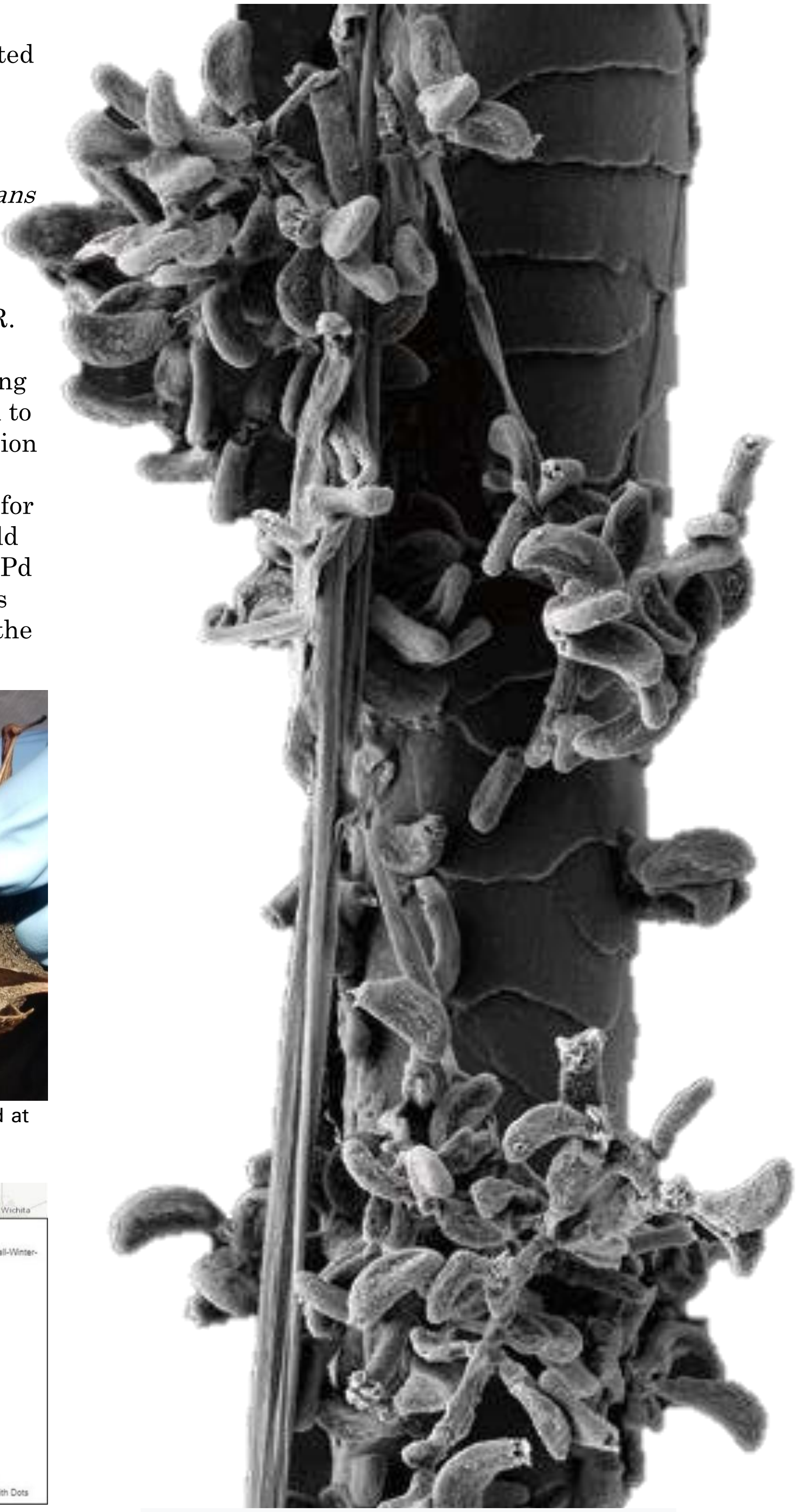


Fig. 1.3. Z Bar's place in white-nose syndrome occurrence map



A bat hair colonized by Pseudogymnoascus destructans (Credit: Gudrun Wibbelt, Andreas Kurth, David Hellmann, Manfred Weishaar, Alex Barlow, Michael Veith, Julia Prüger, Tamás Görföl, Lena Grosche, Fabio Bontadina, Ulrich Zöphel, Hans-Peter Seidl, Paul M. Cryan, and David S. Blehert)

2. BLACK-FOOTED FERRET

(*Mustela nigripes*)

THE IUCN RED LIST OF THREATENED SPECIES™

LEAST CONCERN LC | NEAR THREATENED NT | VULNERABLE VU | **ENDANGERED EN** | CRITICALLY ENDANGERED CR | EXTINCT IN THE WILD EW | EXTINCT EX

U.S. Fish & Wildlife Service

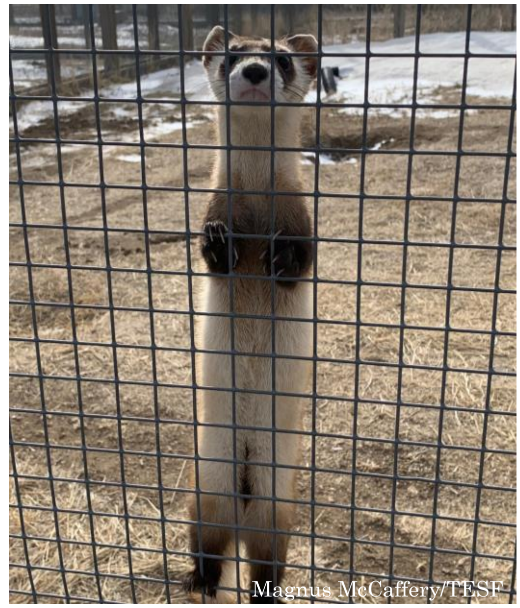
Listing Status under the Endangered Species Act

ENDANGERED

New Mexico Department of Game & Fish

New Mexico State Listing Designations

Species of Greatest Conservation Need; Protected Furbearer



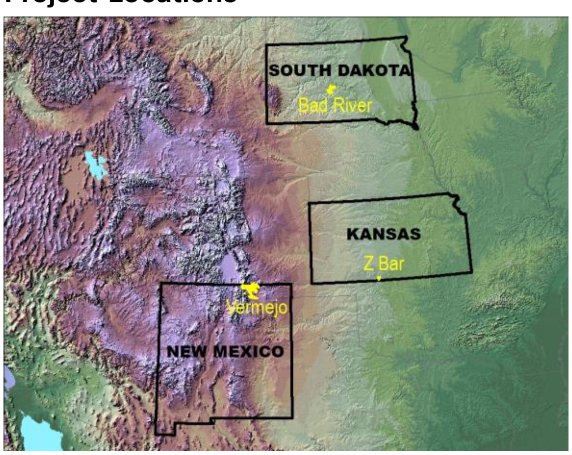
Project Biologists


Magnus McCaffery


Dustin Long

Threats – The conservation challenges for black-footed ferrets are attributable to disease, habitat loss, and related declines in prey. Conversion of native grasslands to agricultural land, widespread prairie dog eradication programs, and non-native diseases, such as plague, have reduced ferret populations to less than 2% of their original range.

Project Locations



Project Partners

BLACK-FOOTED FERRET RECOVERY IMPLEMENTATION TEAM

TESF is a member of the Executive Committee of the Black-Footed Ferret Recovery Implementation Team (BFFRIT). The Executive Committee includes representatives from 40 organizations that represent federal, state, tribal, non-profit, private, and international entities (Appendix 2.1). As an Executive Committee member, TESF is involved with reviewing the overall management and direction of the Recovery Program and provides board policy and planning guidance to the US Fish & Wildlife Service and the BFFRIT subcommittees (Conservation, Education and Outreach, and Species Survival Plan Subcommittees).

Goal – Restore black-footed ferret populations to three Turner properties.

Objectives – Contribute to federal black-footed ferret recovery objectives (Table 2.1) by reintroducing black-footed ferrets onto large/stable prairie dog complexes (i.e. ferret habitat) on three Turner properties:

Bad River Ranches

- Establish a Conservation Zone (CZ) at Bad River Ranches' Ash Creek Recovery Area (ACRA) with a black-tailed prairie dog complex of 607 ha (1,500 acres).
- Maintain CZ prairie dog complex at densities of ≥ 3.63 prairie dogs/ha.
- Once target CZ prairie dog acreages have been attained, we will establish and manage a black-footed ferret population that includes approximately 49 breeding adults.

Vermejo Park Ranch

- Establish CZs at Gunnison's and black-tailed prairie dog sites.
- Maintain CZ prairie dogs at densities of ≥ 3.63 prairie dogs/ha.
- Once sufficient CZ prairie dog acreages have been attained, we will establish and manage a black-footed ferret population that includes approximately 34 breeding adults.

Z Bar Ranch

- Establish a CZ at Z Bar with a black-tailed prairie dog complex of 404 ha (1,000 acres).
- Maintain CZ prairie dog complex at densities of ≥ 3.63 prairie dogs/ha.
- Once target CZ prairie dog acreages have been attained, we will establish and manage a black-footed ferret population that includes approximately 39 breeding adults.

Black-tailed prairie dog colony on Bad River Ranches

Table 2.1. Black-Footed Ferret Recovery Criteria

Downlisting	*Delisting*
Maintain captive breeding population: ‣ ≥280 adults (105 males, 175 females), ‣ distributed among ≥3 facilities.	Maintain captive breeding population: ‣ ≥280 adults (105 males, 175 females), ‣ distributed among ≥3 facilities.
Free-ranging black-footed ferrets: ‣ totaling ≥1,500 breeding adults, ‣ in ≥10 populations, ‣ in ≥6 of 12 States within historical range of the species, ‣ with ≥30 breeding adults in any population, ‣ ≥3 populations on Gunnison's and white-tailed prairie dog colonies. ‣ Maintain these for ≥3 years prior to downlisting.	Free-ranging black-footed ferrets: ‣ totaling ≥3,000 breeding adults, ‣ in ≥30 populations, with ≥1 population in each of ≥9 of 12 States within historical range of the species, ‣ with ≥ 30 breeding adults in any population, ‣ and ≥10 populations with 100 or more breeding adults, ‣ ≥5 populations on Gunnison's/white-tailed prairie dog colonies ‣ Maintain these for ≥3 years prior to delisting.
Maintain ~247,000ac (100,000ha) of prairie dog occupied habitat at reintroduction sites.	Maintain ~494,000 ac (200,000 ha) of prairie dog occupied habitat at reintroduction sites.

Table 2.2. Black-Footed Ferret Reintroduction Sites on Turner properties

Site	*CZ (ha)*	*§Density (P)*	*# ferret family groups$^{\Psi}$ supported (R)*
BRR	607	62	49
VPR	1,334	20	33
Z Bar	404	75	39

***** Equation from Biggins (1993):

$$\mathbf{R} = \sum_{i=1}^{n}(A_i \times P_i) \div 763 \; for \; (A_i \times P_i) \geq 272.5$$

where…

R = number of ferret family groups supported by prairie dog complex,
A = area of colony with at least 3.63 prairie dogs/ha,
P = prairie dog density (per ha) in area A,
763 = prairie dog numbers required to support one ferret family group$^{\Psi}$ for 1 year,
272.5 =minimum prairie dog number needed to support one ferret family group for 1 year,
i = colony number, and
n = the number of colonies in the complex.

Ψ = ferret family group of 2 adults and 2 kits
§ = 2005 prairie dog density estimates

Supporting Rationale for Objectives

Our objectives will assist with federal recovery criteria (Table 2.1) for free-ranging black-footed ferrets by establishing large, protected prairie dog complexes on Turner properties. These complexes will serve as ferret reintroduction sites once sufficient prairie dog acreages have been achieved.

Management of reintroduction sites aims to maintain stable prairie dog complexes, with minimum densities of 3.63 prairie dogs/ha across at least 2,156 ha (5328 acres). While it is anticipated that prairie dog densities at our reintroduction sites will exceed 3.63 prairie dogs/ha, this density threshold serves as a benchmark for meeting the breeding requirements of black-footed ferrets (Biggins et al. 1993; Tuckwell & Everest 2009).

A prairie dog colony complex represents the basic management unit of black-footed ferret recovery and is defined as a group of prairie dog colonies distributed so that black-footed ferrets can migrate among them commonly and frequently (Forrest et al. 1985). A prairie dog colony subcomplex is a smaller unit within a larger complex. The inter-colony distances of 7-km and 1.5-km are used to determine which colonies are included in a complex and subcomplex, respectively, based upon recorded black-footed ferret movements (Biggins et al. 1993, 2006).

Population viability analysis modeling of black-footed ferrets in the Conata Basin, South Dakota suggests that approximately 10,000 acres (4,047 ha) of prairie dog colonies connected by a maximum distance of 1.5 km are required to sustain a ferret population with greater than 90 percent probability of persistence over 100 years (CBSG 2004). While our areal prairie dog coverage will not meet this 10,000-acre threshold, each property's prairie dog complex will be composed of colonies that are separated by no more than 1.5 km, and active management will be implemented as appropriate to maintain the viability of the ferret population.

In toto, reintroduction sites on Turner properties could contribute around 118 ferret family groups (2 adults and 2 kits) across three populations, and encompass three states within the species' historical range, including one Gunnison's prairie reintroduction site.

Strategies

- Plague management to maintain prairie dog complexes (where appropriate).
- Targeted prescribed fire and bison grazing to maintain prairie dog complexes and stimulate prairie dog colony growth (where appropriate).
- Monitoring prairie dog areal extent and densities to inform black-footed ferret reintroductions, and the number of ferret family groups to manage for at reintroduction sites (Table 2.2).
- Black-footed ferret reintroductions, monitoring, and management once target prairie dog acreages have been achieved.

Project Background – Black-footed ferrets are an obligate predator of prairie dogs and prairie dogs historically required bison grazing throughout a large portion of their historic range in order to persist. Hence, the black-footed ferret project is a natural fit for many Turner properties and provides the opportunity to merge commodity production and native species conservation and restoration in a single cause.

All captive and wild black-footed ferrets can be traced to the last seven wild individuals of the species, captured in Meeteetse, WY and brought into captivity in the mid-1980s. Today, black-footed ferrets remain one of the planet's rarest mammals with a wild population of less than 300 individuals.

TESF's contribution to ferret recovery began in 1998 with the construction of an outdoor preconditioning facility at Vermejo. Naïve, cage reared ferrets were placed in outdoor pens that simulated a wild environment. Ferrets in these pens lived in active black-tailed prairie dog (*C. ludovicianus*) burrows and were exposed to live prairie dog prey. Here, they honed natural predatory instincts which prepared them the wild. Females bred, whelped and weaned kits in these pens. Ferrets preconditioned or born in outdoor pens, and exposed to live prey, have higher post-release survival rates than those that have not. From 1999-2006, 393 ferrets were preconditioned at Vermejo's facility.

From 2005-2007 at Vermejo, and 2009-2011 at Bad River Ranches, TESF took the next step in preconditioning ferrets by implementing a wild preconditioning approach. At Vermejo, female ferrets and their kits were released onto a 1,000-acre prairie dog colony, surrounded by electric netting to reduce the risk of ferret mortality from terrestrial predators (e.g. coyotes and badgers) as they adjusted to life in the wild. At Bad River, we used a similar strategy, but without electric netting. After 1-3 months of wild preconditioning, ferrets were captured and transported to permanent release sites. Of the ferrets released for wild preconditioning, we recaptured 48% at Vermejo (n=75) and 45% (n=37) at Bad River for transport to permanent release elsewhere.

In 2008, we began year-round ferret releases on black-tailed prairie dog colonies at Vermejo and in 2009 TESF documented the first wild-born ferret in New Mexico in over 75 years.

Despite our best efforts to establish a population of ferrets at Vermejo that would contribute to federal recovery objectives (Table 2.1) – an effort that involved increasing black-tailed prairie dog acreages from 500 acres to over 10,000 acres and releasing 196 ferrets – it became clear from ferret survival rates over a 9-year period, that it was unlikely that Vermejo's black-tailed prairie dog colonies could support a stable ferret population. Although the ferrets generally did well on these colonies, with reproduction documented when spring precipitation was sufficient to support a robust prairie dog population, these good years were routinely offset by drought years in which prairie dog pup survival rates were below 10%, causing the ferret population to collapse. During these drought years we documented the loss of all female ferrets and their kits, although male ferrets appeared to be largely unaffected. Due to the failure of ferrets to survive and reproduce during drought years, and the likelihood that droughts will become more frequent and severe, in 2013 we decided to withdraw from ferret releases for the foreseeable future on black-tailed prairie dog colonies at Vermejo.

2012 marked the first year TESF began ferret releases on the Gunnison's prairie dogs which occupy the high elevation mountain meadows of Vermejo. Historical records indicate 89% of the ferret specimens collected in New Mexico were captured on Gunnison's prairie dogs and one of the last specimens collected in the state was trapped on Vermejo at Castle Rock (Fig. 2.1). Survival and reproduction rates of ferrets living on Gunnison's colonies at Vermejo suggests a population of ferrets that meet delisting requirements could be established, provided we are able to control sylvatic plague.

Fig. 2.1. Castle Rock represents one of Vermejo's high elevation mountain meadows that supports Gunnison's prairie dogs

Currently there are two options available to mitigate plague on prairie dog colonies: (1) application of insecticide at prairie dog burrows (deltamethrin dust or fipronil grain) which kills the fleas that serve as the vector for plague, and (2) distributing Sylvatic Plague Vaccine (SPV) bait on colonies to vaccinate prairie dogs against the disease. However, an SPV field trial in 2017 at Bad River was not effective at controlling plague, while deltamethrin proved effective. Fipronil grain has also been shown by research to be an effective plague mitigation approach. However, all of these plague management techniques are expensive when the chronic, annual treatment of large acreages is required (Table 2.3). A novel application approach for fipronil, whereby relatively low amounts of fipronil is formulated into bait-form (FipBit) is currently under development by Randy Matchett of the USFWS. This holds promise as a relatively cost-effective technique for managing plague.

Table 2.3. Estimated costs of various plague mitigation methods

Method	Cost/acre
Deltamethrin dust	25.00^{\Phi}$
Fipronil grain	26.50^{\Phi}$
SPV	23.41^{\Phi}$
FipBits*	5.85^{\Psi}$
* = Not yet available. Under development	
Φ = Product cost + estimated application costs	
Ψ = Estimated cost of bait production + application	

Project Activities in 2019 – We prepared and submitted draft documents to the USFWS to initiate the enrollment of VPR and the Z Bar Ranch in a programmatic black-footed ferret Safe Harbor Agreement (SHA). With SHAs in place on VPR and Z Bar, these properties would join Bad River Ranches which was enrolled in the Safe Harbor Program in 2017.

Bad River Ranches, SD: The black-tailed prairie dog complex in the Ash Creek Recovery Area (ACRA) at BRR was impacted by plague in 2018, declining from 1,800 acres to ~ 300 acres. 2019 mapping indicated a remaining coverage of 303 acres. We dusted 167 acres of this area in 2019 (Fig. 2.2) and aim to rebuild this CZ to a prairie dog complex of ≥ 1,500 acres in the coming years with a view to future black-footed ferret reintroduction.

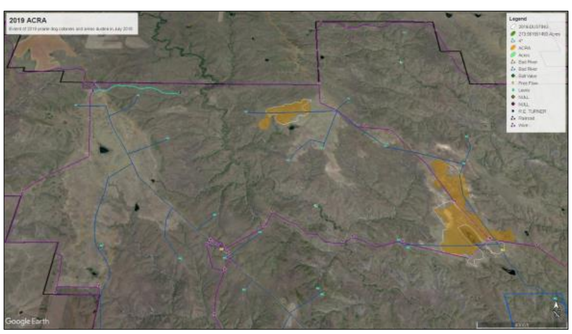


Fig. 2.2. Results of prairie dog colony perimeter mapping at Bad River Ranches, showing the 303-acre extent of ACRA's Conservation Zone (CZ) in 2019. 167 acres were dusted in 2019.

Z Bar: We delineated an area of approximately 1,000 acres of the Z Bar Ranch as a black-tailed prairie dog CZ. Black-footed ferret releases in this area will require prairie dog coverage of 1,000 acres of this CZ. 2019 mapping of prairie dog colonies within the CZ indicated 6 discrete prairie dog colonies forming a black-tailed prairie dog complex (colonies within 1.5 km a neighboring colony; Fig. 2.3), covering a total area of 288 acres within the CZ. We also mapped three satellite prairie dog colonies, totaling 32 acres, within 1.5 km of the CZ boundary; Fig. 2.3). There was no net change in 2019 prairie dog coverage in the CZ relative to 2018 acreage. Efforts in 2020 will aim to strategically target management on unoccupied habitat within the CZ to encourage expansion and merging of discrete colonies.

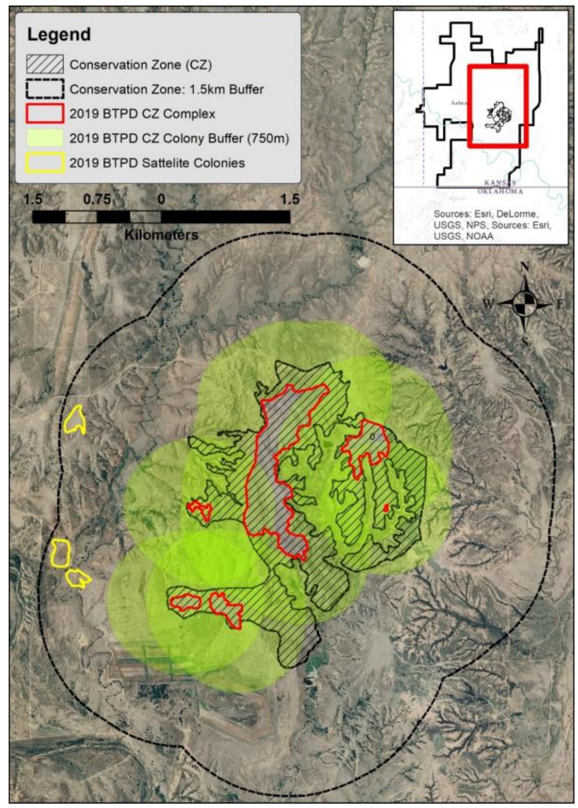


Fig. 2.3. Results of 2019 prairie dog colony perimeter mapping in the Z Bar Ranch Conservation Zone (CZ), and Satellite Colonies within 1.5 km of the CZ edge.

VPR: We delineated potential areas of VPR to serve as prairie dog CZs: a 2,000-acre CZ, encompassing Castle Rock Park was identified for Gunnison's prairie dogs (Fig. 2.4), and a 4,545-acre area of short-grass prairie was defined for black-tailed prairie dogs (Fig. 2.4: inset map). Within CZs, we aim to manage for prairie dog coverages of 2,000 acres and 1,500 acres for Gunnison's and black-tails, respectively, to support future ferret releases. In spring 2019, we captured 1,262 Gunnison's from the Headquarters colony and released them predominantly within the Castle Rock CZ (some were released in the adjacent Bremmer Park area). The purpose of this effort was two-fold: (1) Gunnison's population recovery from a plague epizootic in the Castle Rock/Bremmer Park complex was occurring slowly and it was our hope that this translocation of prairie dogs would stimulate population recovery, opening the door to ferret releases in the near future and, (2) the Gunnison's at Headquarters present human health and aesthetic concerns and were slated for removal by VPR management. Capture and translocation of Gunnison's prior to this treatment was consistent with our philosophy of using non-lethal methods of control when possible. We aim to repeat a capture effort at the Headquarters colony to translocate any surviving Gunnison's to the Castle Rock CZ.

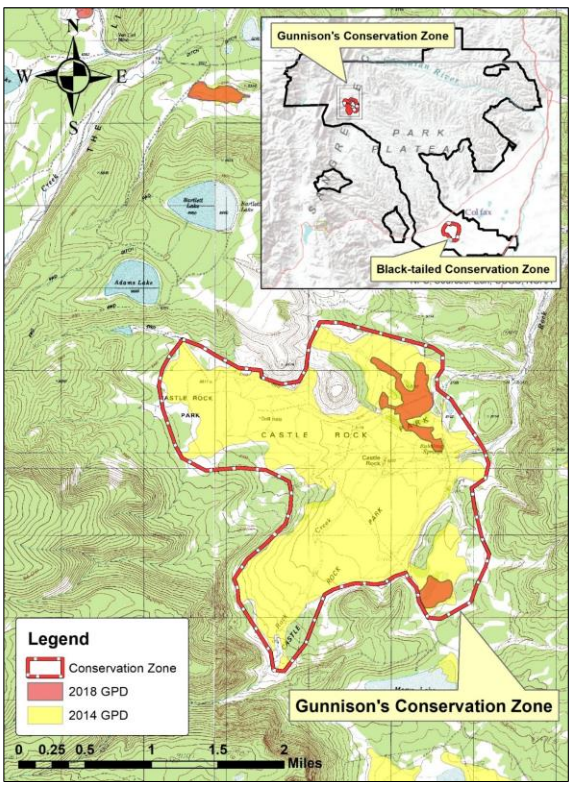


Fig. 2.4. Proposed Conservation Zones (CZ) at Vermejo Park Ranch. Main map shows Gunnison's prairie dog (GPD) colony extent in 2014 and 2018. No GPD were observed in the GPD CZ in fall 2019, despite translocations to this area in spring 2019.

Proposed Future Activities and Considerations – As demonstrated at Vermejo and Bad River, ferret recovery is inextricably linked to prairie dog conservation and active plague management. In 2020 we aim to increase the acreage of prairie dog complexes within Conservation Zones on BRR and VPR. This will involve application of fipronil bait to prairie dog complexes, and associated monitoring of prairie dog areal extent and densities.

We will also continue to support efforts to develop FipBits. Once all safety and regulatory approvals for this plague mitigation technique have been resolved, we stand ready to help with the production of FipBits by producing the bait in TESF's Bozeman lab.

Appendix 2.1 – Collaborating members of the BFFRIT Executive Committee

3. BOLSON TORTOISE

(*Gopherus flavomarginatus*)

Project Biologists


Chris Wiese


Scott Hillard

Threats – Population decline, and range contraction are due to collection for food as well as habitat loss. Recent estimates suggest fewer than 2,000 bolson tortoises remain in the wild.

Project Locations

Partners (see Appendix 3.1)

The Appleton Family | Lynnie Appleton | Jim Jarchow, DVM | Heidi Hubble | Matt Keeling | Tricia Rossetie | Andrew Lincourt | Dennis Bramble, PhD | Howard Hutchison, PhD | Donald Miles, PhD | Taylor Edwards, PhD | Robert Murphy, PhD | Peter Koplos, DVM | Stephen Divers, DVM| Sean Graham, PhD | Vicky Milne, DVM | Susan Serna

Goal – We aim to establish a free-ranging, minimally managed, wild bolson tortoise populations in the northern Chihuahuan Desert.

Objectives

Captive population – During the next 20 years, we will use captive breeding to produce juveniles to build a large captive population of bolson tortoises.

Wild Population – We will use the captive population to establish up to four wild bolson tortoise colonies on suitable private and/or public lands in the U.S. Each colony will have at least 250 adults, and exhibit: a male to female ratio of around 1:1, stable or positive population growth, and evidence of reproduction.

Project Background – To prevent the extinction of bolson tortoises in the wild, we are working to establish free-ranging populations on the Ladder and Armendaris ranches in New Mexico. These ranches lie at the northern tip of the species' prehistoric range. The largest and rarest of the six North American tortoise species, the bolson tortoise once ranged throughout most of the Chihuahuan desert, but its current range now comprises only a small area in north central Mexico where the states of Durango, Chihuahua, and Coahuila meet. Due to a suite of political, social, economic, and safety issues, the status of the bolson tortoise in the wild is largely unknown. The last population survey, conducted in the 1980s, estimated a population of fewer than 10,000 animals. However, continued habitat degradation and loss make it likely that this number has since decreased.

Our starting point for the bolson tortoise reintroduction project was a group of 30 bolson tortoises that were collected and bred over a period of nearly 40 years by a private individual in Arizona. This collection was donated to TESF in 2006: 26 adults (plus 7 hatchlings) were moved from Arizona to the Armendaris to serve as a captive breeding colony for our reintroduction program. Four tortoises (2 males, 2 females) were donated to the LDZG, where they are on exhibit.

Successful breeding programs on the Armendaris and at the LDZG have hatched over 800 new tortoises since 2006. Hatchlings and juveniles are kept on native forage in outdoor, predator-proof enclosures until they are large enough to be released (about the size of the native box turtle, or ~100 mm shell length). Tortoise growth rates depend both on the weather and forage availability. It typically takes between 3 and 6 years for a hatchling bolson tortoise to reach 100 mm.

With their powerful front legs, tortoises dig burrows in which they spend over 95% of their time. The burrows are an important part of a healthy desert ecosystem – providing shelter for myriad other species of mammals, birds, reptiles, and insects.

Project Activities in 2019

As of October 2019, the bolson tortoise project has 28 adult bolson tortoises that serve as the founder population for all juveniles produced by the project (plus a pair of adult tortoises at the El Paso Zoo that have not yet contributed offspring but may do so in 2020). To date, we have produced over 920 hatchlings, and as of fall 2019, 604 of these juvenile tortoises were confirmed to be alive. During the period 2012-2019, a total of 211 larger juveniles (shell length > 100 mm) have been equipped with transmitters and moved from predator-proof enclosures to predator-accessible enclosures. 160 (75%) of these radio-transmittered juveniles were confirmed to be alive in the fall of 2019.

Personnel – The work for this project was carried out by TESF biologists Chris Wiese and Scott Hillard with help from one full-time and one part-time summer technician whose main responsibilities consisted of tracking tortoises on the Armendaris and Ladder Ranches and feeding and watering juvenile tortoises in the headstart pens on the Ladder Ranch (April – October).

Successes and milestones attained in 2019
The bolson tortoise project reached important milestones in 2019:

- We added 67 hatchlings to our population
- We established a new partnership with researchers from Ohio University who are studying the thermal ecology of *Gopherus* to model the impacts of climate change on the tortoises.
- We once again hosted Dr. Dennis Bramble and Dr. Howard Hutchison, who are studying bolson tortoise burrows and anatomy to better understand the relationships between different members of the *Gopherus* species and their historical geographic distributions.
- With the help of volunteers drawn from TTR staff and the local community, we renovated the Armendaris Deep Well pen so it can once again house tortoises.

Twenty-one juvenile tortoises called Deep Well "home" by the end of 2019. They will be joined by additional tortoises in 2020.

- TTR guides and TESF and Ladder Ranch staff also pitched in to build an educational tortoise holding pen ("Tortugarium") at Ladder Headquarters for ranch guests and visitors. The tortugarium serves as a sanctuary for hybrid gopher/bolson tortoises that closely resemble pure-blooded bolson tortoises but should not be allowed to propagate as they are not a natural species. These hybrids probably all originated from a single (misguided) back-yard pairing in Las Cruces in the late 1960s, and several of them have been found as pets in people's back yards, or as escapees wandering through the desert in NM and AZ. We hope to sequester the hybrids and allow them to live out their lives in the Ladder Tortugarium.
- The newest addition to our breeding group, Abby Q, who is on breeding loan to the El Paso Zoo, carried a clutch of 17 (!) eggs in spring 2019 (average number of eggs is ~5). Unfortunately, the eggs appeared to be infertile. Abby Q had been introduced to the zoo's male bolson tortoise only recently, though. Abby Q and "EP" were observed mating in fall 2019, and we hope that Abby's 2020 clutches will produce viable offspring. These would add important genetic diversity to the population.

Captive Breeding Program

Captive adults and subadults – The captive bolson tortoise group on the Turner Ranches consists of 24 adult bolson tortoises: 13 females and 11 males (Table 3.1). An additional 4 tortoises (2 males, 2 females) reside at the LDZG in Carlsbad, NM. In 2018, a new breeding pair was established at the El Paso Zoo. It consists of a large male (EP, found feral in El Paso in 2011) and a large adult female ("Abby Q") that was acquired from the Albuquerque BioPark in February of 2018. EP and Abby Q have not yet produced any offspring. The El Paso Zoo also houses two subadult tortoises (1:1) that were transferred to the El Paso Zoo from the Turner Ranches in 2010. Lastly, three bolson tortoise subadults from the Turner group were loaned to the Turtle Conservancy in 2017. They reside at the Behler Center in Ojai, CA.

Table 3.1. Adult and subadult bolson tortoises in the 2019 captive population. LDZG, Living Desert Zoo and Gardens State Park in Carlsbad, NM; TC, Turtle Conservancy.

Tortoise location	Sex	ID
Turner ranches	Female	1,2,4,A,F,G,J,K,L,P,S,T,X
Turner ranches	Male	B,C,D,H,M,N,O,U,W,Y,Z
LDZG	Female	CBF, Mrs. Belaroux (Mrs. B)
LDZG	Male	CBM, Mr. Belaroux (Mr. B)
El Paso Zoo	Female	Abby Q (adult)
El Paso Zoo	Male	EP (adult)
El Paso Zoo	Female	07-CB12 (juvenile)
El Paso Zoo	Male	09-F1 (juvenile)
Behler Center (TC)	Male	11-CB81, 11-CB82, 13-CB120

Husbandry strategies (adult tortoises) – Our approach to managing the adult breeding colony is to be as hands off as possible. Towards this end, we surveyed and health-checked the TESF tortoises in the fall of 2019 but otherwise monitored them visually. In years with severe drought we provide supplemental irrigation to the forage in the tortoise pens, but this was not necessary in 2019. However, we did continue to intensively manage adult females during nesting season (April – July).

Hatchling production – We used three steps to produce hatchlings as part of our captive breeding objective:

1. Monitor tortoise nesting using a combination of radiography, weight monitoring, palpation, and direct observation to determine number and maturity of eggs carried by each female tortoise.
2. As the time for nesting approaches, move gravid females to smaller enclosure where they choose nest sites and nests are protected in place.
3. Collect hatchlings, mark them with a unique code, and bank blood for future genetic studies and paternity testing.

2019 Egg collection – We used well-established methods (radiography combined with palpation and weight monitoring) to time the transfer of gravid females to an enclosure where nests would be protected while the eggs developed in the ground.

Table 3.2 summarizes the eggs produced and collected (and hatchlings hatched) for each of the adult female tortoises in the Turner group. The tortoises produced a total of 24 clutches in 2019. This is lower than the average, most likely caused by a relatively prolonged cool spring in 2019. This also manifested in the absence of a third clutch of eggs in 2019, unlike most years.

We protected 23 of the 24 nests (Pancha only made one clutch with 2 eggs in 2019, which we were unable to find) containing a total of 107 eggs. Four eggs cracked or broke during egg-laying and were thus non-viable. We left all 23 nests in the ground in the protected ATP pen for most of the incubation period in 2019, and only transferred the eggs to incubators a few days before the expected hatch date. No eggs were artificially incubated for the entire egg development period in 2019.

Egg incubation – Nests were marked so we could find them again at the end of the incubation period, and the nests were protected from accidental excavation with a 1' x 1' mesh. HOBO dataloggers were deployed in most nests to record incubation temperatures. Eggs remained in the ground until shortly before hatching, at which point they were placed into labeled trays and transferred to an incubator (the "pipping chamber"). Eggs were collected after ~90 days of incubation in the ground. A total of 9 nests had live hatchlings or pipping eggs by the time they were excavated. Most eggs hatched after a few days in the incubator (average days to hatching: 101.3; range: 89-131).

Hatchlings remained in the incubator for up to two weeks to finish hatching and absorb residual yolk before being moved to outdoor holding tanks.

Hatchlings – Following complete yolk absorption, hatchlings were weighed, measured, and marked with a unique tag that is attached to the shell with two-part epoxy (the tortoises eventually receive PIT-tags as well, but not until they are much larger). We also generated a photographic record for each hatchling and drew a drop of blood for banking.

A total of 67 tortoises hatched from incubated eggs on the Armendaris in 2019, bringing the total number of tortoises produced by our captive adults to over 800 since project inception. In addition to the 67 hatchlings emerging from known nests or artificially incubated, we also found 2 unmarked small tortoises in the enclosure. These animals most likely hatched from a nest we were unable to locate in 2016. Both "found" hatchlings were added to the group of 2019 hatchlings and were transferred to headstart enclosures.

Table 3.2. Egg production and hatching success in 2019 for each female in the Turner group.

ID	No. of eggs in successive clutches (1st / 2nd / 3rd)	No. of eggs recovered & incubated	No of offspring produced	Hatching success rate
1	5 / 5 / -	10	5	50
2	4 / 3 / -	7	4	57.1
4	5 / 4 / 4	13	10	83.3
A	6 / 6 / 5	17	12	70.6
F	4 / 4 / -	8	4	50
G	9 / - / -	9	3	33.3
J	5 / 4 / -	9	6	66.7
K	4 / 4 / 2	6	6	100
L	3 / 7 / 6	16	13	81.2
P	3 / 3 / -	6	2	33.3
S	5 / 5 / -	6	3	50
T	4 / 5 / -	9	9	100
X	4 / 6 / -	9	6	66.7
TOTAL	**61 / 56 / 17**	**125**	**83**	**-**
MEAN	**4.7 /4.3/1.3**	**9.6**	**6.4**	**64.8**

Hatching success rates – A total of 67 hatchlings emerged from 107 potentially viable eggs in 2019. This makes for a 62.6% hatching success rate, in line with previous observations (Table 3.3). All Turner females except for Pancha contributed to this reproductive effort in 2019 (Table 3.2). Overall hatching success rates vary widely amongst females (Table 3.2), and for a given female from year to year. However, overall hatching success has remained relatively consistent for the last 9 years (Table 3.3), and ranges from a low of 53.4 in 2015 to a high of 69.4% in 2011. The 2019 hatching success rate was about average.

Table 3.3. Hatching success rates of Turner group tortoises since 2010. This rate is the percentage of eggs that hatched from those that were placed into incubators. Eggs not incubated were either lost, broken, or not collected.

Year	No. of eggs hatched	No. of eggs recovered & incubated	No. of eggs not recovered	Hatching success rate
2010	51	78	13	65
2011	50	72	3	69
2012	63	118	10	53
2013	87	126	8	69
2014	96	172	11	56
2015	76	140	32	54.3
2016	54	89	55	61
2017	83	137	44	60.6
2018	83	125	9	64.8
2019	67	107	6	62.6
Mean	**71**	**116.4**	**19.1**	**61.5**

Over the past few years, we maximized the number of bolson tortoise juveniles produced to enable the implementation of the next phase of our conservation program – establishing wild populations. Several factors, including age, size, and number of reproductive years, contribute to the fecundity of each individual female. The number of offspring produced per female, and the number of offspring from each female currently alive, varies nearly 5-fold. We aim to normalize these numbers over the next few years, thus allowing each female to contribute similar numbers of offspring to the conservation efforts.

Juvenile headstarting – The objective of the headstarting component of the captive bolson tortoise program is to produce large numbers of tortoises for eventual release by maximizing juvenile survival rates until individuals attain a size that is relatively resistant to predation (~100 mm shell length). This involves:

- Overwintering hatchlings indoors during their first winter while providing ample forage and summer-like temperatures.
- Holding juveniles in covered, predator resistant outdoor enclosures until they reach 100 mm shell length.
- Provisioning tortoises with supplemental food (mostly native forage) and water as needed.
- Surveying juvenile tortoises twice a year (spring/fall) to monitor growth rates and health.

Since 2006, our captive population has grown to about 650 tortoises in the population at the end of 2019. The overall survivorship of bolson tortoise juveniles in our project lies around 70%.

All juvenile tortoises not large enough to be held in unprotected enclosures were managed in headstart enclosures in 2019 with supplemental feeding and watering. Headstart pen maintenance includes grass-clipping and weeding to remove non-forage plants from the enclosures. Wild globemallow plants and wild grape leaves were harvested from the Turner ranches and provided in the enclosures 3-5 times a week for supplemental feeding.

While individual growth rates vary between animals, all tortoises appear to be growing at acceptable rates (>10% per year) using these protocols.

Tortoise Surveys and Health Checks – With the help of our long-term veterinarian and collaborator, Dr. Jim Jarchow, we surveyed the tortoises in the fall of 2019 and performed health checks on as many individuals as was feasible. Health and growth data provide an opportunity to identify juveniles that might need additional management to attain their full growth potential. The 2019 health checks revealed that, overall, the juvenile and adult bolson tortoises on the Ladder and Armendaris ranches continue to be in good or excellent health and no special treatments were required in 2019.

Release studies – In the fall of 2012, we began outfitting large juveniles (> 100 mm shell length) with transmitters and moving them from the predator-proof headstart enclosures to the predator-accessible fenced areas that also house (or could house) the adults on the Armendaris and Ladder Ranches. Although the ultimate goal is to establish unfenced wild populations, the fenced "releases" provide important information regarding the behavior and predation pressures for released tortoise juveniles until all of the required state and federal permits are in place to allow true, unfenced releases. For example, the release studies thus far revealed that in most years, most of the juvenile tortoises do not travel long distances from the release site. Since 2012, we have transferred a total of 250 juvenile tortoises to predator-accessible (but fenced to comply with permit requirements) enclosures on the Armendaris and Ladder ranches. Of these, we found 213 (85%) to be alive at the end of 2019. We moved a total of 42 juvenile tortoises from headstart pens to open enclosures in 2019.

These release studies also revealed that, in general, tortoises were lost for a number of reasons, but not due to one specific predator over others. Problems associated with environmental conditions that contributed to increased incidents of bacterial and fungal infections caused by particularly wet winter conditions were an important factor as well.

In 2017, we obtained a small grant from the Mohamed bin Zayed Species Conservation Fund to outfit ten juvenile tortoises smaller than 100 mm shell length (70 mm - 90 mm) with transmitters and release them in predator-accessible pens to begin to understand predation pressures on small tortoises. All ten tortoises that were part of the study in 2017 were still alive in 2019, but by now have outgrown the experiment. We plan to outfit a new cohort of 10 small tortoises with transmitters to repeat the experiment in 2020.

Future Activities and Considerations – Our major objectives for 2020 will be to:

- Continue building a robust captive population of tortoises as a source for wild releases.
- Initiate releases of juvenile tortoises on the Armendaris so we can begin to build a strong, repatriated, minimally managed, wild population.
- Continue to seek and collaborate with additional partners to expand the scope of the bolson tortoise project
- Continue our search for additional breeding adult tortoises to introduce additional genetic diversity into our breeding group
- Continue our efforts to obtain state and federal permits to release tortoises outside of enclosures on Turner lands

The methods we will employ to achieve these objectives will include:

- Collecting the eggs of genetically underrepresented females and incubating them to ensure continued robust hatchling production. We plan to leave a large portion of the eggs to develop in natural nests.
- Surveying tortoises at least once a year.
- Increasing forage availability in headstart pens by harvesting plants from the environment.
- Enhancing available forage.
- Transferring juveniles to predator-accessible enclosures to free up space in the headstart pens.
- Monitoring released juveniles to track survivorship and movements.

Outreach and other activities – We hosted Julia Joos, a graduate student in Don Miles's lab at Ohio University, for a week in August of 2019. Julia is studying the thermal ecology of *Gopherus* species to model the effects of climate change on long-term tortoise survivorship. Julia is planning on returning to the Armendaris Ranch in 2020 for a more extended field season (4-6 weeks).

We also hosted emeritus professors Dennis Bramble (University of Utah) and Howard Hutchins (UC Berkeley) who are comparing the *Gopherus* fossil record with anatomical and physiological features of currently alive *Gopherus*. For their studies, they took measurements of live tortoises of all ages, examined numerous carcasses, and measured the dimensions of active burrows.

As part of our preparations for eventual releases of bolson tortoises outside of enclosures on the Armendaris and Ladder Ranches, several volunteers from the New Mexico Herpetological Society joined us for two weekends in August and September to look for box turtles. Together, we walked over 64 miles of surveys in the Wildhorse pasture on the Ladder Ranch and found zero box turtles. In contrast, we found 11 box turtles in the area between the two bolson tortoise enclosures on the Armendaris Ranch, starting with the first turtle within 45 min of the start of the surveys. We marked all turtles and outfitted a few of them with transmitters in an attempt to monitor their health and movements in the long term and thus gain a better understanding of the potential impacts any contact with bolson tortoises may have on the resident box turtle population. This project is powered by volunteers and is supported by the transmitter company Holohil, who generously donated the transmitters for this project.

Appendix 3.1. Contributors to the Bolson tortoise project

Type of Support	**Individual/Organization**
Funding	The Turtle Conservancy Lynnie Appleton
Veterinary	Dr. Jim Jarchow, DVM Dr. Peter Koplos, DVM El Paso Zoo
Tortoise Donation	The Appleton family LDZG Albuquerque BioPark Susan Serna
Supplies Donation	San Antonio Zoo Dr. Peter Koplos, DVM
Volunteer Labor	Heidi Hubble, Matt Keeling, Tricia Rossetie, Andrew Lincourt, TTR staff, Ladder Ranch staff
Training	Dr. Stephen Divers, DVM *Endoscopy training*
Intellectual	Dr. Sean Graham
Research	Dr. Vicky Milne, DVM. *Endoscopy. Temperature dependent sex determination*
	Dr. Dennis Bramble, PhD. (Emeritus)
	Dr. Howard Hutchison, PhD. (Emeritus)
	Dr. Donald Miles, PhD Julia Joos, MS *Tortoise thermal ecology*
	Dr. Taylor Edwards, PhD. *Bolson tortoise genetics*
	Dr. Robert Murphy, PhD. *Bolson tortoise genomics*

A 2019 hatchling bolson tortoise

4. CHIRICAHUA LEOPARD FROG

(*Lithobates chiricahuensis)*

Project Biologists

Cassidi Cobos

Carter Kruse

Magnus McCaffery

Threats – Range-wide decline of Chiricahua leopard frogs (CLF) due to a suite of factors, including:

- Disease
- Invasive species
- Habitat degradation and loss
- Increased drought event severity/duration

Project Location

Project Partners

Administrative

Administrative

Research: Dr. Jamie Voyles

Goal – To maintain viable CLF population levels on the Ladder Ranch and to contribute to range-wide recovery of the species.

Objectives

Population Objective – Over the next 10 years, we will ensure CLF occupancy of at least 70% of suitable lentic habitats in at least two major drainages on the Ladder Ranch to maintain a minimum of two CLF populations (comprised of > 1 subpopulations) on the Ladder Ranch. At least one subpopulation in each drainage will exhibit a geometric mean growth rate over a five-year period of $\lambda \geq 1.0$.

Habitat Objective – Monitor and manage natural wetlands, stock-water pond habitats, and stream channels in at least two major drainages on the Ladder Ranch (e.g. Seco and Las Palomas creeks) to provide high quality and secure overwintering, breeding, foraging, and dispersal habitat that meets the life history requirements of all life stages of CLFs in to support viable populations on the Ladder Ranch.

Captive Breeding Objective – Over the next 10 years, and in coordination with the USFWS, we will hold adult CLFs from up to nine populations from across the species' range in the captive Ladder Ranch ranarium facility. Adults from each population will be held in isolated population-specific cages and managed to promote breeding. All viable egg masses produced will be managed to optimize successful tadpole emergence, and tadpoles will be reared to late tadpole stage (Gosner 30+) prior to transference to suitable habitat or other captive holding facilities in coordination with the USFWS to assist with this agency's range-wide species recovery objectives.

Captive Holding Objective – Over the next 10 years, we will coordinate with the USFWS to hold captive CLFs from any location within the species' range in up to five artificial refugia sites on the Ladder Ranch (i.e. stock tanks, that will conserve genetically or geographically unique stocks of CLFs in peril (i.e., habitat destruction and disease), or CLFs that require a temporary relocation for their survival (e.g. during a drought that dries a stock tank, a population threatened by ash or sediment flow). Refugia may also serve as a source of egg masses, tadpoles, and adult CLFs for translocation to recovery sites, for augmentation, or to repopulate habitats after environmental disasters. Surplus CLFs from these facilities may also be used for research purposes.

Research Objective – Over the next 10 years, we will work collaboratively with state, federal, and/or academic partners to design and carry out work on at least one research/monitoring project on the Ladder Ranch per year, to inform and support CLF recovery actions and adaptive management. Results from these studies will be used in reports and/or submitted for peer-reviewed publication.

Project Background – TESF has worked in partnership with the USFWS, and the NMDGF to conserve the CLFs on the Ladder Ranch since 2001. The conservation value of the Ladder Ranch's 62,950 ha of diverse habitat in New Mexico cannot be overstated. As home to the last, large CLF population in New Mexico, the Ladder Ranch plays a crucial role in the survival of this species. The ranch is one of four CLF Management Areas within the Mimbres-Alamosa CLF Recovery Unit (Figure 4.1). From a broader conservation perspective, the Chihuahuan Desert Ecoregion is a WWF Global 200 Priority Ecoregion, conservation of which will help maintain a broad diversity of Earth's ecosystems, and the Ladder Ranch itself is recognized as a Key Conservation Area by The Nature Conservancy. Numerous factors are involved in the range-wide decline of this species, including disease, nonnative species invasions, habitat degradation, and an increase in the severity and duration of drought events. Perhaps in response to reduced natural habitat availability and drying climatic conditions, CLF have been found to naturally colonize man-made livestock water tanks.

This behavior motivated us to adapt these tanks for use as escape-proof CLF refugia. These serve the purpose of temporary holding facilities for small, putatively unique populations that are at high risk of extirpation in the wild.

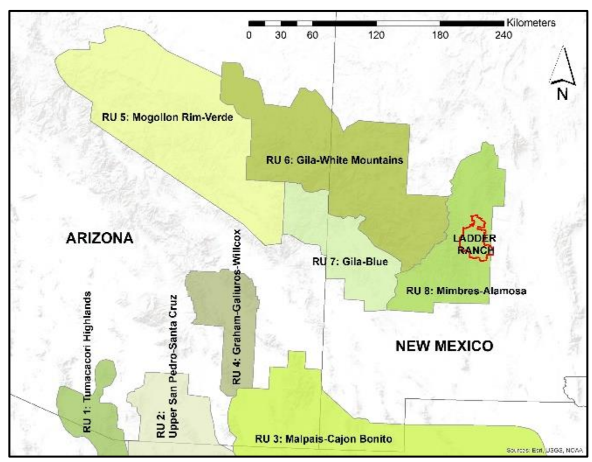


Fig. 4.1. The Ladder Ranch is a CLF Management Area within Recovery Unit (RU) 8

Supporting Rationale for Objectives – The 62,950 ha Ladder Ranch in Sierra County, NM is recognized in the federal CLF recovery plan as an area with a high potential for successful recovery actions, and as such is designated as a CLF Management Area within Recovery Unit (RU) 8 (Fig. 4.1.).

The ranch supports a large CLF population in both natural wetlands and artificial stock water sites. For the frog to be considered for delisting, the recovery plan mandates that each RU has: (i) at least two CLF metapopulations located in different drainages, and at least one isolated population, that exhibit long-term persistence and stability; (ii) aquatic breeding habitats that are protected and managed; (iii) the additional habitat required for population connectivity, recolonization, and dispersal is protected and managed, and that (iv) causes of decline have been reduced or eliminated, and commitments to long-term management. Specific actions to achieve recovery include: (a) protecting remaining populations; (b) identifying and managing currently unoccupied sites and establishing new populations; (c) augmenting populations; (d) monitoring populations; (e) implementing research to support recovery actions and adaptive management.

Project Activities in 2019

Wild population monitoring – We monitored all known sites occupied by wild CLF during 2019. Minimum count data from this survey work suggests that the Ladder Ranch population remains robust (Table 4.2). However, this population continues to be largely confined to a single drainage (Seco Creek). Our long-term strategy is to improve the likelihood of CLF persistence on the Ladder by augmenting existing populations and expanding the species' distribution through the creation of a network of natural and artificial wetlands. In 2014, we improved wetland habitat in Las Palomas drainage, and translocated CLF into one of these sites. However, since the sites were created Plains leopard frogs have colonized the area and frogs have tested positive for *Bd*.

Habitat actions on the Ladder Ranch –

- Removed the majority of cattail from Pague Well (Fig. 4.2).
- Removed cattail regrowth from Johnson.
- Applied herbicide for a second year in a row on cattail at LM Bar.
- Added soil in and around Artesia Well.

Fig. 4.2. Cattail removal at Pague

Captive refugia program – We removed CLFs from several of the captive refugia tanks designated for use by the USFWS (Table 4.2). These animals were released in the wild or were brought into the ranarium for breeding.

Overall, refugia tanks designated for both Ladder Ranch and USFWS use produced 56 viable egg masses in 2019 (Table 4.3).

Table 4.1. 2019 minimum CLF counts at wild sites

	Minimum Counts			
Site Name	**EM**	**TP**	**MM**	**AD**
[a]Circle 7	0	0	0	3
[b]Davis (Lower)	1	10	22	18
[b]Davis (Upper)	8	10	32	32
[b]N. Seco	107	10	41	65
[b]Pague	24	100	69	43
[b]LM Bar	18	20	19	45
[b]Fish	0	10	12	11
[b]Johnson	57	>100	290	500
[b]S. Seco	5	0	0	1
[b]S. Seco tinaja	0	50	0	0
[c]Artesia	9	10	34	9

KEY:
a=Las Palomas drainage
b=Seco drainage
c=Ash Canyon drainage

EM=egg mass
TP=tadpole
MM=metamorph
AD=adult

Table 4.2. Number of egg masses (EM), Tadpoles (T), and metamorph (MM)/adult-form (AF) frogs from source populations (Pop.) stocked into USFWS designated captive refugia tanks on the Ladder Ranch in 2019				
Refugia	**Pop.**	**EM**	**T**	**MM/AF**
Antelope	Seco	0	0	0
No. 2	Seco	0	0	11
Seco Well	San Fran	0	0	19
Fox	Animas	0	0	7
Avant	Beaver Cr.	0	0	6
Wildhorse	Cuchillo	0	0	8

Table 4.3. Egg masses detected in captive refugia in 2019		
Refugia	**No. Egg Masses**	**No. Viable**
Antelope	2	2
Seco Well	19	19
Wildhorse	15	15
Fox	9	9
No. 2	10	10
Avant	1	1
No. 16	0	0

Captive breeding: ranarium program

The ranarium (Fig. 4.3) housed adults from eight off-ranch source populations, spanning three CLF Recovery Units, as well as adults from three on-ranch populations (Table 4.4). Egg masses produced in adult cages were transferred to the integrated tadpole rearing facility.

Fig. 4.3. Ladder Ranch ranarium

Table 4.4. CLFs in ranarium cages during 2019			
Cage No.	Source population	No. ♂/♀	Date of entry
1	Seco X Cuchillo	0/2 2/0	5/22/19 7/11/19
2	Alamosa	2/2	7/27/19
3	Beaver Cr. X Diamond Cr.	2/0 0/2	3/29/11 11/2/15
4	ASDM/Kerr N. F. Negrito Divide/LM	2/0 0/1 1/1	4/26/12 9/18/12 5/6/13
5	Diamond Cr. Beaver Cr.	2/0 0/2	11/2/15 3/29/11
6	Blue Cr.	3/1 0/1 0/2	6/16/14 5/1/15 11/2/15
7	Moreno Spr. Moreno Spr. Moreno Spr.	1/0 4/1 0/2	6/28/12 10/17/12 10/29/13
8	Open	-	
9	Las Animas Cave Cr.	4/2 1/4	6/13/13 6/13/15
KEY: Cr. = Creek W.S. = Warm Springs Spr. = Springs LM = Long Mesa Metas = metamorphs			

There are ten tadpole rearing tanks in the ranarium, which can hold around 1,000 tadpoles each. In 2019, 56 viable egg masses were transferred from adult cages to tadpole tanks (Table 4.5). Tadpoles from these masses were released into the wild, or into captive refugia holding tanks in consultation with the USFWS (Tables 4.5 & 4.6).

The Ladder ranarium produced over 15,000 tadpoles in 2019. These tadpoles were released to wild or captive sites across New Mexico on both public and private lands.

Table 4.5. Ranarium egg mass production and management

Cage	Source Pop.	# Egg Mass	Egg Mass Laid	TP Exit Date	TP transfer to
2	Alamosa W.S.	1	8/4/19	9/12/19	Garcia Tank (JER)
		1	8/5/19	9/12/19	
		1	8/22/19	9/12/19	
		1	9/3/19	9/12/19	
4	San Fran	1	4/13/19	6/10/19	Reserve, NM
		1	7/30/19	9/17/19	
3,5	Diamond X Beaver	1	5/28/19	8/13/19	Black Canyon
		1	6/2/19	8/13/19	
		1	6/27/19	8/13/19	
		2	7/22/19	10/22/19	
		1	8/8/19	10/22/19	
		1	9/8/19	10/22/19	
		1	4/10/19	5/15/19	
		1	6/10/19	8/13/19	
		1	7/7/19	8/13/19	
		1	7/8/19	8/13/19	
		1	7/9/19	8/13/19	
		1	7/10/19	8/13/19	
		2	8/11/19	10/22/19	
		1	9/8/19	10/22/19	
		1	9/9/19	10/22/19	
6	Blue	1	4/30/19	6/7/18	Garcia Tank (JER)
		1	5/19/19	10/4/18	
		1	6/17/19	10/4/18	
		1	6/23/19	10/4/18	
		2	6/23/19	10/4/18	
		1	7/7/19	8/29/19	
		1	7/16/19	8/29/19	
		1	7/22/19	8/29/19	
		1	8/4/19	8/29/19	
		3	9/3/19	9/12/19	
7	Moreno	1	6/10/19	7/24/19	Divide Well, Bear Mtn Lodge
		2	7/8/19	7/24/19	
		1	8/11/19	9/25/19	
		2	8/13/19	9/25/19	
9	Animas	2	4/10/19	6/12/19	Cave Creek, Artesia
		2	4/13/19	6/12/19	
		2	5/27/19	7/16/19	
		1	5/28/19	7/16/19	
		1	6/20/19	8/13/19	
		1	7/9/19	8/13/19	
		1	8/1/19	8/2/19	
		2	8/11/19	8/12/19	
		2	8/19/19	8/19/19	

KEY:
Animas = Animas Creek
Diamond = Diamond Creek
Beaver = Beaver Creek
Blue = Blue Creek
San Fran = San Fran Haplotype
Moreno = Moreno Warm Springs

Table 4.6. Production and disposition of offspring produced at the ranarium in 2019

Date	Source	EM	TP	Meta	Release type
5/15/19	Diamond	-	122	-	W
5/15/19	Beaver x Diamond	1	457	-	W
6/10/19	San Fran	1	459	-	W
6/12/19	Animas	2	546	-	W
6/12/19	Animas	2	267	-	W
6/25/19	Blue Cr	1	635	-	C
6/25/19	Blue Cr	1	1841	-	C
7/16/19	Animas	3	705	-	W
7/24/19	Moreno	1	430	-	C
7/24/19	Moreno	2	228	-	W
8/2/19	Animas	1	-	-	W
8/12/19	Animas	2	-	-	W
8/13/19	Animas	2	969	-	W
8/13/19	Beaver x Diamond	3	121	45	W
8/13/19	Beaver x Diamond	5	954	-	W
8/19/19	Animas	2	-	-	W
8/29/19	Blue	1	347	-	C
8/29/19	Blue	3	390	-	C
8/29/19	Blue	4	347	7	C
9/12/19	Alamosa	1	1157		C
9/12/19	Alamosa	3	1350		C
9/12/19	Blue	3	2925		C
9/17/19	San Fran	1	176	1	W
9/25/19	Moreno	3	303	5	W
10/22/19	Beaver x Diamond	8	295	14	W

KEY:
Animas = Animas Creek
Diamond = Diamond Creek
Beaver = Beaver Creek
Blue = Blue Creek
San Fran = San Fran Haplotype
Moreno = Moreno Warm Springs

EM = # of egg masses
TP = # of tadpoles
Meta = # of Metamorphs
W = Wild
C = Captive

Drought Study – We continued working with Jamie Voyles (University of Nevada, Reno) on a federally funded project investigating climate and disease dynamics in amphibian chytridiomycosis. There were 9 mesocosms (Fig. 4.4) with 40 tadpoles in each that simulate different drought treatments. Once the tadpoles metamorphosed, they were sent off to UNR for *Bd* exposure. We had hoped that all tadpoles would metamorphose by October 2018 but that did not occur. The remaining tadpoles were overwintered, and drought treatment started back up in early 2019. Unfortunately, many of the overwintered tadpoles died. The 2019 metamorphs were sent off for *Bd* exposure. Preliminary results show that frogs that were in the fast and slow treatment were more susceptible to *Bd.*

Fig. 4.4. Drought/disease experiment tanks at the Ladder ranarium.

Hybridization – Over the last few years Plains leopard frogs (*Lithobates blairi*) have been seen moving up the Animas, Seco, and the Las Palomas drainages. In 2018, while capturing frogs at Johnson well we found several odd-looking frogs that had characteristics of both CLF and PLF. CLF and PLF hybridization has not been previously recorded.

We conducted two studies to investigate if these two species were hybridizing. First, we set up four artificial tanks and crossed CLF and PLF (2 CLF females x 2 PLF males, 2 PLF females x 2 CLF males, 2 CLF females x 2 CLF males, 2 PLF females, 2 PLF males). Unfortunately, no breeding occurred in any of the tanks. The second part of our study focused on whether the odd-looking frogs we were seeing in the wild were genetically hybrids. To do this, we collected 20 CLF, 20 PLF, and 20 hybrid looking frog toe clippings from a variety of locations on the ranch. All samples were sent to Pisces Molecular for analysis and the results showed evidence of hybridization between the two species.

Fig. 4.5 Hybrid found at Fish well

5. LESSER PRAIRIE CHICKEN

(*Tympanuchus pallidicinctus)*

U.S. Fish & Wildlife Service

Listing Status under the Endangered Species Act

STATUS REVIEW

Project Biologists

Grace Ray

Dustin Long

Threats – Rapid, range-wide decline due to habitat loss and fragmentation.

Goal – Restore ~25,000 acres of the Z Bar mixed grass prairie to a condition suitable for lesser prairie chickens, and to integrate the project into existing bison production and black-tailed prairie dog restoration efforts at the ranch.

Objective – We will increase lesser prairie-chicken numbers at the Z Bar by managing for a diverse landscape mosaic that includes breeding, nesting and brood rearing habitats within close proximity to each other.

Strategies

- Prescribed fire to improve brood rearing habitat and control woody vegetation. Pastures will be burned at least once every 10 years.
- Mechanical removal of woody vegetation from the uplands to limit avian predation and improve suitable lesser prairie-chicken habitat.
- Using grazing to produce a mosaic of habitats that include lightly grazed pastures with robust standing vegetation, and heavily grazed pastures with minimal standing vegetation.

Project Partners

Administrative

Funding

Supporting Rationale for Objective

The Z Bar once supported a modest lesser prairie-chicken population with at least 2 lek sites on the ranch (Fig. 5.1). The population has since decreased, with only occasional sightings of individuals now reported. WAFWA recommends habitat blocks (i.e. lek complexes) of 21,000 – 25,000 acres to support a viable prairie chicken population. The 42,500-acre Z Bar has sufficient existing and potential habitat to meet that lek complex requirement.

Project Background

The lesser prairie-chicken project at the Z Bar represents one of TESF's newest conservation efforts on Turner properties. Beginning in early 2015 we began to manage 32,525 acres to benefit lesser prairie-chickens through a cooperative 10-year agreement with WAFWA. Central to the agreement is habitat restoration, which includes the removal of woody vegetation from the uplands on 1,949 acres, prescribed fire in each pasture at least once every ten years, and a prescribed grazing plan intended to help create the vegetative mosaic required by lesser prairie-chickens. By year two of the project, we had satisfied all required habitat restoration and grazing requirements (Fig. 5.2). In March 2016, 41,000 acres of the Z Bar burned in what ended up being the largest wildfire in Kansas history. Ecologically, the Z Bar largely benefitted from the fire as it served to refresh native grasses, increase ecosystem heterogeneity, and eliminate invasive woody brush and trees from the uplands; all to the benefit of lesser prairie-chickens. Because of this wildfire no prescribed burns were performed in 2016 or 2017.

Over the course of this project lesser prairie-chickens have routinely been observed and sightings at the Z Bar appear to be increasing; however, we have yet to verify that lesser prairie-chickens are reproducing on the ranch.

Fig. 5.1. Male lesser prairie-chicken on a lek site. Lesser prairie-chicken surveys are performed during the spring breeding season when males and females congregate on historical "booming grounds" (credit: Dominic Sherony).

Fig. 5.2. An upland site on the Z Bar *before* (in 2012) and *after* mechanical removal of eastern red cedar and prescribed fire.

Project Activities in 2019 – While lesser prairie-chicken sightings at the Z Bar continue to increase, it is unlikely the ranch supports a breeding population. This assumption is supported by the annual lek surveys that are performed by the TESF, WAFWA, and the TNC over the past five years, which have not detected any leks on the ranch. Additionally, in 2018 TESF made the additional effort to determine prairie-chicken populations on the Z Bar by establishing and monitoring artificial leks (Fig. 5.3) at three sites reported to have been used by prairie-chickens in the past.

Fig. 5.3. Artificial lesser prairie-chicken lek used to verify chicken populations and as a means to congregate the few widely scattered individual birds on the property.

Each artificial lek contained six male decoys, a large speaker transmitting a recording from a "booming ground", and four game cameras arranged to photo capture any chickens attracted to the site. No prairie-chickens were detected on the artificial leks in 2018 or 2019. Having confirmed with relative certainty the Z Bar does not support a breeding population of lesser prairie-chickens we will begin the process of critically evaluating habitat and population trends to determine whether conditions support translocating prairie-chickens to the ranch.

Results from WAFWA's 2019 lesser prairie-chicken habitat surveys indicate the Z Bar continues to make good progress in restoring habitat. For example, in each of the last four years the ranch has surpassed predicted habitat values. In 2018 we continued to improve and expand lesser prairie-chicken habitat by removing trees using a "ball and chain" (Fig. 5.4-5.6) and prescribed fire.

Fig. 5.4. Six foot “ball and chain” used to remove tree carcasses in the Z Bar uplands in 2018.

Fig. 5.5. Before treatment with “ball and chain” in 2018.

Fig. 5.6. After treatment with “ball and chain” in 2018.

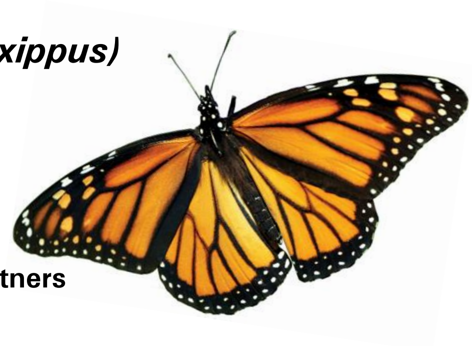
There remains, however, one habitat component–brood-rearing habitat–which may be population limiting at the ranch. To remedy this shortcoming, we petitioned and received permission from WAFWA to increase bison grazing in 2019 which, in combination with an increase in prescribed fire (Fig. 5.7). should result in an increase in that specific habitat type.

Proposed Future Activities & Considerations

The direction of the lesser prairie-chicken project at the Z Bar hinges on whether we are able to document reproduction and an increase in the population over the coming years. Existing habitat evaluation metrics suggest the habitat requirements for the species have been met at the Z Bar, yet the population remains low. Our next effort will work to determine why the on-ranch chicken populations remains low. Whether due to vegetative composition, vegetative community structure and arrangement, distance from source populations, or a combination of the aforementioned factors, or others; these parameters will be examined by a graduate student, funded in part by TESF/TEI and Montana State University, over the course of 2020 and 2021. In the meantime, TESF/TEI, WAFWA, and our additional project partners continue our diligent efforts in researching and understanding habitat needs of the lesser prairie chicken by incorporating focused bison grazing, prescribed fire, thorough monitoring of habitat conditions, and a final “cleanup” of the remaining eastern red cedars at the Z Bar Ranch.

Fig. 5.7. A prescribed fire utilized in creating desirable habitat in the Red Hills, KS.

6. MONARCH BUTTERFLY (*Danaus plexippus*)



U.S. Fish & Wildlife Service
Listing Status under the Endangered Species Act
STATUS REVIEW

Project Biologists

Magnus McCaffery

Dustin Long

Project Partners

Funding

Threats – The primary threat to monarch butterflies is habitat loss and pesticides.

Project Location – Z Bar Ranch, KS; Bad River Ranches, SD; Avalon Plantation, FL

Goal – Restore native milkweed and other wildflowers to benefit monarch butterflies and other native pollinators.

Objective – To increase suitable habitat for monarch butterflies and other native pollinators on Turner properties through milkweed (*Asclepias spp.*) and other native wildflower plantings, as well as habitat management. Within five years, we aim to reestablish robust, reproducing populations of swamp milkweed (*A. incarnata*) at the Z Bar and Avalon to include > 500 plants at four sites on each property. At Bad River we will collect seeds from extant showy milkweed (*A. speciosa*) stands and distribute them in recently disturbed areas. We will also determine if showy milkweed is an effective vegetative barrier to black-tailed prairie dog expansion. As these and other milkweed species become established, we will provide local ecotype seeds to partners and other landowners who want to improve habitat for native pollinators.

Strategies – We will increase pollinator habitat through milkweed plantings and habitat management. At the Z Bar and Bad River, we will collect local milkweed seeds and broadcast those seeds in unoccupied suitable habitat. At Avalon we will collect swamp milkweed seeds, germinate them in plug pots and plant them in unoccupied suitable habitat.

Supporting Rationale for Objective

Most Turner properties lie within the spring and fall migration routes of the monarch butterfly (Fig. 8.1) and can reasonably be expected to support monarch populations with restoration and conservation of milkweeds and other wildflowers. The Z Bar and the Avalon are particularly well suited to monarch butterfly conservation because both properties support prescribed fire which results in diverse wildflower communities. Both are also located where the first generation of monarchs migrating north from Mexico lay eggs, setting the foundation for the species' multi-generational transnational migration.

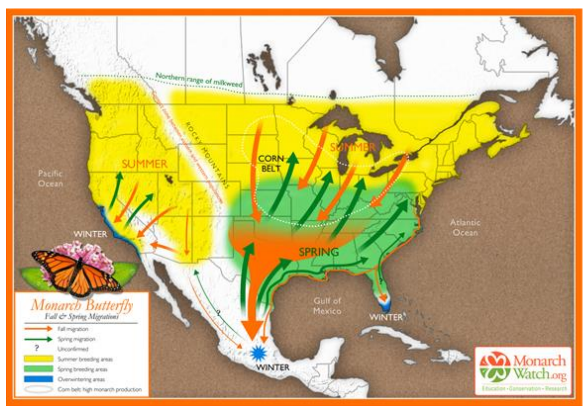


Fig. 6.1. Monarch butterfly migration routes.

All Turner properties have extant populations of milkweed which are beneficial as nectar and pollen sources for native pollinators. However, most of those milkweed populations are sparse and homogenous, and some milkweed species are less desirable than others as host plants for monarch butterflies (Fig. 6.2).

Fig. 6.2. Female tarantula hawk (*Pepsis spp.*) feeding on nectar from a broadleaf milkweed (*A. latifolia*) plant at the Z Bar. While not a highly preferred monarch host plant, broadleaf milkweed is a valuable nectar source for monarchs and other native pollinators.

At Avalon and the Z Bar, a highly preferred host plant for monarchs—swamp milkweed—is largely absent, while at Bad River another preferred host plant—showy milkweed (Fig. 6.3)—exists, but in widely scattered and small stands. Why these two preferred host plants are uncommon—particularly swamp milkweed at Avalon and Z Bar—is unknown although it seems likely that it is a legacy of herbicide use at those properties. With assisted colonization and habitat management we aim to increase the suitability of these properties for monarch butterflies and all native pollinators.

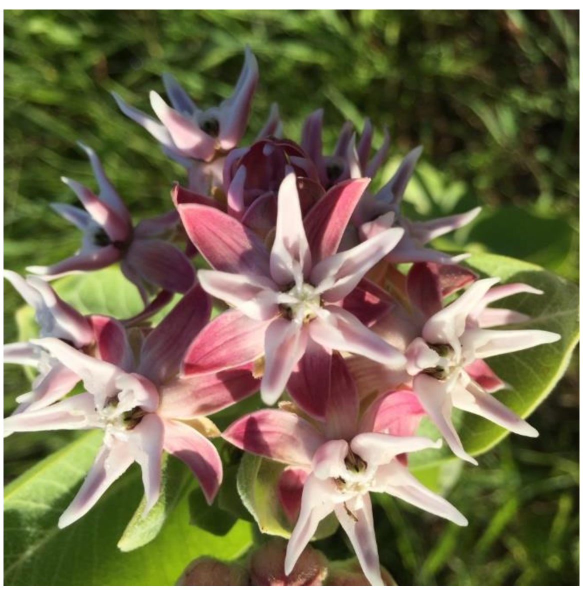


Fig. 6.3. Showy milkweed is ubiquitous throughout the western U.S. and is found on all Turner properties in the Great Plains. Showy milkweed is a preferred monarch host plant and we are attempting to improve existing stand vigor and establish new stands at the Z Bar and Bad River.

Project Background

In response to the unprecedented decline of such an iconic insect, TESF teamed up with federal, state, and non-profit partners to initiate multiple monarch butterfly habitat conservation and recovery projects on Turner properties. Central to this effort will be restoring preferred monarch host plants on Turner properties, and adapting management practices to benefit these early successional, disturbance-loving plants.

Beginning in 2015, we began annual milkweed surveys at Avalon, Z Bar, and Bad River to determine species abundance and diversity to guide restoration efforts. Results indicated a robust redring milkweed (*A. variegata*) community but few other species at Avalon, while Z Bar supports the most diverse milkweed community of the Turner properties where nine species were identified–many of which persist in relatively large stands. Both Avalon and the Z Bar support vibrant and robust wildflower communities; a reflection of the sensible use of prescribed fire on those landscapes. Two milkweed species have been documented at Bad River, with showy milkweed being the most common.

We have investigated two principal methods to increase milkweed diversity and abundance: seed plantings and plug plantings, with the latter showing more promise for restoring an extirpated milkweed species. Plug plantings at Avalon and seed plantings at Bad River originated from local ecotype specimens, whereas the seed and plug plantings at the Z Bar and plug plantings at Bad River were regionally sourced.

Project Activities in 2019

The local ecotype swamp milkweed planting efforts at Avalon, which began in 2016, produced seed pods for the first time in 2018. These seed pods were collected, dried, and cold stratified prior to planting in spring 2019. The prepared swamp milkweed seeds were germinated and grown in a greenhouse on the Avalon Plantation for three months (February-May 2019), then 180 swamp milkweed plugs were planted at 27 locations around the property in spring 2019.

7. RED-COCKADED WOODPECKER

(Picoides borealis)

U.S. Fish & Wildlife Service

Listing Status under the Endangered Species Act

ENDANGERED

Project Biologists

Greg Hagan

Mike Phillips

Threats – Red-cockaded woodpecker populations are in decline due to habitat destruction and degradation.

Project Location

Goal – Restore red-cockaded woodpeckers to the Avalon Plantation.

Objective – Restore at least 20 breeding groups to the Avalon Plantation that can persist with minimal management. Once this is achieved, Avalon will be available as a donor site for translocations to other recovery sites.

Project Partners

Administrative, Funding

Administrative

Strategies

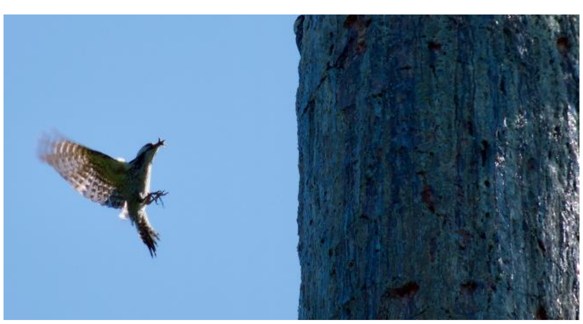
- Restoring abandoned clusters (an aggregate of cavity trees) by providing ≥ 4 artificial cavities per abandoned cluster.
- Establishing recruitment clusters by installing ≥ 4 artificial cavities per recruitment cluster.
- Using fire to maintain RCW habitat suitability.
- Pre-burn mowing (2 acres) around all clusters to protect cavity trees from prescribed fire.

Project Background – RCWs depend on mature pine forest habitat that have longleaf pines averaging 80-120 years old or loblolly pines averaging 70-100 years old. In the last century, RCWs have declined as pine forest habitats changed through timber harvest and agriculture. Pine savannah and open forest encompassed over 200 million acres at the time of European colonization, and longleaf pine communities may have covered 60-92 million of those acres. Today, fewer than 3 million acres remain. RCWs once ranged from Florida to Maryland and New Jersey, west to Texas and Oklahoma, and inland to Missouri, Kentucky, and Tennessee.

RCWs are a cooperative breeding species, living in family groups consisting of a breeding pair, which may also include one or two male helpers (females can also become helpers, but do so at a lower rate than males). The limiting habitat requirement for RCWs is the availability of tree cavities, which the birds excavate in live pine trees. RCWs are the only North American woodpecker to excavate cavities in living trees, with the excavation of a new cavity often taking several years to accomplish. A group of cavity trees occupied by a potential breeding group (an adult female and male, with or without helpers) is termed a cluster, and is the metric used to measure RCW populations.

In 1998, we initiated a collaboration with the USFWS to reintroduce RCWs to the Avalon Plantation. This involved translocating 10 birds per year for five successive years to Avalon, and was the first effort by a private landowner, state or federal agency to reintroduce a population of woodpeckers into an area where there was no remaining extant population.

While the population expanded steadily during the first nine years of the project, during 2007-2009 there were signs that growth was slowing. An assessment of cluster status was undertaken in 2010, where it was determined the population comprised 13 active groups, 2 inactive groups, and 6 abandoned groups (i.e., showing no evidence of RCW activity for 3+ years). An aggressive approach was undertaken to restore the abandoned clusters, establish new recruitment clusters in priority habitat, and cavity tree management. These actions had a positive effect, with the population reaching 20 active groups, 4 inactive groups, and 1 abandoned group by the end of 2018 (Fig. 7.1); the highest number of active clusters on Avalon since project inception.



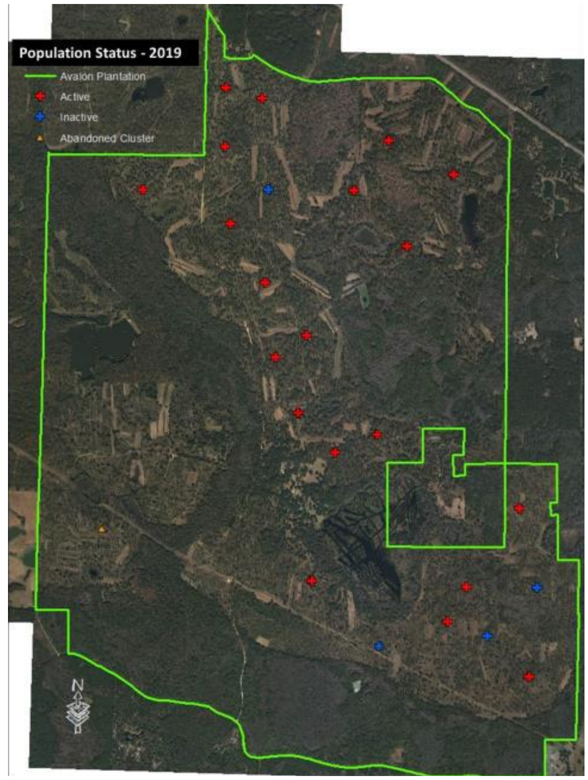


Fig. 7.1. 2019 RCW Cluster Status at the Avalon Plantation

Project Activities in 2019

Cluster Status - Comprehensive cluster surveys were conducted in March, June, and October 2019 to ascertain activity status, demographics, and cavity tree composition. A total of 25 RCW clusters were located throughout the property–twenty active groups, 4 inactive groups, and 1 abandoned are currently established on the property (Fig. 7.1). Moreover, several new natural cavity trees (active and inactive) were discovered throughout the clusters. This is a positive sign demonstrating Avalon's pine overstory is suitable for the species. Each cluster was also monitored throughout the year, usually in January, March, June, and October. Monitoring checks are used to ensure each cluster has minimum of 4 suitable cavities and for activity status (active or inactive).

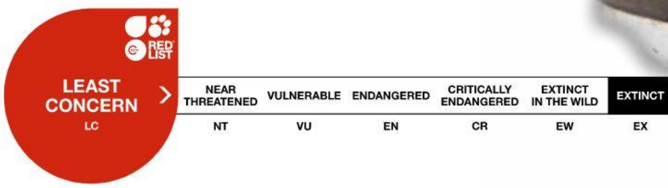
Supplemental Cavities – Three supplemental cavities were installed in two clusters to ensure each cluster contained the required minimum of four suitable cavities. It appears each cluster lost cavities to natural mortality or significant weather events. All clusters/cavities were inspected following any significant weather event.

Cavity Tree management – All clusters and cavity trees were mowed in late January 2019 in advance of the burning season. All cavity trees were marked (pink flagging) throughout the property prior to mowing and the burn season. Approximately 48acres were mowed during the reporting period (2 acres/cluster). No cavity tree mortality was experienced throughout the entire burning season. Moreover, prior to any activity within or near cluster sites, operators are typically reminded of the location of cavity trees.

Prescribed Fire – Approximately 60% of the entire property was burned during of the reporting period. Application of fire was initiated in early March was concluded by early April.

8. ARCTIC GRAYLING

(*Thymallus arcticus)*



Project Biologists

Eric Leinonen

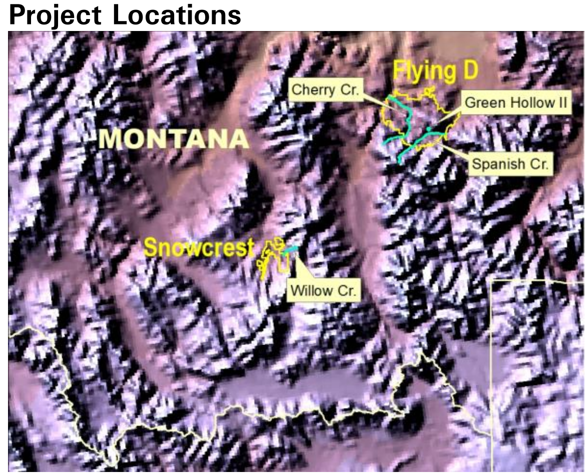
Carter Kruse

Project Partners

Funding *Funding/Management*

Threats – Although Arctic grayling are widespread throughout drainages of the Arctic and northern Pacific oceans, the species is now extinct in Michigan, and populations in southwestern Montana have declined due to competition from non-native trout and habitat alterations. Fluvial (river-dwelling) Arctic grayling in Montana were once widespread in the Missouri River basin above Great Falls. Over the past century, populations have declined in both range and abundance, and currently the species occupies approximately 4% of historic range in Montana. Prior to restoration efforts, fluvial Arctic grayling in Montana could only be found at low densities in an 80 km reach of the Big Hole River. In 2010 the USFWS ruled that the Upper Missouri River Distinct Population Segment (DPS) was warranted for listing under the Endangered Species Act but precluded by higher priorities. By August 2014, the USFWS determined that conservation efforts by federal, state, and private organizations had improved the species status to a point where listing was no longer warranted. Arctic grayling are considered a Species of Greatest Conservation Need by Montana Fish Wildlife and Parks (MTFWP).

Project Locations



Project Recognition

MTFWP & USFWS Arctic Grayling Conservation Award (2014)

Goals
Maintain a conservation brood stock of Big Hole fluvial arctic grayling in Green Hollow Reservoir II to support range-wide restoration efforts. Restore self-sustaining populations of arctic grayling on Turner Ranches and surrounding landscapes to improve their conservation status.

Objectives – To manage fluvial Arctic grayling in Green Hollow II in a manner that promotes a healthy arctic grayling brood stock supporting restoration efforts in southwestern Montana. The brood fish will be disease free, average 10 inches in length, and provide at least 200 adult females for spawining and 300,000 eggs for restoration each year. Arctic grayling restoration on Turner Ranches will be implemented in at least two sites, exhibit densities of 20 adult fish (i.e., $\geq$100 mm total length) per km, with successful recruitment (i.e., young of year or multiple age/size classes present) at least once every three years.

Project Background
TEI has been a partner in grayling conservation in Montana since 1998 when Big Hole fluvial arctic grayling were stocked into Green Hollow Reservoir II on the Flying D Ranch to establish a conservation brood stock. The brood stock was intended to serve as a genetic reservoir for Big Hole grayling and a source of grayling eggs for restoration projects across southwestern Montana. Over the past 20 years, TBD has provided invaluable assistance towards grayling restoration by managing the reservoir and brood stock population for these purposes. In 2002 a fish barrier was constructed on Green Hollow Creek above the reservoir to prevent grayling from moving into and spawning in the creek channel. Since 2003 TBD has worked to remove non-native trout from the reservoir and inflowing creek. Each spring TBD staff assist MTFWP with disease sampling and spawning of grayling. Over the past four years (2015-2019), Green Hollow II grayling have provided about 1.8 million eggs for research on reintroduction of grayling in Michigan, reintroduction projects throughout southwest Montana, and large-scale restoration in Yellowstone National Park.

Unusually high spring runoff in 2011 deposited large amounts of gravel in the Green Hollow Reservoir II inlet below the barrier and despite efforts to disrupt spawning grayling naturally reproduced below the fish barrier in 2012-15. Since in 2016 a bypass system has been installed annually for about 4 weeks in the spring to reduce spawning in the creek inlet (Figure 8.1). The wild born offspring from 2012-15 resulted in too many grayling in the brood pond and smaller average adult sizes. In 2015 a decision was made to transfer some of the post-spawn grayling from Green Hollow II to lower Green Hollow Creek (below Green Hollow Reservoir I). Over 500 grayling were moved in 2015, an additional 536 were captured and moved during spring trapping activity in 2016, and another 279 in 2018. These fish have unrestricted movement into Spanish Creek and, ultimately the Gallatin River, thus represent the first stocking of fluvial arctic grayling into the Gallatin River system since their local extinction. Additionally, grayling have escaped from Green Hollow II and established a self-sustaining population in Green Hollow Reservoir I (e.g., Main House Pond). Fish from this population likely have and will continue to escape into Spanish Creek, providing a chronic, soft introduction of grayling to the Spanish Creek watershed. MTFWP has confirmed angler reports of grayling caught in the Gallatin River and Flying D fishing guides also report numerous grayling caught in Spanish Creek. Electrofishing surveys have yet to document natural reproduction in either the Gallatin River or Spanish Creek.


Fig. 8.1. Aerial view of fish barrier, inlet channel (to Green Hollow II), and bypass system.

TBD staff introduced grayling into lower Cherry Creek (below Cherry Falls and outside of the WCT restoration project area) for the first time in 2016 and have continued annual spring introductions since that time. A total of 85,000 fertilized eggs have been stocked into lower Cherry Creek using remote stream-side incubation (RSI) devices from 2016-19. RSI's improve hatching success and allow newly hatched grayling to volitionally leave the incubator and enter the stream habitat.

Project Activities in 2019

TBD prepared for the annual spring grayling spawn at Green Hollow II by netting and holding several hundred grayling in early May (Fig. 8.2). A total of 319 grayling pairs were spawned over two days (May 13th and 16th) and produced an estimated 400,900 eggs for grayling restoration in southwest Montana, including Yellowstone National Park. This was the largest total egg take ever from the Green Hollow brood stock. There continues to be concern that there are too many grayling in the pond, thus approximately 680 fish were moved into lower Green Hollow Creek after the egg take.

Fig. 8.2. Male arctic grayling in holding tank prior to spawning.

TBD staff introduced 40,000 grayling eggs into lower Cherry Creek (below Cherry Falls and outside of the WCT restoration project area) via remote stream-side incubation (RSI) devices in 2019 (Fig. 8.3). The RSI's were placed in a controlled flow environment (i.e., irrigation ditch) rather than in the stream in order to provide the hatching grayling a higher chance of short-term survival once they leave the RSI's (Fig. 8.4). After flowing in the ditch for some distance below the RSI's, the water and newly hatched grayling were diverted back into the creek.

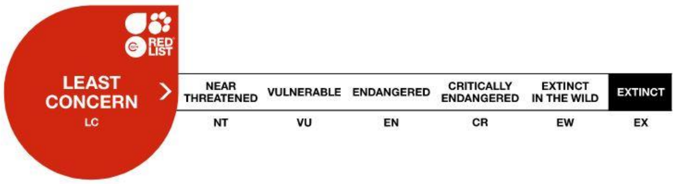
Fig. 8.3. Eyed grayling eggs ready to be placed into the RSI's. Eyed eggs have been held in a fish hatchery long enough (about 10 days) for the eye of the fish embryo to develop. This is the best time to place the eggs in the incubators.

Modest electrofishing monitoring efforts in the spring and fall of 2019 failed to capture grayling in lower Green Hollow, Spanish, or lower Cherry creeks. Nevertheless, Flying D fishing guides and MTFWP continue to confirm angler catch of grayling in Spanish Creek and the Gallatin River.

Fig. 8.4. Remote streamside incubators (RSI's) with grayling eggs placed in an irrigation ditch alongside lower Cherry Creek. This slower water environment (as opposed to the creek) in the spring has the potential to increase survival of the newly hatched fish.

9. WOLVES

(*Canis lupus)*



9a. MEXICAN GRAY WOLF

(*Canis lupus baileyi*)

U.S. Fish & Wildlife Service

Listing Status under the Endangered Species Act

ENDANGERED

Project Biologists

Cassidi Cobos

Mike Phillips

Chris Wiese

Threats – Once common throughout portions of Arizona, New Mexico, Texas, and Mexico, human persecution resulted in the extirpation of the Mexican wolf in the wild. Current challenges include political pressures against wolf releases, illegal shootings, and lack of space for population expansion. Additionally, due to the small founder population, diminished genetic diversity appears to be affecting the fecundity and survival of wolves in the wild. Limited pen space in the captive breeding program restricts the size and reproductive output of the captive population.

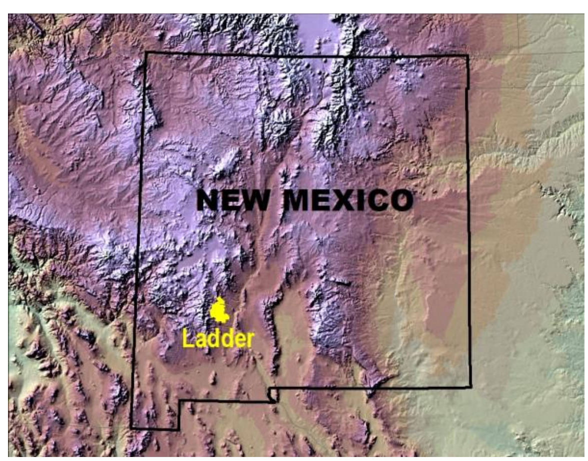
Detailed Listing Designations

- ESA: Endangered – portions of AZ, NM where this wolf subspecies is known to occur: AZ, NM except for –
  - *Experimental Population, Nonessential:* portion of AZ north of I-10 and south of I-40; portion of NM north of I-10 (in west), north of the NM-TX border (in east), and south of I-40 (see Fig. 9c.1)

Project Partners

Administrative Funding	**Mexican Gray Wolf Species Survival Plan (SSP)** Managed under the AZA, the SSP is a collaborative effort amongst zoos, organizations like TESF, USFWS, Mexico's Fish & Wildlife Agencies to coordinate the breeding and management program to ensure long-term sustainability of captive-based animal populations.

Project Location



Project Background – Mexican gray wolves (MGW) are a distinct subspecies of gray wolves that roamed most of the southwestern US and portions of Mexico until they were functionally eradicated in the wild through aggressive government-sponsored predator control measures. By the time the Mexican gray wolf was listed as endangered under the ESA in 1976 it was on the verge of extinction. Wildlife biologists captured the last five wolves remaining in the wild and began a captive breeding program. As a result, the subspecies is now secure in captivity.

Reintroductions of MGWs into the Blue Range Wolf Management Area (BRWMA) that spans portions of eastern Arizona and western New Mexico began in 1998, and reintroductions in Mexico began in 2011. About 110 wolves were free-ranging in the BRWMA and ~25 in Mexico in 2017.

Goal – Contribute to recovery of Mexican Gray Wolf populations in the wild in the US and Mexico.

Objective – During the next five years, TESF will continue to support Mexican Gray Wolf recovery by providing a captive facility on the Ladder Ranch that houses up to 25 wolves at any one time, including breeding pairs and wolves transitioning between the wild population and captivity. The Ladder Ranch facility will respond to the needs and overall project goals set by the USFWS and the Species Survival Plan on an annual basis.

Strategies – As a member of the Mexican wolf species survival plan (SSP), we adhere to the management guidelines that standardize captive management in both the US and Mexico. The mission of the SSP is to contribute to Mexican wolf recovery through captive breeding, public education, and research. The SSP uses several criteria to determine the eligibility of a wolf for release. These include: genetic makeup in relation to both captive and wild populations (i.e., "surplus" to the captive community and underrepresented in the wild), reproductive performance, behavior, and physical suitability. It is critically important that release candidates exhibit natural behaviors, especially fear and avoidance of humans. We therefore take steps to prevent socializing or habituating the wolves housed at the LRWMF to minimize conflict with humans once released into the wild. In accordance with SSP recommendations, we reinforce the wolves' natural avoidance behavior to humans by providing as much privacy and as little disturbance as possible. This includes minimizing the length of time an animal is held in captivity and minimizing contact with humans during husbandry and maintenance events (i.e., we feed only once or twice a week, and we spend as little time as possible inside the wolf pens during husbandry and maintenance).

Supporting Rationale for Objectives – The Ladder Ranch has been actively involved in Mexican Gray Wolf recovery since 1997, beginning with construction of the Ladder Ranch wolf management facility (LRWMF). As one of only three pre-release facilities nationwide, the LRWMF plays an important role in the USFWS's implementation of wolf reintroductions to the wild by providing pre-release care and acclimatization for animals eligible for release to the wild. The LRWMF also assists with specific management needs associated with reintroductions in the Blue Range Wolf Recovery Area by serving as a "halfway house" between the wild and traditional holding facilities (zoos and wildlife sanctuaries) for wolves that are removed from the wild for medical reasons or for depredating livestock. The LRWMF is managed collaboratively by TESF and the USFWS. Since we began housing wolves in 1998, over 140 different wolves have passed through the LRWMF facility.

Project Activities in 2019

Wolves housed at the LRWMF in 2019

A total of 7 different wolves were held at the LRWMF in 2019, with a maximum of 5 at any one time. The studbook identification numbers (and a brief synopsis of the history) of the wolves housed at the Ladder Ranch during 2019 are summarized in Table 9a.1. Wolf movements are summarized in Table 9a.2. Notes on individual wolves can be found below.

Feedings, Observations, Transfers, and Health Checks

Feedings: Mexican gray wolves held at the LRWMF are fed a combination of foods recommended by the SSP. These are: Mazuri® Exotic Canine Diet (aka "kibble"), Central Nebraska classic canine diet (aka "carnivore logs"), and native prey species. Mazuri® Exotic Canine Diet is a meat-based kibble diet preferred by most zoos that meets the nutrient requirements of all wolf life stages. Carnivore logs are composed predominantly of horsemeat and fortified meat byproducts that are frozen into 5-pound logs. These are protein-rich and also suitable for all life stages. Prey animals (mule deer, oryx, elk, rabbits, and bison) are mainly provided as meat scraps and/or bones salvaged from road-kill or from hunts on the Armendaris and Ladder Ranches and are sporadically fed as supplemental food.

Water: A new water pump was installed in 2019. The water that supplies the wolf pens is first pumped from Animas Creek into a 5,000-gallon holding tank by a pump. Water from the holding tank is then used to fill (by gravity) smaller holding tanks (500 or 2,500 gallons, respectively), which in turn are used to provide water to the wolves in one or two 50-gallon tubs placed in each wolf pen. The 50-gal tubs are cleaned and/or topped off regularly to ensure that all wolves have access to fresh water at all times. In addition, we occasionally treated the water in the secondary holding tanks with very dilute bleach (>1:2,000, which is the dilution used to treat well-water for human consumption) to prevent algal growth.

Observations: We observed animals from the blind on a regular basis to monitor their overall health, behavior, and wellbeing. In addition, we observed daily (or twice daily) from the blind when wolves first arrived at the facility, during the breeding season, and around putative whelping times. Informal observations took place during scheduled feedings, where we obtained a visual of animals in the facility and checked for signs of injury or illness. In addition, we made regular use of trail cameras to get close-up views of individual wolves.

F1538 hanging out on a capture box

Health Checks: All wolves received thorough health checks, vaccinations, and anti-parasite medication before arriving at the LRWMF. Similarly, all wolves leaving the LRWMF in 2019 received deworming and anti-parasite medication (ivermectin, revolution, and/or praziquantel) before their departure from the facility and received vaccinations as warranted. The goal is to perform health checks and update vaccinations for each wolf once a year (usually done during the cooler months). All wolves in the facility at the end of December 2019 were current on their vaccinations and treatments.

Cassidi Cobos and Tricia Rossettie handling F1535 during health checks.

Oral ivermectin treatment for heartworm prevention: In mid-September 2016, following the recommendation of USFWS veterinarian, Dr. Susan Dicks, we started a regimen of once-a-month oral ivermectin treatment of all wolves to prevent heartworm. We followed the protocol developed for and approved by the MGW SSP. Briefly, full-strength ivermectin is first diluted 1:250 with propylene glycol. For every 10 lbs of wolf, 1 ml of the diluted ivermectin is then mixed with thawed canine logs (for example, for a wolf weighing 60 lbs, we would mix 6 ml of diluted ivermectin into one log). The wolves are fed the medicated wolf log on a regular feeding day, followed by the remaining amount of untreated food on the following day.

Semen collection: Due to the government shutdown in early 2019, semen collections at the Ladder were cancelled for 2019.

Breeding season: Two wolves (F1633/M1400) were paired at the LRWMF during the 2019 breeding season in the hopes that they would produce pups that could be cross-fostered into the wild in 2019. F1633 did not arrive in New Mexico until the middle of December. She was introduced to M1400 at the time of her arrival. F1633 and M1400 were wary of each other initially, but eventually became used to each other. They did not seem to become super friendly with each other, though. Although she was raised in a multi-cohort group at Wolf Haven, F1633 seems a little socially awkward, often attempting to play with M1400 in a manner that seemed to scare him. In the end, it appeared that F1633 (who was only just shy of two years old during the breeding season 2019) did not come into heat, and no breeding activity was observed during extensive breeding observations throughout February and March 2019.

Births in 2019
There were no pups born at the Ladder Ranch Wolf Management Facility in 2019.

Deaths in 2019
There was one death at the LRWMF during the reporting period. F1444 died within 24 hours of arriving at the facility on April 18, 2019. She had been caught in the wild and had spent the night before she arrived at the LRWMF in a crate. She was cleared for transport by USFWS veterinarian Dr. Susan Dicks, but all personnel who came in contact with F1444 noted a particularly unpleasant odor associated with F1444. At the LRWMF, F1444 slowly and somewhat reluctantly emerged from the crate, looking sore and disheveled. She moved away from the crate, deeper into the enclosure, and settled at the far end of the pen, but she never moved much from there during subsequent observations a few hours later on the same day, or the next morning. By 5 PM on day 2, she lay motionless under a tree in the same location (Fig. 4). Closer inspection revealed that she was not breathing and had passed away. There was no evidence of a struggle, and no wounds or injuries were detectable. We transferred the carcass to USFWS law enforcement the following day. Necropsy results, and the results of the investigation into the cause of death, are still pending.

Releases
There were no releases of LRWMF wolves in 2019.

Facilities
In November we worked on some much-needed erosion control issues in pen 1. This involved staking down railroad ties and back filling areas in the pen.

Off-site Activities and Outreach
We participated in a spectrum of wolf-related activities during the reporting period including organizing captures at the LRWMF and participating in captures and health checks at the SWMF, conducting breeding observations at the LRWMF and the SWMF, wolf transfers to and from other US wolf holding facilities or the BRWMA.

Proposed Future Activities and Considerations
As one of only three pre-release facilities in the country, and the facility closest to the wild BRWMA population, the SWMF, and Mexico, the LRWMF plays an important role as a transitional facility for wolves that are being transferred between captivity and the wild. This includes wild wolves that need to be moved to captivity due to livestock depredations, as well as releases of captive-bred wolves to support the wild population.

Cross-fostering is a technique in which very young pups (less than 10 days old, i.e. before they can see or hear) from genetically desirable captive wolf pairings are swapped or introduced to denning wild wolf parents. This technique eliminates concerns of captive-born wolves habituating to humans because pups are introduced to the wild prior to their being able to perceive sights and sounds. Cross-fostering has been used successfully to increase the genetic diversity of red wolves in North Carolina (Waddell et al., 2002), and has also been tested in European gray wolves (Scharis and Amundin, 2015). Moreover, it has been used successfully in 2014, 2017, and 2018 to place captive-born MGW pups into the den of a wild wolf pack that was known to rear young that avoid conflict with humans (USFWS, 2015, 2017).

Because the Mexican wolf holding facilities are currently at capacity, not all captive wolves are allowed to breed. In turn, this means that not all wolf-holding facilities participate in the breeding program. Breeding pairs are carefully chosen using several criteria, including genetics, compatibility, and need. Mexican gray wolves produce pups only once a year: they generally breed in February or March and whelp 2-6 pups in April or May. For 2020, the LRWMF will hold one breeding pair whose pups will be valuable to the captive population as well as being candidates for cross-fostering efforts.

In this way, we will continue our strong support of the USFWS-led efforts to recover the MGW in the Southwest. In 2020, we plan to continue to serve as caretakers of important wolves, participate in hands-on activities (captures, health checks, transfers, surveys, etc.) and mandatory training sessions, and participate in SSP-related management activities (for example, annual meetings).

Table 9a.1 Wolves housed at the Ladder Ranch Wolf Management Facility in 2019

Wolf ID	Sex	Birth Date	LRWMF Pen	Date arrived at LRWMF	Eligible for release or translocation	Transferred From
F1538	**F**	**5/16/16**	**4**	**11/9/17**	**No**	**Sedgwick**
Notes: F1538 was transferred from the Sedgwick County Zoo to the LRWMF at the end of 2017. She was alone in a pen throughout 2019. She was moved out of the LRWMF and transferred to the Wolf Conservation Center in New York in December 2019.						
M1400	**M**	**4/17/15**	**3 and 2**	**11/9/17**	**Yes**	**EWC**
Notes: In 2017, M1400 was paired up with F1431 for the 2018 breeding season, however no pups were produces. At the end of 2018, M1400 was separated from F1431 and introduced with F1633 for the 2019 breeding season but again did not produce pups. In October of 2019, M1400 was moved to pen 2 and was reintroduced to F1431. The pair was released into the wild in Mexico in early 2020.						
F1633	**F**	**5/11/17**	**3**	**12/18/18**	**Yes**	**Wolf Heaven**
Notes: F1633 was paired with M1400 for the 2019 breeding season but did not produce pups. In October 2019, the pair was split up and F1633 was paired with M1394. The new pair was sent to Cananea in Mexico in 2020 and is scheduled for a wild release at a later date.						
F1444	**F**	**4/2015**	**2**	**4/18/1**	**No**	**BRWRA**
Notes: F1444 was a wild removal. When she arrived at the LRWMF she had a strong unpleasant odor. Within 24 hours of arrival she was found deceased under a tree. She was sent off for a necropsy.						
F1835	**F**	**4/2018**	**5**	**6/3/19**	**No**	**SWMF**
Notes: F1835 was a wild born wolf and brought in for depredations. She spent the first couple of months at the SWMF. In June of 2019 she was transferred to the LRWMF. She was transferred to the ABQ BioPark in November 2019.						
M1394	**M**	**2013**	**3**	**10/18/19**	**Yes (MX)**	**SWMF**
Notes: M1394 was removed from the wild in September 2019 and placed at the SWMF. In October he was transferred to the LRWMF and paired up with F1633. The pair was sent to Cananea in Mexico in 2020 and is scheduled for a wild release at a later date.						
M1431	**M**	**5/9/15**	**2**	**10/18/19**	**Yes**	**Wolf Heaven**
Notes: In 2017, F1431 was paired up with M1400 for the 2018 breeding season, however no pups were produces. At the end of 2018, F1431 was separated from M1400 and moved to the SWMF and was introduced with a new mate for the 2019 breeding season but again did not produce pups. In October of 2019, F1431 was separated from M1400 and was reintroduced to F1431 for 2020 breeding season. The pair was released into the wild in Mexico in early 2020.						

Table 9.a.2 Summary of wolf movements in and out of the Ladder Ranch Wolf Management Facility

Wolf #	Pen	Birth date	Trans to LR	Trans out LR	Origin	Destination	Eligible for release or translocation?	
F1538	4	10-May-16	9-Nov-17	12-Dec-19	Sedgwick	WCC	no	born at Sedgwick
M1400	2	17-Apr-15	9-Nov-17	9-Jan-20	EWC	Mexico	yes	born at EWC
F1633	3	11-May-17	18-Dec-18	9-Jan-20	Wolf Haven	Mexico	yes	born at Wolf Haven
F1444	1	~April 2015	18-Apr-19	20-Apr-19	BRMWA	died	no	wild-born
f1835	5	~April 2018	3-Jun-19	12-Nov-19	SWMF	ABQ BioPark	no	wild-born, Prieto Pack
M1394	3	2013	18-Oct-19	9-Jan-20	SWMF	Mexico	yes(MX)	wild-born
M1431	2	9-May-15	18-Oct-19	9-Jan-20	Wolf Haven	Mexico	yes	born at Wolf Haven

9b. ROCKY MOUNTAIN GRAY WOLF

(*Canis lupus*)

Project Biologists

Val Asher

Mike Phillips

Threats – Wolves are a polarizing issue, thus limiting expansion of the species current range.

Project Location

Goal – To understand the ecology of wolves on the Flying D ranch and inform wolf recovery efforts throughout the species' historical range.

Objective – Over the next five years we will locate and identify predator-killed prey and analyze wolf scats to determine predation characteristics of the wolf population on the Flying D ranch. All carcasses will be evaluated for cause of death, body condition and any predisposition to predation by classifying femur marrow and boiling leg bones and jaws to identify arthritis or injuries. During this time, we will monitor the Flying D's wolf population and will work cooperatively with the Flying D ranch manager and Montana Hunting Company to track bison herd health, herd size and the resident elk and deer population. Knowledge of these dynamics and the practicality of living with wolves on a working landscape will be shared by conducting tours for visiting guests.

Supporting Rationale for Objective
Uncertainty over the ecosystem impacts of wolves fosters intolerance for wolves in the west. An abundant prey base on the Flying D allowed the ranch to support what was once the largest pack in MT (24 individuals in 2011), before it split into two packs. The ranch practices an ecologically sustainable management style which also benefits the persistence of large carnivores. We can maintain a healthy wolf population on the ranch by understanding food habits, prey health and the effects wolves have on ranch activities.

Project Background – In 2000, we assigned our wolf biologist to assist the USFWS and later MTFWP, with wolf recovery in Montana. We remain the only private organization ever permitted under the ESA to assist the USFWS with wolf recovery and it was a notable achievement for us to be involved for over 9 years with the daily implementation of recovery and management. With delisting imminent, we shifted our focus in 2010 to wolves on the Flying D. Wolves first established themselves on the ranch in 2002. In 2011, they were at their highest numbers before splitting into two packs. Both packs made use of the entire ranch (over 113,000 acres) and the bordering forest. Both bison and elk numbers are monitored by the Flying D ranch manager and Montana Hunting Company. In addition to understanding wolves and their effects on ranched bison and wild elk, we have participated in two ongoing studies on the ranch. Both anthrax (*B. anthracis*) and brucellosis (*Brucella abortus*) affect ungulates and potentially carnivores through scavenging.

Project Activities in 2019

Wolf population

The Beartrap pack produced 16 pups this year and we were able to confirm where the two breeding females whelped each litter of pups (Fig. 9b.1). Using Montana Fish, Wildlife and Parks criteria where final counts end Dec. 31, 2019, our highest visual count at the end of the year was 14 individuals (though we feel this count is an underestimate and expected at least 20-22 individuals). We continue to maintain two working radio collars, both on older females. The Beartrap pack uses the entire ranch and occasionally travel through neighboring properties to the north. No known wolf mortalities occurred in 2019.

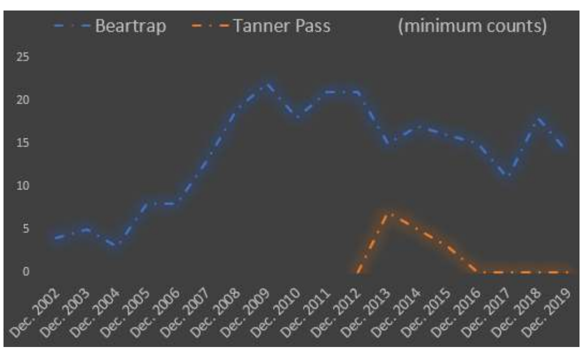


Fig. 9b.1. Minimum number of wolves in the Beartrap and Tanner Pass packs from 2002 to 2019

Food habits

Of the 1,351 carcasses investigated since monitoring began in 2010, 451 were documented as predator kills. 317 were attributed to wolves, with the remainder categorized as coyote (90), mountain lion (11), bobcat (2), bear (9), and 18 as unknown predator.

Bison are the dominant ungulates on the Flying D, numbering around 3300-5400 individuals. With a bison population almost twice as large as that of elk, we assume that encounter rates between bison and wolves are higher than between elk and wolves. However, wolves are more successful at killing elk, or are actively selecting elk to prey upon (Fig. 12b.2).

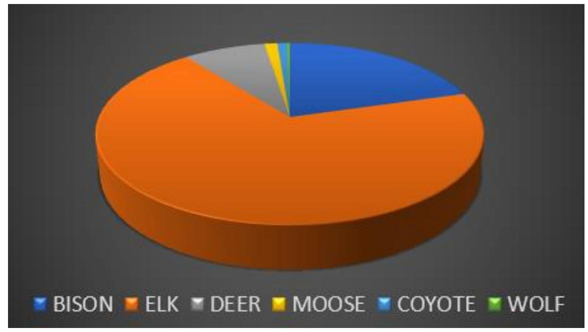


Fig. 9b.2. Percentage of wolf kills by prey species.

Eight years of scat data was analyzed from 2010-2017. Elk were the main food source for wolves, which was consistent with our kill data (Fig.9b.3). Deer were also an important food source but because of their small size, are much harder to find. Bison hair was visually identified between adult and bison calves less than ~ 4 months of age (i.e., red calves). Red calf hair was detected in only 2% of wolf scats, suggesting that this livestock type is not readily predated by wolves.

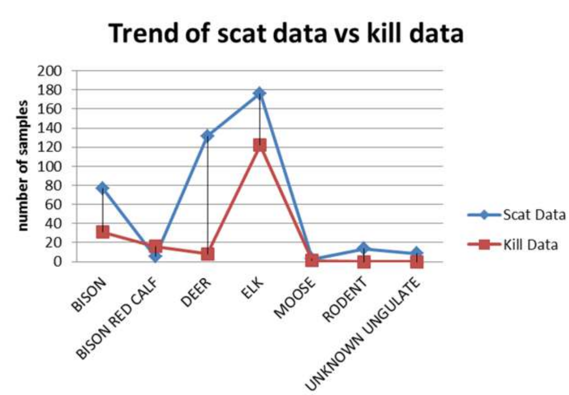


Fig.9b.3. Comparison of wolf scat data to observed verified wolf kills.

Prey Vulnerabilities

A generalization of wolf-prey systems is that wolves tend to select prey that are disadvantaged (e.g., young, old, sick/injured). Environmental traps, maternal behavior and herd health also influence an animal's predation risk.

We evaluated predisposition to predation using femur marrow of wolf-killed elk and deer. We also examined leg bones for arthritis or abnormalities. The femur marrow has been used as a standard for evaluating bone marrow fat content, as this is one of the last fat resources the body utilizes. Healthy bone marrow is white, firm, and waxy to the touch. In a state of malnutrition or disease the marrow is red, solid and slightly fatty to the touch. In an advanced starvation, the bone marrow is red to yellow, gelatinous and wet to the touch due to the high-water content. Femur marrows of prey species were collected and categorized as "white/waxy", "red/firm" or "red/gelatinous" (Fig. 9b.4).

Marrow was collected from 257 wolf killed ungulates showing 70% in marginal to poor health condition.

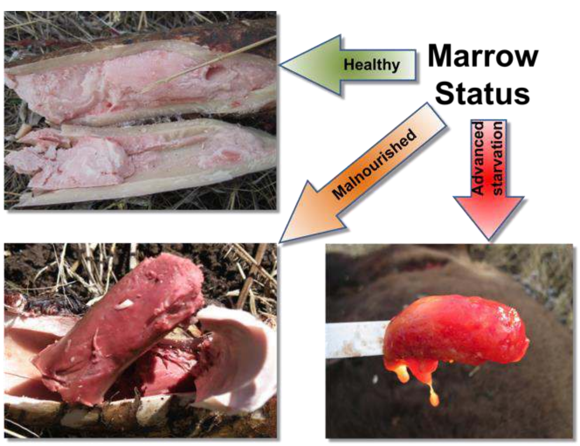


Fig. 9b.4. Femur marrow helps determine the condition of prey species.

A second dramatic vulnerability has been disfigured/injured hooves and legs. Of the 388 elk carcasses investigated of varying cause of death, 45 (12%) had visible deformities. Interestingly, 35 (78%) were killed by wolves (Fig. 9b.5). Wolves have an acute ability to recognize even the slightest lameness and it would make sense that they would test these individuals over one that shows heartiness. Once legs have been boiled we can see in more detail the calcification and arthritis that has developed (Fig.9b.6)

Fig. 9b.5. Examples of elk legs with visible and varying deformities

Fig. 9b.6. Abnormal front left hoof from bull elk and normal front right from same individual

More data is needed to determine if this is related to injury or other causes. In addition, we have begun to collect and boil legs from all elk found regardless of visible injury to the hoof or legs to determine if there are any differences between predator kills and elk that die from other causes. We plan to compile and finalize this data at the end of 2020.

Education

Information dissemination is important as we learn more about wolves on the ranch. In 2019, we conducted 15 tours and talks on the Flying D totaling ~113 since 2010. We also share our population estimates with MTFWP and data with both the Anthrax and Brucella projects. Finally, we continue to produce monthly and annual reports on wolf activities and food habits.

Proposed Future Activities and Considerations – With the newly deployed GPS collar, we look forward to learning how often the Beartrap pack leaves the ranch, (Fig. 9b.7), and, measuring the success of finding carcasses using cluster data. Of the 2,328 locations received since the collar was deployed in August 2018, we learned this female, (SW039), has been off the ranch one percent of the time. The majority of these off ranch events have taken place in the winter months. SW039 also made a quick visit to the Green ranch. This is the first time we have documented a Beartrap pack member crossing the Madison river.

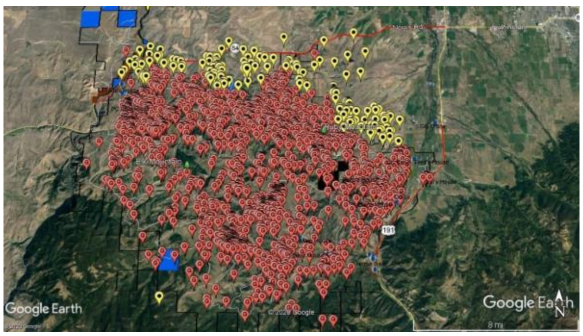


Fig. 9b.7. Red balloons show locations of the collared female (SW039) on the Flying D. Yellow balloons indicate locations north of the FDR boundary (August 2018-December 2019)

Publications in Prep or Review in 2019 – Ungulate Use of Locally Infectious Zones (LIZs) in a Re-Emerging Anthrax Risk Area Morgan A. Walker1,2, Maria Uribasterra1,2, Valpa Asher3 , José Miguel Ponciano4 , Sadie J. Ryan2,5, Jason K. Blackburn1,2,*

Carcass-Camera Trap Study – We are working with the University of Florida's Anthrax project using cameras on carcasses to understand ungulate/scavenger visitations over the long term and that relationship for disease transmittal. A graduate student has been assigned to the study with a completion date for her masters in May of 2019.

Mexican wolf/Livestock council - We continue to hold a seat on the Mexican Wolf/Livestock Council to assist in technical support related to compensation for depredations and proactive measures to avoid wolf livestock conflicts in the southwest.

American Kestrel Partnership – 2019 is our sixth year that nesting boxes have been placed on the ranch. Of the ten boxes deployed we continue to have a >33% average of occupation and fledgling success. This year we partnered up with the Audubon Society and banded 13 chicks and 1 adult female.

9c. ROCKY MOUNTAIN WOLF PROJECT

(*Canis lupus*)

U.S. Fish & Wildlife Service

Listing Status under the Endangered Species Act

ENDANGERED

Detailed Listing Designations (see Fig. 9c.1)

- ***ESA Endangered:*** AL, AR, CA, CO, CT, DE, FL, GA, IA, IN, IL, KS, KY, LA, MA, MD, ME, MI, MO, MS, NC, ND, NE, NH, NJ, NV, NY, OH, OK, PA, RI, SC, SD, TN, TX, VA, VT, WI, WV. Parts of AZ, NM, OR, UT, WA: (1) North AZ (north of I-40); (2) North NM (north of I-40); (3) West OR (west of Hwy 395, Hwy 78 north of Burns Junction, west of Hwy 95 south of Burns Junction); (4) Most of UT (south and west of Hwy 84, south of Hwy 80 from Echo to UT/WY border); (5) West WA (west of Hwy 97, Hwy 17 north of Mesa, west of Hwy 395 south of Mesa).
- ***ESA Delisted:*** Northern Rocky Mountain Distinct Population Segment (MT, ID, WY, eastern WA and OR, north-central UT.

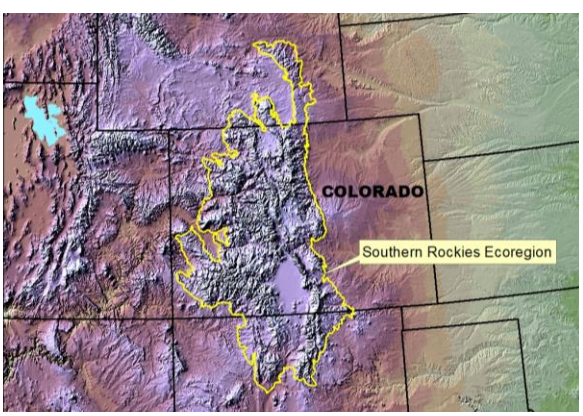
Project Staff

Mike Phillips (Biologist)

Cheney Gardner (Media Director)

Threats – Wolf recovery is a divisive issue in the U.S., limiting the species' distribution to about 15% of historical range.

Project Location – Western Colorado portion of the Southern Rockies Ecoregion (SRE)



Science Advisory Team – E.O. Wilson, Barry Noon, Joel Berger, Kevin Crooks, Phil Cafaro, Marc Bekoff, Joanna Lambert, Mike Phillips, Dave Mech, Rolf Peterson, Doug Smith, John Vucetich, Phil Hedrick, Rich Reading, Bob Wayne, Bridgett vonHoldt, Ed Bangs, Carter Niemeyer, Diana Tomback, Andrew Gulliford.

Project Partners – The Rocky Mountain Wolf Project (RMWP) is a coalition of individuals and organizations dedicated to returning wolves to the public wild lands of western Colorado. Active supporters of the RMWP include:

Fig. 9c.1. Listing status of *C. lupus* in the conterminous United States

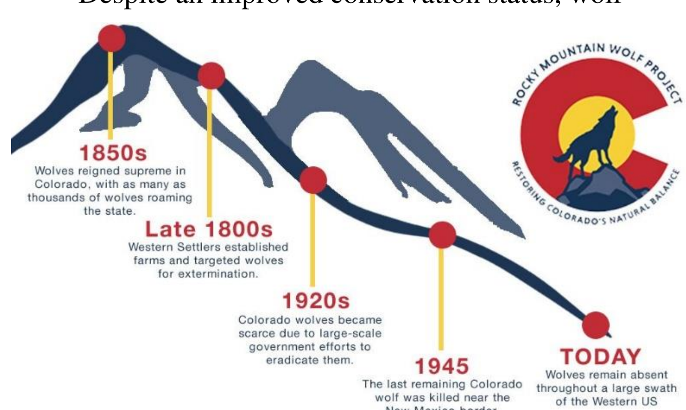
Goal – Provide the public with science-based information about restoring gray wolves to the SRE of western Colorado.

Objective – RMWP will engage in public education and outreach, as well as broad-based coalition building, to catalyze gray wolf restoration to the SRE of western Colorado. This will advance species recovery and serve as a conservation model for restoring other wide-ranging, controversial species.

Project Background – Wolves historically occurred throughout the U.S., with the species common in Colorado up to the mid-1800s. With human expansion, wolves were exterminated until Colorado's last wolf was killed in 1945 near the New Mexico border.

Over the last few decades wolves have returned to parts of their historical range, with re-establishment in Minnesota, Michigan, Wisconsin, Montana, Idaho, and northwestern Wyoming. Wolf packs are also beginning to gain a foothold in Washington and Oregon.

Despite an improved conservation status, wolf



recovery is not complete. No convincing argument about wolf recovery can be put forth without a discussion of restoration to the SRE. Why? Because of widespread public support for the notion, because no other region in the U.S. offers the same expanse of suitable public land not already occupied by the species, and because of the ESA's recovery mandate.

Successful wolf restoration in the northern Rocky Mountains and Great Lake states underscores the practicality of accomplishing the same in the SRE. This is bolstered by research that showing the SRE's great capacity to support wolf numbers and distributions that would satisfy the spirit and intent of the federal and Colorado endangered species acts.

The SRE is the best remaining area for gray wolf restoration in the U.S. It stretches from central Wyoming, through western Colorado, and into north-central New Mexico (Fig. 9c.2). The Colorado portion of the SRE includes over 17 million acres of public lands with abundant native prey. This is more public land than is available to wolves in the Yellowstone area and central Idaho. This prodigious public land base coupled with robust ungulate populations make western Colorado a motherlode of opportunity for wolf restoration. A viable, self-sustaining, wolf population there would: 1) have at least 250 adult wolves, 2) exhibit stable or increasing population trends over 8 years, 3) be naturally connected with wolf populations elsewhere at a rate not less than 0.5 genetically effective migrants per generation averaged over a period of two successive generations (i.e. eight successive years), and 4) be monitored and managed per a science-based conservation plan implemented by Colorado Parks and Wildlife.

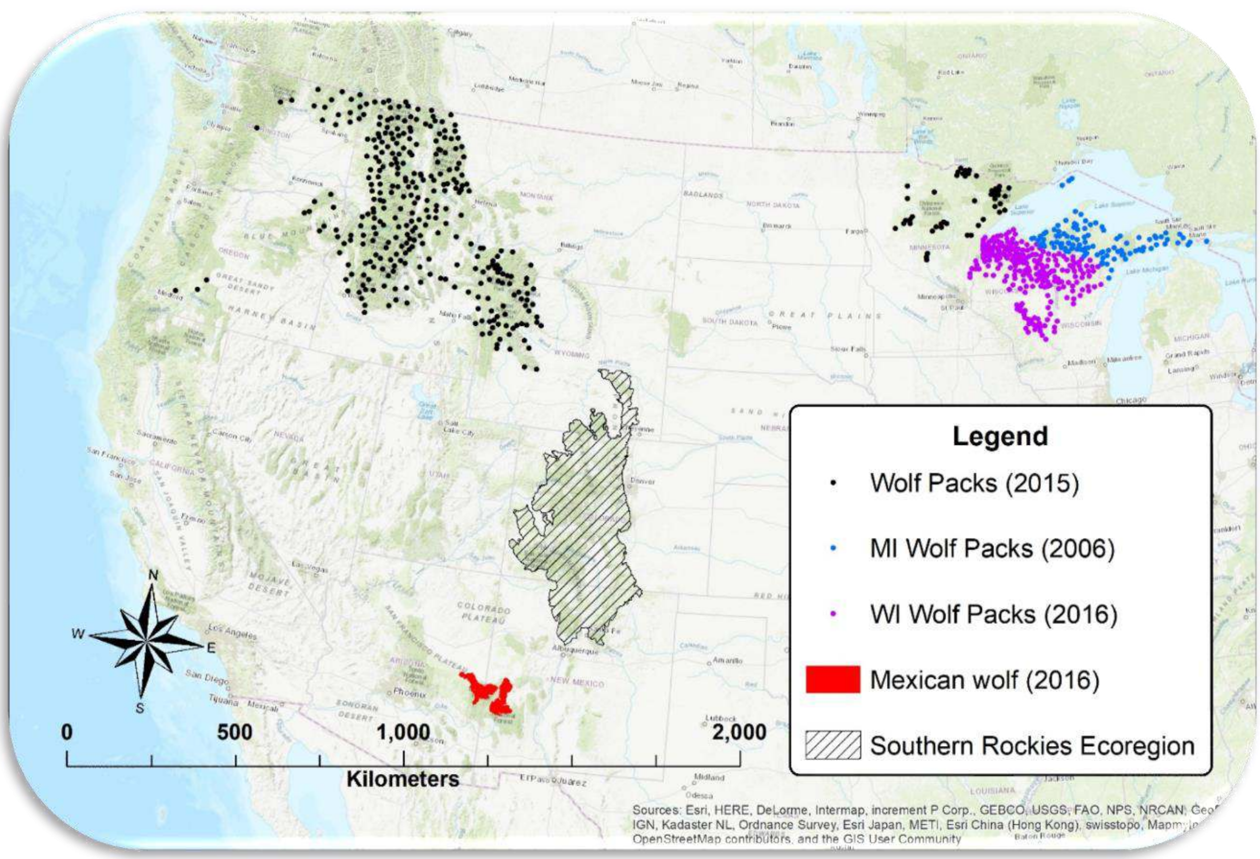


Fig. 9c.2. Distribution of wolf packs, estimated during the period 2006-2016, in the conterminous U.S. relative to the Southern Rockies Ecoregion. Wolf pack locations were obtained from relevant state gray wolf annual reports and georeferenced using ArcGIS 10.0. Michigan (MI) wolf packs represent 2006 data, Wisconsin (WI) pack locations and home ranges for Mexican wolves were recorded in 2016. All other locations in Minnesota, Montana, Wyoming, Washington, and Oregon were georeferenced from pack data collected in 2015. It is estimated that for the wolf packs portrayed, there are approximately 4,000 individual wolves in Great Lakes region, 1,500 individuals in Northern Rocky Mountains, and about 113 Mexican wolves

Two studies have estimated the SRE's wolf carrying capacity. The first, conducted in 1994, estimated that the SRE's Colorado portion alone could support > 1,000 wolves, while the second used sophisticated modeling to estimate that the entire SRE could support 2,000 wolves.

The public is supportive of restoring wolves to the SRE. A 2001 poll revealed that 71% of Coloradans supported restoration (Fig. 9c.3), with widespread majority support among various demographic groups. A more recent poll of 600 Colorado voters in 2014 revealed continued support for wolf restoration (Fig. 9c.4).

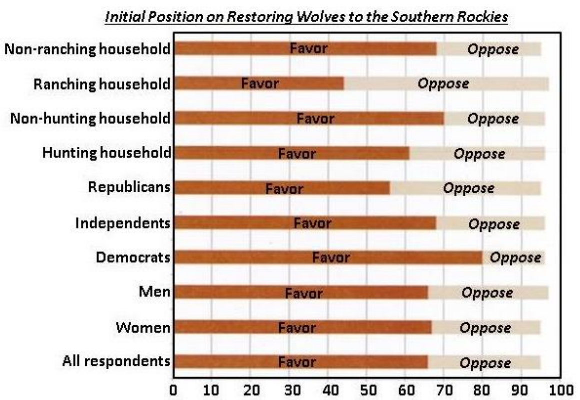


Fig. 9c.3. Results of a 2001 public opinion survey revealed widespread support for restoring wolves to the Southern Rockies. Source: Decision Research, 2001.

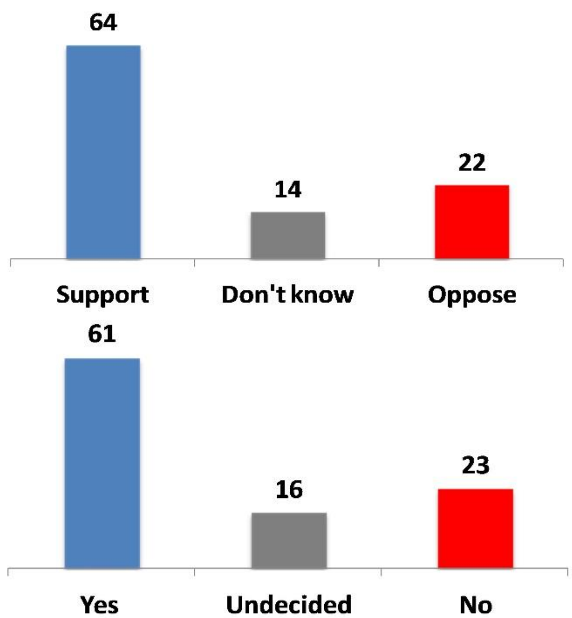


Fig. 9c.4. Results of a 2014 poll measuring support and opposition for reestablishing wolves in western Colorado (top panel), and support (yes) or opposition (no) for a combined wolf restoration ballot measure (bottom panel).

Overall, the findings suggested a high degree of social tolerance for wolf reintroduction in Colorado across the state.

Western Colorado is a vast area of high quality and secure habitat that is mostly located on public land managed for natural resources. Restoring the gray wolf there represents an outstanding opportunity to advance recovery of the species throughout a significant portion of its historical range, as mandated by the federal ESA.

From an ecological perspective restoring wolves to western Colorado would provide nature with grist for recreating a wolf population that stretches from the Arctic to Mexico. Nowhere else in the world has greater potential to achieve large carnivore conservation across such a vast landscape. when considering such a vision, wolf biologist Dr. L. D. Mech concluded:

> *"Ultimately then, this restoration could connect the entire North American wolf population from Minnesota, Wisconsin, and Michigan through Canada and Alaska, down the Rocky Mountains and into Mexico. It would be difficult to overestimate the biological and conservation value of this achievement."*

The work of the RMWP seeks to educate Coloradans, as well as the broader public of the U.S., of the ecological implications of restoring the evolutionary potential of wolves and reestablishing their role as a keystone species throughout the Rocky Mountain west. Evolutionary and ecological restoration of the species will be hindered if wolf recovery remains limited to the northern Rocky Mountain and the Great Lakes states. Wolf reintroductions to western Colorado would represent an important step for restoring the species to a significant portion of its historical range and would pave the way towards species recovery.

By 2013 it was clear that the USFWS did not intend to advance wolf restoration to the area based on the agency's only authority to do so – the federal ESA mandate. Consequently, a non-federal approach is needed.

Project Activities in 2019 – The RMWP continued to invest in outreach to educate Coloradans on the benefits of restoration and realities of living with wolves. At the same time, the Rocky Mountain Wolf Action Fund was formed with the intention of securing a voter mandate for restoring the species to Colorado through a statewide campaign. On 10th December, 2019, 215,370 signatures were submitted to the Secretary of State's office, which determined that the RMWAF had collected sufficient signatures to secure placement on the 2020 ballot.

<u>RMWP Education and Outreach Activities</u>

Over the last three years, the RMWP has developed an innovative arts program that allows Colorado-based artists tell the story of wolf recovery. To that end, the RMWP has worked with muralists, musicians, film festivals and podcast hosts to raise our profile and refute the myth of the big bad wolf.

Mural Campaign by Valerie Rose: Muralist Valerie Rose has worked with the RMWP since 2018 and has created original art for fundraisers, event invitations and the popular "Wolf Will Reappear" mural at the Living with Wolves exhibit at the Museum of Boulder.

In 2019, Valerie completed four new walls for the Aspen Middle School, Pueblo Library InfoZone, Greenspaces office and Woods Boss Brewery (Fig. 9c.5). These murals are in high traffic areas and include the RMWP website and social media information. To celebrate the mural campaign, Denver's Woods Boss brewery hosted a benefit "Wolf Awareness Night, featuring wolf-related trivia, live music and special beers. Said Valerie: "With murals, the visibility is high and the whole community sees it. You don't have to go to an event to see it or already be interested in the topic – you just pass by it and you experience it."

The Aspen Middle School mural evolved out of a partnership with the Aspen Center for Environmental Studies and the Integrated Language Arts program at the school. Eighth grade students chose to study the RMWP and the history of wolves in Colorado. The students presented their research and were able to make a lasting mark on the school by working with Valerie on a mural on an outdoor side wall.

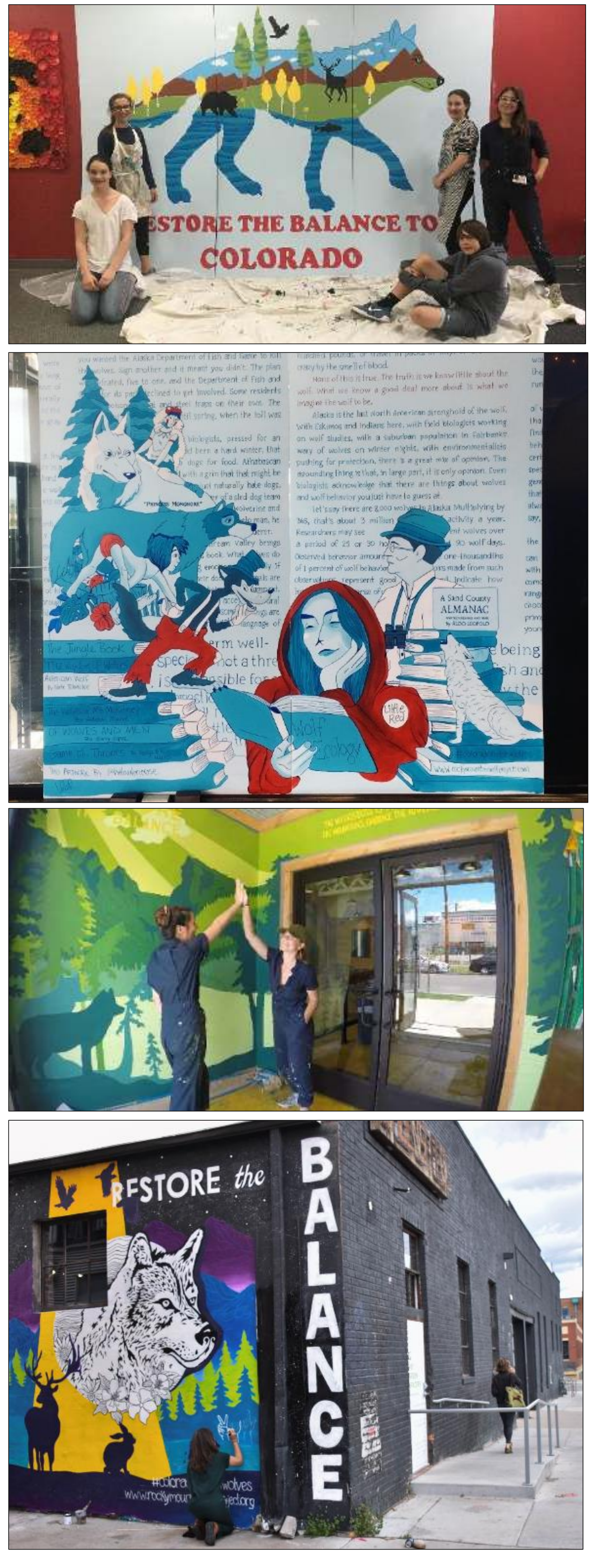


Figure 9c.5. Valerie Rose painted four murals in support of gray wolves across Colorado, including working with Aspen Middle School and the Aspen Center for Environmental Studies on a research project culminating in designing and painting a mural

Lost Walk Band Concerts and Fall Tour: The Lost Walks band was formed in 2015 by Denver-based musicians, dancers and visual artists with the goal of raising awareness for protecting wolves and returning the species to Colorado. Since 2018, the band, in conjunction with the RMWP, has performed their rock opera “Wolf, Woman, Man” across the state and donated proceeds from album sales, merchandise and live shows to the RMWP.

In Spring 2019, the Band performed as part of Denver’s Rhino Week, organized by Global Conservation Corps, at Ratio Brewing in downtown Denver. Before the performance, the event organizers hosted a “conservation conversion” featuring representatives from GCC, the RMWP and Lost Walks. In Fall 2019, Lost Walks launched a 10-day tour across the state. The band is currently working on a second album. Singer Jen GaNun told Westword magazine, “We’ve got all the bones finished. We have a goal of performing it by summertime. I’d like to have it out there before people start voting.”

Meet the Real Wolf film: The series of films created by Grizzly Creek Films on behalf of the RMWP continue to draw interest nationally and internationally. In 2019, “Meet the Real Wolf” was screened at Oxford University’s Conservation Optimism Film Festival and the Environmental Film Festival Australia in Melbourne, Australia. It won the Animation Category as well as best overall at the Conservation Optimism Film Festival. The film “Great Old Broads for Wolves” was screened at the Sisikiyou Filmfest in southern Oregon and the Fresh Coast Film Festival in Marquette, Michigan, where it also aired on the local PBS station WNMU.

Living with Wolves exhibit: The Living with Wolves exhibit spent time at three locations across the Colorado in 2019, beginning with the Museum of Boulder, which hosted open workshops throughout the spring to discuss the restoration of wolves to Colorado, including “Wolves, Ranching and Coexistence” featuring Colorado rancher and wolf advocate Peter Guercio Fig. 9c.6) and “The Science behind Wolf Recovery and How to be a Better Advocate,” lead by CSU professors and RMWP Science Team members Kevin Crooks and Becky Niemec.

The Living with Wolves photo exhibit left the Museum of Boulder in late May and was installed at the InfoZone at the Rawlings Public Library in Pueblo, Colorado. The opening reception was sponsored by the Colorado chapter of the Sierra Club and the Pueblo City-County Library District, and the exhibit featured a new mural by Valerie Rose that was inspired by how wolves have traditionally been displayed in literature, from “Little Red Riding Hood” to “Of Wolves and Men.” She said, “I was inspired to use this specific design … because you can look at it and then walk over to the science section and read about wolves or walk to the fiction section and read a different book that portrays them in a different way.”

After leaving the Pueblo Library, the exhibit was installed at the Cheyenne Mountain. Located in Colorado Springs, the Cheyenne Mountain Zoo (Fig. 9c.6) was named 4th Best Zoo in North America by USA Today and has been a strong partner of the RMWP and RMWAF as an active signature gathering location. The Zoo housed the exhibit through 2019, with the photo display arranged near the Zoo’s newest enclosure to attract maximum foot traffic.

Figure 9c.6. The Living with Wolves photo exhibit is currently on display at the Cheyenne Mountain Zoo.

RMWP Speakers Series: In September, the RMWP hosted multiple events in Boulder, including partnering with Patagonia Boulder for a packed presentation/ film night featuring science team members Mike Phillips and Dr. Joanna Lambert. Mike Phillips also presented to the CU Wildlife Club (an RMWP college chapter) and gave a public lecture on the CU campus titled "Nature's Arch Stone: Restoring the Gray Wolf to Colorado." Mike also hosted a "Conservation Coffee Talk" with Natural Habitat Adventures company, as well as a fundraiser at Shine restaurant in Boulder.

Figure 9c.7. Science team members Dr. Joanna Lambert and Mike Phillips spoke to a standing room only crowd at Patagonia Boulder, the brand's highest performing store. Mike also spoke with the CU-Wildlife Club, delivered a public lecture on campus, hosted a "Conservation Coffee Talk" with local environmental companies, and participated in a benefit night at Shine restaurant.

In October, science team member Mike Phillips was invited to speak as part of the prestigious Chancellor's Distinguished Lecture Series at the University of Colorado-Denver on "Wildness Restored: The Wolf's Return to Colorado." Presented by the Damrauer Fund, the lectures are free and open to the public. To accompany the lecture, Mike joined fellow science team member and professor Diana Tomback for a conservation biology course. The Colorado Sierra Club & DU Biology Club also hosted a film fest on campus titled "Come Join the Pack: Why Restore Wolves to Colorado."

Also, in October, the RMWP was invited by Wildlife Protections Solutions, an organization using technology to protect endangered species, to table at a conservation expo in Denver. For the second year, the RMWP was also selected as a partner for TEDx Boulder. Aside from placing RMWP material around the CU-Boulder theater, organizers introduced the RMWP to the 1000+ person audience and started a group howl.

In November, science team member Mike Phillips was invited to speak on "The History and Future of Wolf Recovery" at the Denver Museum of Nature and Science, the premier natural history and science center in the American West. The heavily attended talk took place in the Ricketson Auditorium and focused on the past, present and future for wolf recovery in Colorado.

Figure 9c.8. Science team member Mike Phillips was invited by the Denver Museum of Nature and Science to speak on the status of wolf recovery across the Rockies, with a focus on Colorado.

RMWP Events and Coalition Activities

In January, February and March, Defenders of Wildlife organized a series of "Ranching with Predators" workshops in Durango, Gunnison, Rifle, Walden, Steamboat Springs and other West Slope areas to dispel many myths related to ranching with wolves and provide coexistence tools. Presenters included wolf biologist and former Wildlife Services trapper Carter Niemeyer, Alberta rancher and co-existence advocate Joe Englehart and Montana rancher Hilary Anderson.

The Colorado Chapter of the Sierra Club organized events throughout the year. Ecologist Delia Malone presented to groups across the state including: the "Women in Conservation" event hosted by the Great Old Broads chapter in Montrose; Vita High School in Centennial, CO; Boulder Rights of Nature event; the Hearthfire Books' speaker series in Evergreen, CO; and on a panel hosted by the High Country Conservation Advocates and featuring ranchers, biologists and a film presentation in Crested Butte, CO. The Chapter also tabled at the Colorado BBQ Challenge in Frisco, Colorado and the Denver County Fair.

Figure 9c.9. The Colorado Chapter of the Sierra Club organized events across the state, including a speaking opportunity for ecologist Delia Malone at Hearthfire Books in Evergreen, CO and a booth the Denver County Fair.

RMWP coalition members in Durango and the surrounding area formed the Southwest Colorado Wolf Cooperative guided by the mission statement: "We are dedicated to creating a positive and sustainable environment for the return of wolves to Colorado. We envision diverse communities coming together to ensure that Colorado's wild and working landscapes can thrive today and for future generations." Through their work, science team members Mike Phillips was able to represent the RMWP before the Tribal Council for the Southern Ute Tribe in Durango, CO.

For the fourth consecutive time, RMWP volunteers participated in the Outdoor Retailer (Summer) Market at the Colorado Convention Center in downtown Denver. The outdoor industry expo is the largest in the country and brings together 85,000 industry professionals from 1,400 global brands. Through an introduction made at Outdoor Retailer, the RMWP was also invited by the Jefferson County Open Space to host a table during the National Public Lands Day party in Golden, Colorado.

In the Fall, the Colorado State University Chapter of the RMWP sought out opportunities for events around Fort Collins, including hosting a table at Bohemian Nights NewWest music festival; Fall Harvest Brewfest; and Elk Fest, one of Colorado's biggest wildlife events, in Estes Park.

In August 2019, Colorado State University conducted an online survey of 734 state residents titled "Public Perspectives on Wolf Reintroduction and Management in Colorado." The study found that an estimated 84% of Coloradans intend to vote for wolf restoration. The study examined the level of public support for wolf reintroduction; how support varies by demographics, geography and identification with interest groups; and how Coloradans see wolves in impacting their lives.

Voting intentions were similar across the different regions of Colorado: 84.9% of Front Range residents, 79.8% of Western Slope residents, and 79.3% of Eastern Plains residents indicated they would vote in favor of wolf reintroduction. The study found that support for wolf reintroduction was strong across demographic groups. Voting intentions were consistently high (>80%) among those who both did and did not identify as gun rights advocates, property rights advocates, hunters, and ranchers. Individuals who identified as wildlife advocates, animal rights advocates, and conservationists indicated greater support for reintroduction than those who did not, as did pet owners compared to those with no pets.

Overall, the findings suggested overwhelming support for reintroducing wolves in Colorado.

Colorado State University considered other, new efforts to promote and study coexistence with wolves and other predators within the state in 2019, including:

1. Faculty members intend to use wolf restoration as the flashpoint for developing a Center of Excellence for resolving human-carnivore conflicts and are holding a workshop on February 4 – 5, 2020 in Glenwood Springs to explore the needs and strategies of wolf management.
2. In 2020 the Center for Collaborative Conservation at CSU intends to fund a Fellows Program to explore new solutions to conflicts between people and predators with an emphasis on the social, economic, and political aspects of wolf management in Colorado.

Proposed Future Activities and Considerations – Following the success of the education and outreach activities of the RMWP in 2019, RMWP non-profit partners, conservation advocates, science team members and volunteers have expressed a renewed commitment to restoring natural balance in the state by creating a future for the gray wolf, a much maligned but indisputably important species, in Colorado.

10. DESERT BIGHORN SHEEP

(*Ovis canadensis nelsonii)*

U.S. Fish & Wildlife Service

Listing Status under the Endangered Species Act

NOT LISTED

New Mexico Department of Game & Fish

New Mexico State Listing Designations

DELISTED

Project Biologists

Charles "Hunter" Prude

Carter Kruse

Detailed Listing Designations – Desert bighorn sheep ("sheep") were listed as an endangered species in New Mexico in 1980 when fewer than 70 remained statewide. Declines were attributed to disease (transmitted from domestic sheep), overhunting, and habitat changes. Early restoration efforts were hampered by mountain lion predation. With concerted management by NMDGF, including captive breeding, translocation, and mountain lion control, sheep populations recovered sufficiently to down-list the species in 2009, and delist in 2011. The project described herein was integral to the delisting process.

Project Location

Project Partners

Funding Research — *Research* — *Funding* — *Funding Management Research*

Goal – Establish a self-sustaining desert bighorn sheep population in the Fra Cristobal Mountains (Armendaris Ranch) that contributes to improving conservation status of the species in NM.

Objectives

We will work cooperatively with the NMDGF to maintain a desert bighorn sheep population in the Fra Cristobal Mountains that exceeds 300 desert bighorn sheep and includes at least 120 adult ewes. Ideally, 15-20 adult ewes will be translocated from the Fra Cristobal population every 2-4 years to restore, improve, or maintain other populations of sheep in New Mexico. The Fra Cristobal population will support hunter harvest of 4-8 mature rams annually. All mountain lions observed in the Fra Cristobal Mountains will be captured, collared with a GPS transmitter, and tracked to identify habitat use and prey composition. We will work to develop sustainable alternatives to the current targeted mountain lion management in the Fra Cristobal Mountains by 2025.

Project Background

It is unknown whether the Fra Cristobal Mountain Range on the Armendaris Ranch ever supported native sheep; however, habitat was deemed suitable to support sheep. In a collaborative restoration effort TESF and NMDGF introduced 37 sheep from the NMDGF captive Red Rock population into the Fra Cristobal Mountains in 1995. An additional seven rams were added to the population in 1997. From 1995-2014, 50 mountain lions were captured and removed in the Fra Cristobal mountains. This intensive mountain lion control helped the sheep population to grow to a minimum count of 154 individuals in 2010, and 272 by 2017, including 138 ewes (Table 1; population estimate of 300-350 sheep after adjusting for survey sightability), constituting the largest sheep population in the state. Growth of and emigration by the Fra Cristobal population resulted in a new sheep population in the neighboring Caballo Mountains by 2006, which now includes over 200 individuals (2019 survey). With successful establishment of the Fra Cristobal sheep population, collaborative efforts have shifted from recovery (e.g., introductions, intensive monitoring, and intensive predator control) to management and sport harvest of the population. Since delisting in 2011, over 50 mature rams have been harvested on the Fra Cristobal Mountains through a public-private partnership with NMDGF. Perhaps more importantly, 79 sheep have been transplanted from the Fra Cristobal's to support sheep restoration and recovery elsewhere in New Mexico.

In 2014, predator control transitioned from the lethal removal of all known mountain lions within the Fra Cristobal mountains to a less invasive strategy of removing only those lions that are documented to kill multiple sheep. Mountain lions are captured, collared, and prey selection is monitored with GPS point cluster analyses. Once a mountain lion is documented to have killed three ewes or five total sheep it is subject to removal. Since that time, 7 of 21 collared lions using the mountains have been removed due to predation on sheep (see Table 2). Substantial information on lion prey selection and diet has been gathered since 2014. Research is currently underway to determine if non-lethal methods can be used to reduce or prevent lion predation on sheep.

In late 2017 and continuing into 2018 we documented suspicious mortalities of four collared sheep (3 ewes/1 ram). These sheep were part of a group of 30 ewes and rams that were collared in 2016 for a research project assessing sheep survey techniques. Histopathological analysis of blood and tissue samples collected from the collared sheep mortalities and from hunter harvested rams revealed that *Mycoplasma ovipneumoniae*, a bacterium that can cause pneumonia in sheep, was present in the Fra population. The strain of mycoplasma identified suggests it was carried to the Fra population from the San Andreas mountain range. Based on information from collared sheep, it is estimated that a minimum 15% of the Fra Cristobal sheep population perished due to disease exposure in 2018, hence the lower population counts in fall 2018 and 2019 (Table 10.1). Disease is always a management concern with sheep, and we will continue work with NMDGF to monitor and investigate any suspected disease-caused morbidity or mortality of wildlife within the Fra habitat area.

Project Activities in 2019

We assisted NMDGF with one helicopter sheep survey in December 2019. A minimum count of 134 sheep were observed during the survey (Table 1; population estimate of 150-172 sheep). We continued disease monitoring in 2019 by testing hunter harvested rams for disease exposure. None of the rams sampled tested positive for *M. ovipneumoniae* infection. However, the Fra population may be experiencing reduced fecundity and recruitment as secondary effects of the 2017-18 disease event. NMDGF identified the strain of *M. ovi* present in the Fra Cristobal population as the Kofa strain, which was likely transferred to New Mexico with sheep that were translocated from the Kofa National Wildlife Refuge to the San Andres mountains on White Sands Missile Range. The *M. ovi* bacteria can be spread between bighorn populations by transient sheep moving between mountain ranges. By the end 2019, it was likely that sheep populations in the San Andres, Fra Cristobal, Caballo, Ladrone, and Sacramento mountain ranges in New Mexico had been exposed to *M. ovi* bacteria.

We detected five new (not previously captured or known) lions using the Fra Cristobal mountains. We also detected two new lions using the Jornada bat caves and found one unmarked female lion dead near a mule deer kill site. We captured and collared four new lions: three males (ARM12, ARM13, ARM14) and one female (ARF07). We recaptured one male lion (ARM14) to exchange collars. Two male lions (ARM12, ARM13) were removed for the depredation of multiple sheep and one male (ARM07) was harvested by a hunter along the Rio Grande (Table 2). Lion predation on bighorn sheep increased in 2019 to 16 documented kills, compared to the annual average of 8 documented kills in previous years.

From 2014 through 2019, more than 80,000 GPS point locations have been collected from collared mountain lions. The spatial data (e.g., movement and habitat use) represented by these GPS locations is currently being analyzed as part of Hunter Prude's graduate degree work. Since 2014, TBD staff have investigated approximately 1,369 GPS clusters, or potential lion kill or feeding sites. Of these, 880 were documented to be kill locations. The diet composition of the mountain lions using the Fra Cristobal mountains and surrounding habitat is diverse, with 32 different prey species documented (Fig. 10.1). Prey species range in size from common carp (*Cyprinus carpio*, $n = 49$) to gemsbok (*Oryx gazella*, $n = 75$). Approximately 45% of the combined confirmed lion diet is composed of smaller prey items that weigh less than 15 kg, however mule deer (*Odocoileus hemionus*, $n = 241$) are the most utilized prey species comprising approximately 30% of the total kills. Predation of oryx increased from 35 total kills at the end of 2018 to 75 total kills at the end of 2019. Desert bighorn sheep comprise approximately 5% (by number) of the diet composition with 47 documented kills to date. Bighorn rams and lambs are killed by lions more than ewes. Lion predation on bighorn sheep increases during the lambing season, February through May.

Table 10.1. NMDGF Fra Cristobal desert bighorn sheep survey results 2011-2019.

Date	Total	Ewes	Y. Ewe	Lambs	Unk	CI	CII	CIII	CIV	Total Rams	Survey Type & [Time in hours]
05/2011	190	68	7	27		25	20	18	25	88	AG[3.8]
05/2012	72	26	-	24	10	2	6	-	4	12	G[8]
05/2013	111	53g	6	26	5	6	4	10	1	22	G[7]
10/2013	201	76	16	24	3-4	18	31	14	18	81	A[6.1]
05/2015	193	72	8	31	1	15	21	28	17	81	AG[5.4]
10/2015	221	108	10	34	1	10	22	14	22	68	AG[5.4]
12/2016	263	110	-	68	2	2	39	28	13	83	AG[5.3]
05/2017	272	138	7	40	-	14	32	31	10	87	A[5.7]
10/2017	242	112	14	27	-	15	30	36	8	89	A[10]
09/2018	78	41	2	9	-	2	4	8	5	26	G[13]
10/2018	179	75	-	25	-	-	-	-	2	79	A[?]
12/2019	134	52	5	12	-	-	-	-	9	65	A[?]

KEY:
CI = Class I Ram (2-4 years old)
CII = Class II Ram (4-6 years old)
CIII = Class III Ram (6-8 years old)
CIV = Class IV Ram (8-16 years old)
Y. Ewe = Yearling Ewe
Unk = Unidentified age/sex
A = Aerial Survey
G = Ground Survey
AG = Combined Aerial and Ground Survey

Table 10.2. The status of mountain lions captured and collared 2014-2019.

Animal ID[1]	Capture Date(s)	Current Status/Comments	Confirmed Desert Bighorn Sheep Kills
AR-M01/BM3	6/6/2014	Dead - hunter harvested 1/3/2016. Killed in San Marcial area.	5 prior to collar malfunction on 10/28/2014
AR-M02	6/15/2015	Dead - killed by other lion on 6/30/2015. May have been killed by AR-F02.	
AR-M03	9/28/2015	Presumed Dead - AR-F03 kitten, VHF collar only, collar confirmed to have fallen off.	
AR-M04	10/17/2015, recaptured on 12/09/2015	Dead - complications during NMDGF relocation attempt on 12/09/2015. Was using urban interface prior to recapture.	
AR-M05	11/15/2015, recaptured 5/3/2016 and 10/2/2016	Dead - removed due to DBS depredation on 3/20/17. Snared and euthanized on last kill. AR-F01 was mother.	1 CI ram, 1 ewe, 5 lamb
AR-M06	10/16/2016	Dead - removed due to DBS predation on 3/27/17. Tracked and shot.	1 ewe, 1 ram, 2 lamb
AR-M07	11/11/2016; recaptured 2/08/2017; recaptured 11/01/17; recaptured 11/8/2018	Dead - hunter harvested 3/14/2019 along Rio Grande near Bernardo, NM (+34.489188, -106.796454)	2 lambs
AR-M08	2/14/2017	Dead - died of unknown causes 2/24/2107. Carcass found on BDA +33.85303, -106.85861	
AR-M09	3/27/2017	Alive - not using Fra Cristobals; using river corridor and eastern plains, including WSMR	
AR-M10	9/22/2017	Dead - removed due to DBS depredation on 11-15-17. Killed by shooter.	3 ewe, 1 juvenile
AR-M11	6/26/2018; recaptured 9/26/2018	Dead - removed due to DBS depredation on 09-26-18. Killed in snare.	3 ewe/lamb, 2 CII ram
AR-M12	1/19/2019	Dead - removed due to DBS depredation by NMDGF contractor in Caballo Mountains on 7/4/2019	3 lamb, 2 CII ram, 1 CIII ram
AR-M13	3/10/2019; recaptured 6/5/2019	Dead - removed for DBS depredation on 8/13/2019. Killed by shooter.	2 ram, 3 ewe, 4 lamb
AR-M14	4/27/2019, recaptured 10/28/2019	Alive. Recaptured on 10/28/2019. Collar exchanged	
AR-F01	3/6/2014, recaptured 2/6/2015	Unknown - recollared on 2/6/2015, collar malfunction, collar dropped off 2/16/2016.	
AR-F02	7/1/2015	Dead - died of unknown causes 12/31/2015. Found under water.	
AR-F03	8/12/2015, recaptured 6/6/2016	Dead - malnourishment and intestinal worms	
AR-F04	10/23/2015	Presumed alive - VHF collar only, captured on camera in Jornada Lava Cave on 6/13/2018. Not collecting location or kill data.	
AR-F05	11/15/2015; recaptured 03/21/2017	Dead - hunter harvested near San Marcial 4/28/2017. AR-F01 was mother.	
AR-F06	10/12/2018	Alive - using Fra Cristobals and riparian corridor	1 ewe
AR-F07	10/29/2019; recaptured 11/17/2019	Alive - incidentaly recaptured at powerline on 11/17/2019	

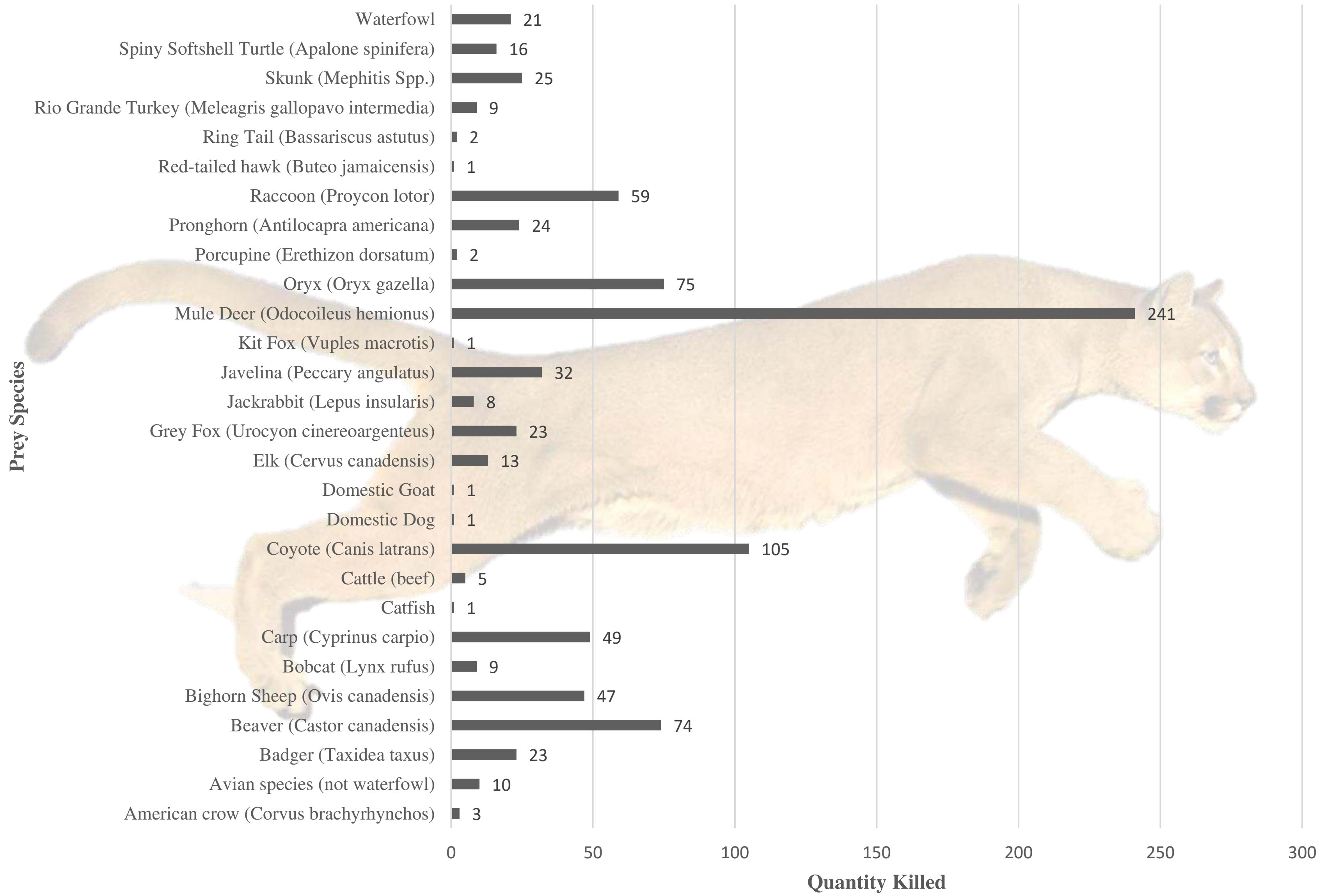


Fig. 10.1. Confirmed mountain lion kills from 2014 – 2019

11. BLOWOUT PENSTEMON

(***Penstemon haydenii S. Watson***)

U.S. Fish & Wildlife Service

Listing Status under the Endangered Species Act

ENDANGERED

Nebraska Game & Parks

Nebraska State Listing Designation

ENDANGERED

Project Biologists

Grace Ray

Carter Kruse

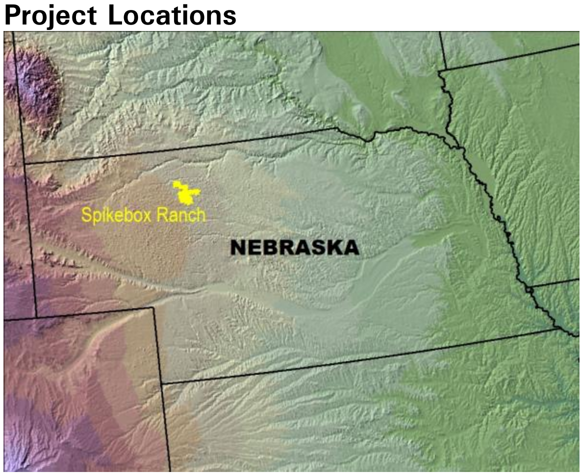
Project Partners

Funding ($10,000)

Funding ($5,000)

Funding ($3,670)

Project Locations



Goal – To work with state and federal partners in order to implement the largest (in acreage) blowout penstemon reintroduction project to date, with the goal of achieving a naturally reproducing and self-sustaining population that contributes to the recovery and potential downlisting/delisting of the species.

Objective – TEI and our project partners will utilize focused bison grazing on a Sandhills prairie pasture to create >800 acres of ideal habitat (i.e. sand dune blowout and migration) for penstemon reintroduction. Once the desired habitat is achieved, approximately 5,000 seedlings and >10 pounds of seed will be dispersed throughout the pasture. Due to the short-lived nature of the species and the understanding that populations fluctuate drastically on a year-to-year basis, penstemon populations remaining above a minimum population threshold of >300 plants will be considered a stable population.

Blowout habitat progression


Successful habitat progression


Blowout penstemon seed collection


Blowout penstemon seed planting

Project Activities in 2019
Contract partners conducted vegetation monitoring of the pasture after two years of extended bison grazing. The 3 monitoring grids (48 vegetation plots each) established in 2017 were repeated to assess the change in ground cover over the previous year. Species composition and vegetative cover classes were collected in each of the 144 plots. Spikebox Ranch employees worked to maintain pasture fences and develop livestock watering points, while successfully grazing the pasture with the yearling and cull bison herds. The project pasture was split roughly in half in 2018 to increase the density of bison grazing and to further speed up the habitat enhancement process. The split of the pasture was very successful and allowed the project partners to advance the project into the next phase of reintroduction. Broadcast seeding of penstemon took place in March (1 lb.) and again in November (3 lbs.). In July of 2019, project partners planted 150 penstemon seedlings (transplants grown by the US Forest Service) into the most desirable blowouts. Approximately 50 young seedlings, as a result of March 2019 seeding, were also observed during this planting event.

Future Activities – TEI and our project partners will continue to monitor the Spikebox penstemon pasture for progress. Partners will plant approximately 1,500 additional seedlings in May of 2020. NGPC and USFWS have received > $20,00 in additional funding to support sister project sites on Fawn Lake (and potentially Deer Creek) Ranch. This project has had great success in its very early stages, and TEI/TBD and partners are looking forward to the projected expansion of activities in 2020, as we move closer towards our goal of delisting the blowout penstemon.


Landscape view-grazed and ungrazed comparison

PUBLICATIONS IN 2019

Clancey, P. T., Shepard, B. B., Kruse, C. G., Barndt, S. A., Nelson, L., Roberts, B. C., & Turner, R. B. 2019. Collaboration, Commitment, and Adaptive Learning Enable Eradication of Nonnative Trout and Establishment of Native Westslope Cutthroat Trout into One-Hundred Kilometers of Cherry Creek, a Tributary to the Madison River, Montana. In American Fisheries Society Symposium (Vol. 91, pp. 589-647).

Carroll, C., Lacy, R. C., Fredrickson, R. J., Rohlf, D. J., Hendricks, S. A., & Phillips, M. K. 2019. Biological and Sociopolitical Sources of Uncertainty in Population Viability Analysis for Endangered Species Recovery Planning. Scientific reports, 9(1), 10130. https://doi.org/10.1038/s41598-019-45032-2

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Ray, G., Ochoa, C. G., Deboodt, T., & Mata-Gonzalez, R. 2019. Overstory–understory vegetation cover and soil water content observations in western juniper woodlands: A paired watershed study in Central Oregon, USA. Forests, 10(2), 151.

Register, K. B., Jelinski, M. D., Waldner, M., Boatwright, W. D., Anderson, T. K., Hunter, D. L., ... & Wolff, P. L. 2019. Comparison of multilocus sequence types found among North American isolates of Mycoplasma bovis from cattle, bison, and deer, 2007–2017. Journal of Veterinary Diagnostic Investigation, 1040638719874848.

PRESENTATIONS IN 2019

Phillips, M. K. 2019. The Case for Land and Wildlife. Invited plenary talk, 2019 Annual Meeting National Caucus of Environmental Legislators. August 3, 2019. Nashville, TN.

Phillips, M. K. 2019. Conservation Biologists and Politicians: Necessarily One and the Same. Colorado University Wildlife Club. University of Colorado Boulder, CO. September 19, 2019.

Phillips, M. K. 2019. History of Wolf Recovery Indicates an Overdue Conversation about Colorado. Pathways: Human Dimensions of Wildlife Conference. Colorado State University, Estes Park, CO. September 23, 2019.

Phillips, M. K. 2019. Nature's Arch Stone: Restoring the Gray Wolf to Western Colorado. University of Colorado, Boulder, CO. September 19, 2019.

Phillips, M. K. 2019. Politics, Science, and Wildlife Conservation. Invited talk. Integrative Biology Departmental Seminar. The University of Colorado - Denver. Denver, CO. October 25, 2019.

Phillips, M. K. 2019. Restore the Howl, Restore the Balance. Shine Restaurant and Potion Bar, Boulder, CO. September 18, 2019.

Phillips, M. K. 2019. The Last Great Restoration Campaign: Wolves and Colorado and a Call to Action. Natural Habitat Adventures Conservation Coffee Talk. Boulder, CO. September 20, 2019.

Phillips, M. K. 2019. The Last Great Restoration Campaign: Wolves and Colorado and a Call to Action. Patagonia Outdoor Retailer. Boulder, CO. September 20, 2019.

Phillips, M. K. 2019. Wildness Restored: The Wolf's Return to Colorado. Invited lecture to the Conservation Biology class at the University of Colorado - Denver. Denver, CO. October 24, 2019.

Phillips, M. K. 2019. Wildness Restored: The Wolf's Return to Colorado. Chancellor's Distinguished Lecture Series. Guest Speaker. University of Colorado Denver - Anschutz Medical Campus Denver, CO. October 23, 2019.

Phillips. M. K. 2019. The History and Future of Wolf Recovery: Western Colorado as the Keystone. Denver Museum of Nature and

Science. Public speaking event. Denver, CO. November 6, 2019.

Phillips, M. K. 2019. Mike latest news/podcasts. Private Lands Protecting Species. Kia Johnson Interview with Mike Phillips in Voices for Biodiversity. January 2019.

Phillips, M. K. August 2019. Audacious Goals, Relentless Action. Ranchers, writers, athletes, artists, conservationists, and entrepreneurs—Meet the innovators who are shaping the future of the American West on the Mountain & Prairie Podcast. August 6, 2019.

Phillips, M. K. 2019. How to Save a Species. Tim Ferris Podcast #383. September 2019

McCaffery, M. 2019. Reinvigorating Rare: A private lands model for imperiled species conservation and recovery. Invited Speaker. TWS Rare Species Workshop. 2019 Joint Annual Conference of the American Fisheries Society & The Wildlife Society. September 29th–October 3rd. Reno, NV.

ACRONYMS & ABBREVIATIONS

ACES = Aspen Center for Environmental Studies
ACRA = Ash Creek Restoration Area
AFS = American Fisheries Society
ATP = Armendaris Truett Pen
AZ = Arizona
AZA = Association of Zoos and Aquariums
BFFRIT = Black-Footed Ferret Recovery Implementation Team
BKT = Brook trout
BLM = Bureau of Land Management
BRR = Bad River Ranches
BRWMA = Blue Range Wolf Management Area
CA = Conservation Area
CCAA = Candidate Conservation Agreement with Assurances
CLF = Chiricahua leopard frog
CO = Colorado
CPW = Colorado Parks and Wildlife
CSS = Chupadera springsnail
CSU = Colorado State University
CT = Cedar Tank
CZ = Conservation Zone
DEA = Draft Environmental Assessment
DNR = Department of Natural Resources
DPS = Distinct Population Segment
EA = Environmental Assessment
eDNA = Environmental DNA
EHD = Epizootic Hemorrhagic Disease
ESA = Endangered Species Act
FL = Florida
FWC = Florida Fish and Wildlife Conservation Commission
GA = Georgia
GADNR = Georgia Department of Natural Resources
GIS = Geographic Information Systems
GLI = Global Landowners Initiative
ID = Idaho
ISU = Idaho State University
ITP = Incidental Take Permit
IUCN = International Union for the Conservation of Nature and Natural Resources
KDWPT = Kansas Department of Wildlife, Parks, and Tourism
KS = Kansas
LBP = Ladder Big Pen
LDZG = Living Desert Zoo and Gardens State Park in Carlsbad, NM
LHS = Ladder Headstart Pen
LRWMF = Ladder Ranch Wolf Management Facility
LTDS = Line Transect Distance Sampling
LTP = Long-Term Protected
MGW = Mexican Gray Wolf
MOU = Memorandum of Understanding
MI = Michigan
MN = Minnesota
MSU = Montana State University
MT = Montana
MT FF = Montana Future Fisheries
MTFWP = Montana Fish Wildlife & Parks
MTTF = Montana Trout Foundation
MVP = Minimum Viable Population
NAFWS = Native American Fish and Wildlife Society
NE = Nebraska
NGPC = Nebraska Game and Parks Commission
NF = North Fork
NFWF = National Fish and Wildlife Foundation
NGO = Non-governmental organization
NM = New Mexico
NMDGF = New Mexico Department of Game & Fish
NMSU = New Mexico State University
NRCS = National Resources Conservation Service
NWE = Northwestern Energy
NWR = National Wildlife Refuge
OCIC = Orianne Center for Indigo Conservation
ODWC = Oklahoma Department of Wildlife Conservation
OR = Oregon
PIT = Passive Integrated Transponder
RCW = Red-cockaded woodpecker
RGCT = Rio Grande cutthroat trout
RGC = Rio Grande chub
RGS = Rio Grande sucker
RMWP = Rocky Mountain Wolf Project
RSI = Remote Streamside Incubation
RU = Recovery Unit
SD = South Dakota
SDGFP = South Dakota Game, Fish and Parks
SF = South Fork
SFGT = Saving Florida's Gopher Tortoises
SGCN = Species of Greatest Conservation Need
SHA = Safe Harbor Agreement
SPV = Sylvatic Plague Vaccine
SRE = Southern Rockies Ecoregion
SSC = Species Survival Commission
SSP = Species Survival Plan
STF = Sandhills Task Force
SWMF = Sevilleta Wolf Management Facility
TBD = Turner Biodiversity Divisions
TEI = Turner Enterprises, Inc.
TNC = The Nature Conservancy
TESF = Turner Endangered Species Fund
TTR = Ted Turner Reserves
TU = Trout Unlimited
TX = Texas
UNM = University of New Mexico
U.S. = United States
USFS = U.S. Forest Service
USFWS = U.S. Fish & Wildlife Service
UT = Utah
VPR = Vermejo Park Ranch
WAFWA = Western Association of Fish and Wildlife Agencies
WCT = Westslope cutthroat trout
WA = Washington
WI = Wisconsin
WLA = Western Landowners Alliance
WMA = Wildlife Management Area
WNS = White-nose syndrome
WNTI = Western Native Trout Initiative
WPM = Western pearlshell mussel
WWF = World Wildlife Fund
WY = Wyoming

Bison and prairie dogs have co-evolved for thousands of years and constitute a grazing association: bison preferentially graze along the edges of prairie dog colonies because of the availability of high-quality forage and tend to rest within colonies. Bison that graze prairie dog colonies have been shown to gain more weight compared to those that feed in off-colony grasslands. Reciprocally, bison benefit prairie dogs by increasing nutrient quality of vegetation through their grazing and deposition of dung and urine, and their grazing lowers vegetation height, helping prairie dogs to detect predators (see Sierra-Corona et al. 2015).