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WILDLIFE
RESEARCH INSTITUTE

TEXAS A&M UNIVERSITY-KINGSVILLE



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Current Research 2018–2019

Editor Alan M. Fedynich, Ph.D.

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December 2019

Report of *Current Research*

September 1, 2018 to August 31, 2019

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FOREWORD



Dear Friends of the CKWRI,

The brushlands of South Texas are renown for swinging between bare dirt and a carpet of grass and wildflowers, depending on the weather. Wildlife populations also rise and fall with the weather, but have adapted to these extremes so

that they show a degree of stability. Small mammals, quail, toads, and deer fawns may be rare in some years, but the populations persist. The high diversity of the wildlife and vegetation in South Texas enables wildlife populations to endure the tough times because there is always a forage plant or prey species available. Diversity enabling stability is one of the foundational principles of ecology.

The Caesar Kleberg Wildlife Research Institute (CKWRI) is like the South Texas rangelands because it too has stability because of its diversity. The diversity starts with the scientists and students who study everything in Texas from the soil and seeds beneath our feet to the migrating birds flying overhead every spring and autumn. Some scientists and students are steeped in management of the region's resources while others are wizards with numbers and technology. Supporting these researchers is an operations staff of 14 wonderful people who are ninjas at working through opaque university processes. They make it possible for our scientists and students to purchase, hire, submit research proposals, have a fleet of vehicles, and follow all the rules.

Feeding this diverse, productive team of scientists, students, and staff are varied and generous donors. These supporters help the CKWRI in many ways. They open their gates and property for research. They fund specific research projects. They provide donations large and small and do so year after year. They provide endowments, thereby ensuring the Institute's pastures are fertile through good times and bad.

Supporting the CKWRI with wisdom, guidance, grounding, contacts, and resources is the Institute's advisory board. This incredible group of enthusiastic, dedicated, and forthright people from throughout Texas ensures the Institute is meeting its mission of doing applied research to support the landowners and managers of our treasured natural resources.

The stability of the Institute's scientists, staff, and advisory board is remarkable. It is far more common for scientists and staff to retire than to leave for another position. Two of our advisory board members, Dick Jones and Jim McAllen, just stepped off the board into an emeritus role after each serving the Institute for 35 years. Our 19 active and emeriti advisory board members represent 325 years of collective service to the CKWRI.

Even with this stability, there is still a need for new faces. The new year will bring 3 new key personnel to the CKWRI's family. Caroline McAllister will start as our Director of Donor Relations, working with Fred Bryant and Gina Cavazos to make sure we are doing right by our donors and cultivating new relationships. Dr. Mike Cherry is the new Stedman Chair for White-tailed Deer Research and will bring an established, impactful research program to Texas. Dr. Evan Tanner is the new Meadows Professor for Semiarid Land Ecology. Dr. Tanner's expertise in wildlife-habitat relationships in semiarid environments will benefit all the research conducted at the CKWRI.

Please enjoy and learn from the abstracts in this year's volume of the Current Research report. As you thumb through the pages, note the diversity of research topics, funding sources, and people. Then remember the relationship between diversity and stability and look forward to many more volumes of impactful Current Research reports.

Sincerely,

A handwritten signature in black ink that reads "David Hewitt".

David Hewitt

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Coates-Kelso Graduate Fellowship for Conservation & Management of White-tailed Deer

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Conservation Status of the Endangered Ocelot in the U.S.—a 35-Year Perspective

Michael E. Tewes

As part of the “37th Annual Faculty Lecture” at Texas A&M University-Kingsville, I reviewed the effectiveness of 4 broad areas of ocelot conservation spanning the period 1991–2016. These programs included (1) landscape corridors and related land purchases, (2) habitat restoration, (3) ocelot road crossing structures, and (4) translocation. In essence, I concluded these 4 conservation programs have failed to provide “A Meaningful Benefit” for ocelot conservation. The details of my presentation can be accessed at <https://www.ckwri.tamuk.edu/annual-faculty-lecture-narrative-tewes>. Proclamations of false ocelot benefits from these 4 conservation areas have 3 consequences: (1) they do not help ocelot recovery, (2) they promote “The Illusion of Achievement” giving the public a false sense that ocelot conservation is advancing (when it is not), and (3) large sums of taxpayer dollars are spent.

Ocelot conservation in the United States has been ineffective and feckless over the past quarter century. More than \$20 million have been spent (not including land purchases), and I believe we have less habitat and fewer ocelots than when I began my research program 35 years ago. It is clear that we need a new paradigm for ocelot conservation.

To effectuate change, new actions should target the resident female ocelots, particularly within the Ranch Population (private lands in Willacy and Kenedy counties). However, time is extremely limited for ocelot survival in the United States. Empowering private landowners to enact a strategic management plan, one that is tailored for ranchers, is the essence of the new paradigm for ocelot recovery.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute and Wild Cat Conservation, Inc.

Assessing Home Range Characteristics of Ocelots Using LiDAR

Maksim Sergeev, Michael E. Tewes, Jason V. Lombardi, and Tyler A. Campbell

The home range of an animal can be described as the area where an animal resides and forages. Animals will

typically select for areas most beneficial to them, based on resource quality and habitat type, among other factors. Determining the characteristics of an individual’s home range can be beneficial in understanding the ecology of that particular species.

Ocelots depend on dense thornshrub for cover and temperature regulation. However, this cover type may be limited in certain areas. Southern Texas is the northernmost extent of the ocelot’s range. In this region, thornshrub habitat has been lost to development for urban expansion and agriculture.

Thornshrub is essential to the endangered ocelot. As such, our objective is to characterize the home range of ocelots in regard to the amount and percentage of cover necessary to sustain a home range.

In this study, we captured 10 ocelots on the East Foundation’s El Sauz Ranch in southern Texas and fitted each with a GPS tracking collar. We will establish home ranges for the collared individuals and use light detection and ranging (LiDAR) technology to obtain images of the areas heavily used by the GPS-collared ocelots. Using the images collected, we can quantify the amount of dense vegetation within individual home ranges. By better understanding the habitat needs of ocelots, conservation strategies can be tailored toward providing enough cover and identifying existing areas with adequate habitat that could improve the sustainability of ocelots in southern Texas.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute, Brown Foundation, and East Foundation.

Road Crossing Patterns of Ocelots in South Texas

C. Jane Anderson, Shelby B. Carter, AnnMarie Blackburn, Amanda M. Veals, Michael E. Tewes, David B. Wester, Humberto L. Perotto-Baldivieso, and John H. Young, Jr.

The U.S. population of the federally listed endangered ocelot is restricted to the Lower Rio Grande Valley (LRGV) of South Texas. Fewer than 80 ocelots occur in 2 isolated breeding populations. The ocelot decline is due to several factors, but ocelot-vehicle collisions are the leading cause of mortality. Wildlife crossing structures may be helpful, but the structures must be placed where they maximize the likelihood of use by ocelots.

This study was initiated to better understand ocelot movement patterns in relation to roads. We analyzed

a telemetry dataset of 51 ocelots (23 females, 28 males) radio-collared in and around Laguna Atascosa National Wildlife Refuge from 1982–2001. We used lines to simulate movement paths between consecutive observed locations and determined the frequency at which these movement paths intersected roads, thereby indicating a successful road crossing.

We are comparing the rate at which ocelots cross dirt, gravel, and paved roads. We will further evaluate whether crossing rates are influenced by sex, duration of monitoring period, or within home range road density. We will also evaluate land cover distribution where ocelots cross paved roads to see whether there are patterns in crossing locations.

Our findings can aid the Texas Department of Transportation and other management entities in developing ocelot conservation strategies. It is anticipated that our findings can be used to guide future efforts to reduce vehicle caused mortalities of ocelots.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute and Texas Department of Transportation: Environmental Affairs.

Ocelot Resource Selection in a Highly Fragmented Landscape

Amanda M. Veals, AnnMarie Blackburn, C. Jane Anderson, Michael E. Tewes, Joseph D. Holbrook, Humberto L. Perotto-Baldivieso, Randy W. DeYoung, and John H. Young, Jr.

Wildlife are faced with landscapes that are becoming increasingly resistant to movements. The causes are often identified as habitat loss and degradation. Roads can be a barrier to movement and dispersal. This is especially true for roads with high traffic volume. Fewer than 80 ocelots occur in the Lower Rio Grande Valley of Texas, where they exist in 2 isolated populations.

There has been an increase in ocelot-vehicle collisions over the last several decades. However, it remains unclear how ocelots adjust their behavior relative to roads. To learn more about this topic, we will pair remotely sensed data with ocelot telemetry locations. This will allow us to assess habitat use, resource selection, and ocelot response to prey availability.

We will examine how spatial and temporal variation influences ocelot habitat relationships using a 35-year (1982–2017) telemetry dataset. This dataset represents 66 ocelots (34 males, 32 females). We will test a set of models that include vegetation cover, road densities, and traffic volumes.

Preliminary results show abundant use and strong selection for woody cover at the home range scale. However, as available woody cover decreased over the 35-year period, temporal changes in habitat selection as well as response to prey availability in habitat use occurred. This shows patterns of resource selection driven by availability of woody cover and lends support for our hypothesis that ocelots avoid roads at the home range scale.

Our findings can be used by agencies for the placement of road-crossing structures to decrease ocelot-vehicle collisions and increase movements for this species. Such efforts are needed to help maintain and restore this endangered species.

Cooperative funding provided by the Brown Foundation, Texas Department of Transportation: Environmental Affairs, and Travis and Bettina Mathis.

Co-occurrence and Resource Partitioning Among Felids in Northeastern Mexico

Jason V. Lombardi, Michael E. Tewes, Arturo Caso, Sasha Carajaval-Villareal, and W. Chad Stasey

The Sierra Tamaulipas Mountains National Protected Area is a rugged region in central Tamaulipas, Mexico. It is home to 6 of North America’s 7 felid species. The region supports robust populations of bobcats, ocelots, and pumas. It also has the northeastern-most populations of jaguars, jaguarundis, and margays. Interspecific interactions have been studied for various combinations of these species. However, there is little research examining factors that influence the co-occurrence of



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CKWRI researchers are studying how multiple wild cat species are able to co-occur in the same geographic area.

these species in a single geographic area. In addition, no studies have examined bobcat-jaguar or jaguarundi-bobcat interactions.

We conducted photo-based camera surveys on Rancho Caracol and Rancho Camotal in the northern Sierra Tamaulipas from May–December 2009. We plan to use a recently-developed multiple species occupancy model with 2 or more interacting species to identify the drivers of co-occurrence patterns of these felids.

Findings from our study will provide valuable information needed to understand species coexistence in northeastern Mexico. Spatial and temporal ecological data documented in this study may also be used in other studies.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute, Tim and Karen Hixon Foundation, Caracol and Camotal ranches, Barry Putegnat, Dean Putegnat, and Wild Cat Conservation, Inc.

The Effects of Roads on Ocelot Survival in South Texas

AnnMarie Blackburn, Amanda M. Veals, C. Jane Anderson, Michael E. Tewes, Humberto L. Perotto-Baldivieso, Randy W. DeYoung, and John H. Young, Jr.

Roads can have negative impacts on wildlife including habitat fragmentation and wildlife-vehicle collisions. These impacts can influence the spatial ecology and population sizes of threatened or endangered species. The ocelot is a federally listed endangered felid found in the Lower Rio Grande Valley (LRGV) of



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Construction of wildlife crossing structures under roads may reduce deaths of ocelots caused by vehicles.

South Texas. The LRGV is one of the fastest developing urban areas in the United States.

Ocelot-vehicle collisions are the highest direct source of ocelot mortality in Texas. Our goal is to analyze the effects of road networks and ocelot-vehicle collisions on ocelot survival rates in South Texas. We will use program MARK and VHF radio telemetry home range data from 1982–2001 to test the effects of home range size, distance to road, distance to the specified road type, road density within home range, percent woody cover occupied, sex, and social status (i.e., resident, transient, disperser) on ocelot survival. Our goal is to determine the likelihood of ocelot mortalities due to vehicle collisions based on the road-related variables listed above.

The results of our study can be used by biologists to help in establishing future locations of ocelot crossing structures. These data should aid Texas Department of Transportation managers planning new roads where ocelots may occur.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute and Texas Department of Transportation: Environmental Affairs.

Characterizing Ocelot Activity Patterns Using Accelerometers

Maksim Sergeev, Michael E. Tewes, Jason V. Lombardi, and Tyler A. Campbell

Understanding the behavior and activity patterns of a species is vital to understanding its overall ecology. As such, many studies have been conducted on animal behavior. However, without consistent observation of the species, it can be difficult to describe their behavior. Obtaining observations can prove difficult for elusive, nocturnal species like the ocelot. This can make it difficult to describe their activity in the wild. Using data collected from animals in captivity may help to describe how individuals in the wild are behaving.

To describe the activity patterns of ocelots in South Texas, we captured 10 ocelots on the East Foundation’s El Sauz Ranch in southern Texas and fitted each individual with a GPS tracking collar. We will use accelerometer data from captive ocelots at the Texas Zoo to describe the activity of ocelots in the wild using accelerometer signatures of known behaviors. By comparing the patterns of known behaviors and behaviors collected in the field, we can describe periods of activity

and identify specific patterns in behavior. Results from this study can improve our understanding of the daily behavior and activity patterns of an endangered species and help maintain and increase the remaining ocelot populations in the United States.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute, Brown Foundation, and East Foundation.

Survey for New Ocelot Populations in South Texas

Jason V. Lombardi, Michael E. Tewes, Maksim Sergeev, and Lon I. Grassman, Jr.

Ocelots are found in 2 isolated populations in southern Texas: the Ranch Population (located on private lands in northeastern Willacy and southeastern Kenedy counties) and the Refuge Population (coastal Cameron County). However, ocelot distribution in other areas of the Lower Rio Grande Valley is unknown.

Previous research has indicated that declines in ocelot distribution across the region can be attributed to loss and fragmentation of preferred woody cover, expanding road networks and associated mortalities from vehicle collisions, and a loss of genetic diversity. In 2019, we used camera photo stations on Tijerina Ranch in Hidalgo County and other private ranches in Willacy County to assess potential ocelot distribution. Based on aerial imagery, we will evaluate the woody cover found on these locations to determine preferred vegetation cover types. This study will give researchers insights about areas where ocelots may occur or have the potential to occur in the future.

Cooperative funding provided by the Raul Tijerina Jr. Foundation.

Accelerating Growth of Ocelot Thornshrub Habitat

Jose G. Cortez, Jr., Sandra Rideout-Hanzak, David B. Wester, Michael E. Tewes, and David E. Ruppert

The ocelot was once a prominent felid species across the southern portion of the United States. At one point their range extended from southern Texas to Arizona. Increases in agriculture and urbanization within Texas have limited the ocelot to 2 populations, which can be



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Graduate student Jose G. Cortez, Jr. showing 1 of the 700 South Texas thornshrub saplings planted in an effort to accelerate ocelot habitat restoration.

found in Willacy and Cameron counties. These populations are widely separated from each other by urban and agricultural development. The objectives of this project are to test different management techniques on newly planted and naturally established thornshrub plants and to measure them to see which treatments are most successful in growing high-quality thornshrub cover for ocelots as quickly as possible.

We have randomly assigned 3 treatments to 480 naturally-occurring thornshrub plants and to 700 newly-planted saplings. These treatments are designed to simulate mechanical disturbance and include shredding, mulching, and a shred and mulch combination.

We are hypothesizing that plants that receive the shred treatment will grow thicker and grow more stems from the base due to the loss of apical dominance. Plants that receive the mulch treatment are hypothesized to have improved soil moisture content and thus an advantage during dry periods. Plants that receive a combination shred mulch treatment might develop a thicker growth form and there may be improvement in soil moisture content.

We have also placed exclosures around several plants to see if browsers are having a significant impact on plant growth and development. Our findings can be used to guide future ocelot habitat restoration efforts in South Texas thornshrub plant communities.

Cooperative funding provided by Texas Parks and Wildlife Department.

The Impact of Road Matrix on Habitat Connectivity for Ocelots in South Texas

Amanda M. Veals, AnnMarie Blackburn, C. Jane Anderson, Michael E. Tewes, Joseph D. Holbrook, Humberto L. Perotto-Baldivieso, Randy W. DeYoung, and John H. Young, Jr.

Wildlife species that depend on large tracts of contiguous habitat can be negatively affected by habitat loss and fragmentation. Consequently, it is critical to understand the relationship between the distribution of species and the remaining habitat to plan effective conservation strategies.

Ocelots are habitat specialists. They require more than 75% horizontal thornshrub plant communities in South Texas. Unfortunately, about 95% of native Tamaulipan thornshrub has been cleared for agriculture and urban development. Consequently, less than 1% is ocelot habitat. It is clear that information is needed regarding the location, size, and density of the remaining habitat patches.

In this study, we will assess (1) the connectivity of woody patches for ocelots and (2) provide information on patch location, size, density, and distance between patches. We will use ocelot movements in calculating landscape connectivity indices. We will also compare current road networks and urbanization to projected changes in 2050 and 2100 based on EPA estimates. We will evaluate the connectivity for these scenarios to determine which habitat patches are most important to ocelots.

Restoration initiatives for ocelot enhancing habitat should benefit from our findings. In addition, our research will also provide insight regarding the cost-effectiveness of restoration strategies.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute and the Texas Department of Transportation: Environmental Affairs.

Comparison of Satellite and GPS Collars on Ocelots and Bobcats

Samuel H. Stone, Jason V. Lombardi, Maksim Sergeev, John P. Leonard, Michael E. Tewes, and Tyler A. Campbell

Global positioning system (GPS) telemetry has been used to study spatial, behavioral, and population ecology of carnivores. Introduction of GPS collars with iridium technology has allowed more accurate collection of location data and the ability to view locations



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Bobcats and ocelots can occur in the same areas, but each species appears to use habitat differently.

in real-time. Such technology can be used to study wild cats.

Ocelots are habitat specialists that prefer dense thornshrub in South Texas. However, bobcats are habitat generalists. Both species co-occur in the thornshrub communities of South Texas.

We will compare the success rate of obtaining GPS locations for satellite and GPS collars for ocelots, compare GPS location transmission rate for each species, and determine if vegetation, animal behavior, and the number of satellites influence GPS collar performance. From 2005–2010, we collared ocelots on the Frank D. Yturria Ranch and from 2011–2019, we collared ocelots and bobcats on the East Foundation's El Sauz Ranch in Willacy County, Texas. Televilt POSREC-science GPS, Lotek Minitrack GPS, and Lotek Litetrack Iridium collars were placed on the study animals.

Preliminary data for 12 ocelots and 7 bobcats indicate that ocelots had 79% success in fix transmission rate and bobcats had a 95% success rate. We did not observe a significant difference between obtaining successful GPS locations between species.

Findings obtained in this study will give us a better understanding of ocelot and bobcat ecology. This information can be used for making informed decisions about ocelot recovery in South Texas. Findings also can be used to help identify the best satellite and GPS collars for future research on ocelots and bobcats.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute, East Foundation, and Tim and Karen Hixon Foundation.

Coexistence Among Ocelots, Cattle, and Nilgai in South Texas

Shelby B. Carter, Michael E. Tewes, Humberto L. Perotto-Baldivieso, C. Jane Anderson, Jason V. Lombardi, Amanda M. Veals, and Tyler A. Campbell

Interspecific interactions can play an important role in population dynamics and distribution of species. About 97% of Texas is privately owned and is primarily managed for cattle and hunting. This often means that habitat management consists of clearing and burning dense brush, which reduces optimal ocelot habitat in South Texas. This study is examining the use of woody habitat by species of economic importance and by ocelots to better understand their coexistence.

In South Texas, ocelots occur in 2 small breeding populations on private and public lands in Willacy, Kenedy, and Cameron counties. The largest known breeding population is located on the East Foundation's El Sauz Ranch in Willacy County. The El Sauz Ranch is a unique, privately-owned property that integrates ranching and wildlife management. Interactions among ocelots, livestock, and large wild ungulates have not been examined. Thus, the goal of this research is to evaluate the coexistence and interaction between ocelots, cattle, and nilgai.

We are using an 8-year (2011–2018) photo dataset to identify abundance and activity patterns. We will evaluate spatial and temporal activity patterns. This will allow us to assess avoidance or overlap by species within the study area and estimate occupancy patterns of each species.

Our results may be used to assist programs that balance ocelot conservation and cattle production. An



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The largest known ocelot breeding population in the United States is on the East Foundation's El Sauz Ranch.

additional outcome will be an increase in our understanding of how ocelots, cattle, and nilgai coexist within the landscape.

Cooperative funding provided by the East Foundation, Brown Foundation, and the Feline Research Program of the Caesar Kleberg Wildlife Research Institute.

Circuit Theory to Estimate Road Crossings for the Endangered Ocelot

Amanda M. Veals, AnnMarie Blackburn, C. Jane Anderson, Michael E. Tewes, Joseph D. Holbrook, Humberto L. Perotto-Baldivieso, Randy W. DeYoung, and John H. Young, Jr.

Ecosystems and landscapes must be connected and permeable to support wildlife populations. With an increasing road network in natural areas, roads serve as filters or barriers to animal movements. Wildlife crossings can be an effective mitigation technique for the negative impacts of roads on species. However, high construction costs limit the number that can be constructed. Therefore, it is important to optimize the placement of crossing structures within road networks in a strategic fashion.

Our project will evaluate models of landscape permeability for the endangered ocelot as a function of road structure and habitat in South Texas. We will build a circuit theory-based model to determine which habitat types are important to ocelots, relative to roads. We will further analyze ocelot movement scenarios in the program CircuitScape 4.0 based on model predictions, which will allow us to develop a landscape connectivity map. This will result in 3 landscape resistance scenarios based on road crossing density and traffic volume. We predict the landscape with the highest resistance to animal movement will have the greatest traffic volume and lowest crossing structure density. Additionally, we will assess ocelot movement risk based on current and projected land use scenarios for the years 2050 and 2100.

This research will help to identify locations for potential road crossing structures that will mitigate ocelot-vehicle collisions. Texas Department of Transportation planners can use this information for existing and future roadways for placement of ocelot road crossing structures.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute and the Texas Department of Transportation: Environmental Affairs.

Effect of Moon-phase on Habitat Use and Movement of Ocelots and Bobcats

Maksim Sergeev, Jason V. Lombardi, Michael E. Tewes, and Tyler A. Campbell

Habitat selection and movement of wildlife are influenced by landscape and environmental factors. For nocturnal animals, visibility can vary by moon phase. As such, the phase of the moon may influence activity and habitat selection of nocturnal species. However, the effects of varying moon stage differ across species.

Prey species often reduce activity during highly visible periods of night. Predator species may increase activity or alter their habitat use. Ocelots and bobcats, nocturnal predators that coexist in southern Texas, may also alter their behavior in response to the phase of the moon.

We predicted that ocelots would increase use of dense thornshrub to reduce their visibility during a full moon. However, as bobcats are habitat generalists and are more active during dawn and dusk, we predicted less influence of moon phase on activity. We collected GPS data on 8 ocelots and 6 bobcats on the East Foundation’s El Sauz Ranch in southern Texas from May 2013 to May 2017. We examined differences in movement and habitat selection to compare periods of high luminosity (± 3 days of a full moon) to low luminosity (± 3 days of a new moon).

We observed differences in movement patterns between moon phases for ocelots, but not bobcats. Ocelots preferred greater canopy cover during full

moons than new moons, whereas bobcats showed no difference between moon phases. However, both species showed greatest use of cover during waxing and waning moon phases (see figure below).

Understanding how environmental factors influence activity and habitat selection can advance our knowledge of predator-prey dynamics. Such information will enhance our understanding of the overall ecology of ocelots and bobcats.

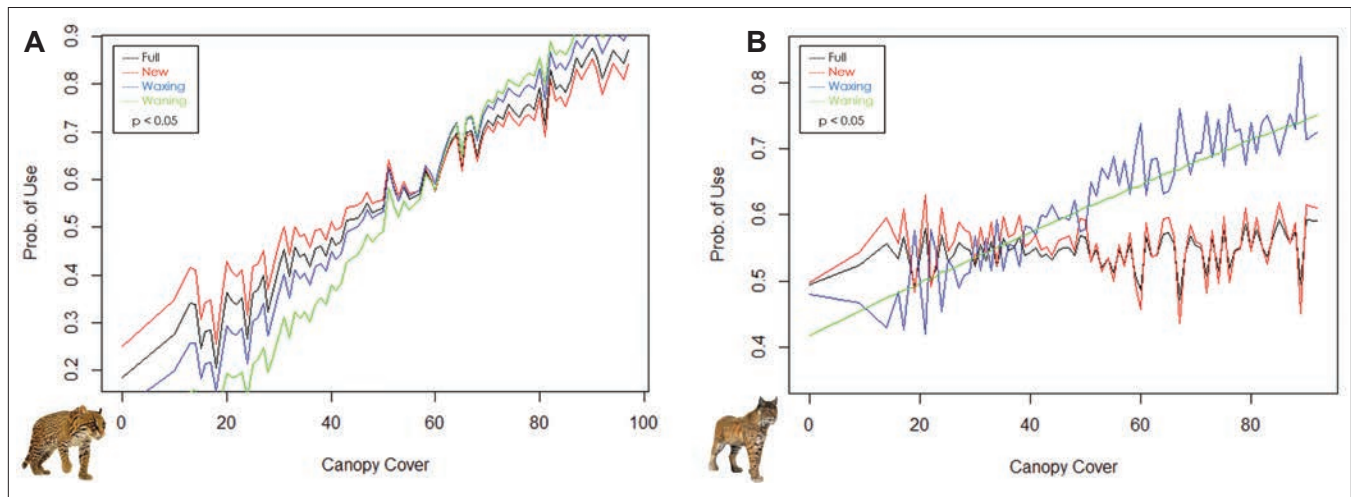
Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute and the East Foundation.

Impacts of Genetic Erosion on Ocelot Semen Traits and its Conservation Consequences

Ashley Reeves, Debra Miller, William Swanson, Clayton D. Hilton, Tyler A. Campbell, Jason V. Lombardi, and Michael E. Tewes

Studies on the cheetah and Florida panther have identified a relationship between low genetic variability and low quality of spermatozoa. This suggests the possibility of various negative effects upon successful reproduction within these felids.

Problems often include sperm deformities, low mobility, and low spermatozoa volume, factors which can reduce the chance of successful production of young ocelots. For an endangered wild cat, low or reduced reproduction can seriously impact population fitness, thereby reducing survival.



The graph of ocelot (A) and bobcat (B) above illustrates use of canopy cover across varying phases of the moon. Both species selected for areas with increased vegetative cover. Use of canopy cover was greatest during waxing and waning moon phases for both species, contrary to our expectations.

Several of our previous research projects have documented loss of genetic variation in ocelots from 1995 to 2005. Those patterns have likely only become worse over the last 15 years. In addition, several inbreeding cases have been documented through genetic methods by our researchers within the 2 ocelot populations in South Texas. These populations include the small isolated Refuge Population on Laguna Atascosa Refuge and the much larger Ranch Population north of the Rio Grande Valley.

We have formed a collaborative project among researchers at the University of Tennessee at Knoxville, the Cincinnati Zoo, and the Caesar Kleberg Wildlife Research Institute to collect and examine semen traits of wild caught ocelots within the Ranch Population at the East Foundation's El Sauz Ranch in Willacy County. Results from this research will be useful in guiding the formulation of conservation strategies that hopefully will improve ocelot reproduction in this fragile population and reduce the chances of their extirpation in South Texas.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute, Cincinnati Zoo, and the University of Tennessee at Knoxville.

Predictive Performance of Ocelot GPS Fix-Rate

Jason V. Lombardi, John P. Leonard, Michael E. Tewes, Humberto L. Perotto-Baldivieso, David G. Hewitt, Daniel G. Scognamillo, and Tyler A. Campbell

Distribution models are used to gain insight about the geographic distribution of a species. These models usually use environmental and climatic data paired with occurrence data (eyewitness accounts or photos). However, little research has examined the usefulness of telemetry data in a species distribution model. Advances in telemetry allow locations to be recorded at greater time frequencies. This provides for a closer look at animal movements and habitat use.

We examined the predictive performance of GPS telemetry data at different fix-rates (0.5–12 hours) to help inform a species distribution model for ocelots in South Texas. From 2014–2017, we captured and collared 9 ocelots on the East Foundation's El Sauz Ranch. We partitioned GPS data in different fix rates and combined datasets with environmental data in program MAXENT to generate species distribution models. We conducted spatial analyses to quantify the amount



© Maksim Sergeev

Because of the dense habitat where ocelots occur, ocelots may slip their tracking collar or the collar breaks.

of presence data each model over- or under-estimated compared to a baseline (12 hours) model.

The findings from this study will help identify the utility of using GPS data in species distribution modeling and develop a baseline methodology for different tracking schedules. It will also help wildlife managers quantify the amount of potential habitat for ocelots in Willacy and Kenedy counties.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute, Wild Cat Conservation, Inc., East Foundation, Annova LNG and their parent company Exelon Generation, Brown Foundation, Tim and Karen Hixon Foundation, Travis and Bettina Mathis, and Ben F. Vaughan, III.

Role of Temperature in Activity of Ocelots in South Texas

Maksim Sergeev, Michael E. Tewes, Jason V. Lombardi, and Tyler A. Campbell

Environmental factors play a major role in the habitat use of wildlife species. One of these is temperature, which is often a major factor in influencing the distribution of species. Often, animals thrive in a specific temperature range, which restricts them to certain areas. Ocelots prefer warmer temperatures and are generally found in Central and South America. However, the northern extent of their range extends into southern Texas. Beyond impacting geographic range, temperature also influences the behavior and habitat use of ocelots.



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Ocelots are very secretive and are found in the dense thornshrub habitat in certain areas of South Texas.

During the day, ocelots will generally reduce their activity levels and remain within dense thornshrub. Doing so provides a shaded environment significantly cooler than the surrounding open areas. To examine how temperature affects ocelots in southern Texas, we captured 10 ocelots on the East Foundation's El Sauz Ranch and fitted each individual with a GPS tracking collar and temperature sensor.

By analyzing temperature readings coupled with GPS locations of collared ocelots, we will be able to determine how temperature affects the activity and habitat use of these endangered cats. A further understanding of how temperature influences ocelots can improve conservation and help guide habitat restoration strategies that could help sustain the ocelot population in South Texas.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute, Brown Foundation, and East Foundation.

Feline Use of the New Highway 77 Crossing Structure for Endangered Ocelots

Michael E. Tewes, Jason V. Lombardi, Samuel H. Stone, and John H. Young, Jr.

At least 4 ocelot mortalities have been documented on Highway 77 in southern Texas. It is likely several other ocelots have been killed, but were not detected or reported. In addition, this transportation corridor is in the process of expanding in structure and traffic

volume as it transitions into Interstate 69—a major transportation corridor linking Canada, United States, and Mexico.

The Texas Department of Transportation (TxDOT) is responsible for maintaining our transportation system within the State while also seeking to minimize environmental impacts. Recently, TxDOT constructed a \$6 million vehicle overpass in northern Willacy County to provide safe passage at ground level for ocelots, bobcats, and other wildlife. This structure is designed to reduce the potential for ocelot mortality in that surrounding area.

We will monitor bobcat and ocelot patterns of crossing use with 2 primary methods. A system of advanced cameras will be placed in strategic locations to document the behavior and success of felid crossings. In addition, GPS tracking collars will be attached to wild cats to obtain high-frequency, high-resolution movements relative to these crossings, as well as movement patterns and habitat use in the surrounding area. This information will be valuable in guiding the placement and construction of future wildlife crossing structures in Texas.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute, Tim and Karen Hixon Foundation, and Texas Department of Transportation.

Effect of Prey Abundance and Diversity on the Coexistence of Ocelots and Bobcats

Maksim Sergeev, Michael E. Tewes, and Tyler A. Campbell

The presence of large carnivores in an environment can be influenced by many factors. Among these, composition and abundance of prey often play a key role in determining the number of large carnivore species that are sustainable within that area. This is particularly true in areas with coexisting species of carnivores.

Ocelots and bobcats are similar-sized felines. Both coexist within a small region of southern Texas. Previous research has indicated that coexistence of similar-sized carnivores is helped by abundant prey. This study was started to examine the relationship between prey populations and the coexistence of ocelots and bobcats.

We captured 10 ocelots and 8 bobcats on the East Foundation's El Sauz Ranch in southern Texas. Each individual was fitted with a GPS tracking collar. By combining GPS locations with small mammal trapping,

we will determine how the small mammal composition influences coexistence of larger carnivores.

Understanding the relationship between predators and prey can improve the conservation of ocelots. In addition, it will shed light on the factors involved in sustaining and managing coexisting carnivore populations within South Texas.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute, Brown Foundation, and East Foundation.

Utility of Wildlife Crossings, Cattle Guards, and Fencing for Ocelots on FM 1847

Jason V. Lombardi, Michael E. Tewes, John H. Young, Jr., and John Herschberger

In the United States, urbanization is threatening wildlife populations. In Texas, 80% of the state’s human population exists in urbanized areas and is rapidly expanding each year. As these areas grow so does the volume of cars on ever expanding primary and secondary roadways, which can have a detrimental effect on wildlife species.

The use of wildlife crossing structures in combination with fencing is regarded as an effective strategy for maintaining habitat connectivity and reducing vehicle collisions with carnivores in other areas of the world. It has yet to be proven for carnivores in Texas.

The ocelot is an endangered felid in South Texas, with less than 80 individuals remaining in 2 isolated populations in eastern Willacy and Kenedy counties

and coastal Cameron County. Beginning in 2019, we will be monitoring FM 1847 in Cameron County to determine the effectiveness of future wildlife crossing structures, cattle guards, and fencing to reduce future ocelot mortality. Passive and active infrared camera-based monitoring stations will be used at 6 future wildlife crossing structures to document potential ocelot presence and possible use of the crossing structures. In addition, we will conduct road kill surveys to determine wildlife-vehicle collision hotspots. This research will enable state agencies and researchers to gain a better understanding of the types of crossing structures used by ocelots and to help reduce future ocelot mortality caused by vehicles.

Cooperative funding provided by Texas Department of Transportation.



© Jason Lombardi

Undergraduate research technician John Herschberger sets up a camera station used to document the presence of wild cats.

DMP Pens Effect on Average White-tailed Deer Antler Size

Stuart W. Stedman, Matthew T. Moore, and Charles A. DeYoung

Deer Management Permits (DMPs) are issued by the Texas Parks and Wildlife Department for confining and breeding a large-antlered buck with up to 20 does. DMP deer and fawn offspring are then released with the goal of upgrading overall antler size on the permitted property.

Research on DMP deer is being conducted on the Faith Ranch in Dimmit County, Texas. Two high fenced areas of 1,100 acres each were established in 2007 and are under identical management, including intensive supplemental feeding. Resident deer were removed from the treatment pasture prior to data collection, and it has been restocked with DMP sired offspring. The control pasture has resident deer that were present when the high-fence was constructed.

DMP pens are stocked with native bucks and does from the Faith Ranch. Fawns are tagged in DMP pens and the control area each year with ear tags specific to year-of-birth. Each fall marked, known-age bucks are captured via helicopter and antler size is compared within age classes across each pasture.

After 11 years of research, average gross Boone and Crockett (B&C) inches of DMP area bucks differed from control pasture bucks as follows: 1.5-year-olds, -1 B&C inch; 2.5-year-olds, +4 B&C inches; 3.5-year-olds, +9 B&C inches; 4.5-year-olds, +13 B&C inches; 5.5-year-olds, +9 B&C inches; 6.5-year-olds, +10 B&C inches; 7.5-year-olds, +11 B&C inches; 8.5-year-olds, +9 B&C inches; 9.5-year-olds, +8 B&C inches, and 10.5-year-olds, +1 B&C inch. The study will continue in 2019.

Cooperative funding provided by the Faith Ranch.

Behavioral Responses of White-tailed Deer to Heat Stress

Jacob L. Dykes, Randy W. DeYoung, Timothy E. Fulbright, David G. Hewitt, Charles A. DeYoung, J. Alfonso Ortega-Santos, Aaron M. Foley, and Tyler A. Campbell

Heat stress is a common threat to wildlife in the South Texas region. Animals often use behavioral adaptations to lessen heat stress. Examples of these

adaptations include seeking shade, wind, or altering activity patterns because these are less costly than physiological changes.

The need for thermal cover may differ by sex, age, or physiological status. For instance, peak lactation in white-tailed deer typically occurs during the hottest months. Thus, females are forced to forage and process foods during the heat to meet their nutritional requirements. Shaded areas exposed to wind should be preferred during summer, but the distribution, availability, and competition for such locations are not well known. The goals of this study are to evaluate the behavioral adaptations of white-tailed deer to heat stress and assess competition for shade with cattle.

We deployed 40 GPS transmitter collars (30 deer, 10 cows) equipped with black-globe thermometers across the East Foundation's El Sauz Ranch in South Texas. Collars are recording location and operative temperature at 30-minute intervals. We also deployed black-globe thermometers across the landscape to monitor fluctuations of operative temperature with variation in herbaceous and woody cover and orientation relative to wind. We will combine temperature and GPS locations with landscape characteristics to identify thermal cover.

Knowledge of deer movements, resource selection, and competition for thermal cover will further our understanding of how heat affects deer and cattle and what landscape features might reduce this type of stress. The results of this study will enable wildlife managers to design brush management regimes that reduce the effects of heat stress on white-tailed deer.

Cooperative funding provided by the Zachry Foundation and the East Foundation.

Reproductive Strategies of Male Mule Deer in a Fragmented Landscape

Levi J. Heffelfinger, David G. Hewitt, Aaron M. Foley, Shawn S. Gray, Warren C. Conway, Timothy E. Fulbright, Randy W. DeYoung, Louis A. Harveson, Daniel D. Olson, and Justin M. Shannon

Mating strategy differs substantially across mammalian species. Most deer species are highly social with males and females occupying the same areas, leading to competition for females during the rut. White-tailed deer use a single-female tending strategy in which a male will frequently check females for

receptiveness. Conversely, little is known about mule deer mating strategy. There is some evidence that suggests they exhibit a harem strategy in which a mature buck defends a group of does against other males. The rut also coincides with migration for some mule deer populations. This creates the potential for different mating strategies.

Our study will use GPS location data of 74 adult males and 81 adult females in the Panhandle of Texas and 199 adult males and 345 adult females in several regions of Utah. We will document and quantify the reproductive strategy of mule deer. Male and female deer were collared in close proximity to each other throughout all study areas. We will use spatial analyses to document interaction patterns between sexes. Moreover, we will be able to quantify mate-search strategies of males throughout the stages of rut and how they differ with age and geographical region.

We expect that mule deer will adopt a mate search strategy that differs from white-tailed deer. Male mule deer will likely show less roaming and revisitation of areas that females occupy. However, search strategy and reproductive behavior may differ if the population is migratory. Our study is the first to explicitly investigate the reproductive strategy of mule deer.

Cooperative funding provided by Texas Parks and Wildlife Department, Boone and Crockett Club, and the Mule Deer Foundation.

Estimating White-tailed Deer Population Sizes Using Drones

Jesse Exum, Aaron M. Foley, Randy W. DeYoung, David G. Hewitt, Jeremy A. Baumgardt, and Mickey W. Hellickson

Estimating population sizes, recruitment, and sex ratios are essential for managing wildlife populations. Helicopters are commonly used to survey white-tailed deer. However, they are expensive, risky, and not always practical for smaller ranches. Camera photo surveys and spotlight counts are viable alternatives. However, they have relatively poor accuracy. Drones are an emerging technology, and they have yet to be fully evaluated for wildlife surveys in South Texas.

We conducted drone surveys on 5 ranches during November 2018. The drone was equipped with a dual thermal and optical video camera. Heat signatures were detected on the thermal imagery, then identification was confirmed, when possible, via optical imagery. Each survey included both daytime and nighttime

flights on each ranch to evaluate population counts under different conditions. We compared drone counts to unadjusted counts from September helicopter surveys.

Analyses of preliminary data revealed that optical footage alone had the lowest counts. The addition of thermal footage during daytime surveys increased detection rates by an average of 112% (range: 48–200%). We observed more deer during nighttime thermal counts than daytime thermal counts, but differences between day and night were highly variable (0–54% difference). During the daytime surveys, we identified species of animals detected in thermal footage 56% (range: 51–66%) of the time using optical footage. Thermal + optical counts during daytime surveys were consistently lower than unadjusted helicopter counts, but differences were variable among surveys (range: 17–148%). Ongoing work will determine the time and season that will yield the most consistent visibility of animals during drone surveys.

Cooperative funding provided by Arroyo Ranch, Dolores-Needmore Ranch, GMD Ranch, and Zacatosa Ranch.

Influence of Forage Quantity and Quality on Body and Antler Size

Seth T. Rankins, Randy W. DeYoung, Timothy E. Fulbright, J. Alfonso Ortega-Santos, Aaron M. Foley, David G. Hewitt, Landon R. Schofield, and Tyler A. Campbell

During a long-term study of white-tailed deer on East Foundation ranches in South Texas, we observed an inverse relationship between sand content and body



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CKWRI researchers are assessing factors that influence white-tailed deer body condition and antler size.

and antler size. This is probably driven by differences in nutrition, but it is not clear if forage quantity, quality, or some combination thereof is responsible. Understanding the importance of forage quantity and quality on deer growth has profound impacts on management strategies. If forage quality, instead of amount, is limiting then lowering the deer population will be a fruitless endeavor.

To determine the importance of forage quantity and quality on deer growth, we are using morphometric data collected from the East Foundation ranches in South Texas. The East Foundation ranches span multiple ecoregions, and deer differ in Boone & Crockett score, body mass, and skeletal size. Since the deer are not hunted or managed, we know that the differences are not due to varying management. We will perform nutrient testing on forage samples and examine the relationships between soil, forage, and deer metrics.

Findings from this research can aid in developing management strategies for white-tailed deer in areas with poor soils. This research will also provide information regarding which nutrient or nutrients might be limiting growth. This, in turn, will allow wildlife managers to implement practices that can increase the quality of deer forage, and eventually the size, health, and reproduction of deer.

Cooperative funding provided by the East Foundation.

Effects of Water Salinity on Supplemental Feed Consumption

Austin K. Killam, Clayton D. Hilton, David G. Hewitt, Aaron M. Foley, and Natasha L. Bell

Surface water in the southwestern United States is often limited because of droughts. Wildlife in this environment are forced to rely on pumped ground water or pools of poor-quality water. This water may contain high salinity levels and dissolved solids that may negatively impact deer. We predict that water quality will affect the nutrition of white-tailed deer by influencing the amount of supplemental feed consumed. In this study, we will focus on salinity, the main cause of poor-quality water in South Texas.

During spring, summer, and fall, when nutritional needs are higher for both sexes of white-tailed deer, it is important for individuals to consume enough vegetation and supplemental feed. To estimate the effect of water salinity on feed consumption of white-tailed deer, we plan to conduct multiple studies at the Albert



© Brian Loffin

White-tailed deer in South Texas rangelands may be forced to drink poor quality water, which likely affects daily intake of supplemental feed.

and Margaret Alkek Ungulate Facility in Kingsville. Individuals will be held in 10 x 13-ft pens and provided with unlimited water at varying salinity levels. This will allow us to determine the upper limit of salinity at which deer will drink and observe how salinity affects daily intake of supplemental feed. Ultimately, the goal of our research is to improve water resource management for white-tailed deer in South Texas—a poorly-understood topic for the species.

Cooperative funding provided by the Albert and Margaret Alkek Foundation.

Influence of Cropland Use on Mule Deer Morphology and Population Parameters

Levi J. Heffelfinger, Laura S. Warner, David G. Hewitt, Shawn S. Gray, Warren C. Conway, Timothy E. Fulbright, Randy W. DeYoung, Aaron M. Foley, and Louis A. Harveson

Habitat changes are a threat to wildlife in many ecosystems. Understanding how species react to landscape changes is important for conservation and management. The most common form of habitat alteration in the Great Plains region of the United States is conversion of native rangeland to row crop farming.

We are investigating the influence of agriculture on mule deer in the Texas Panhandle. We have captured and collared 312 adult males, females, and fawns. Specifically, we are testing how the use of cropland by mule deer affects population health parameters such as body fat, body mass, lactation rates, and antler size.

We will also assess how cropland use, among other habitat and body size measurements, influences adult and juvenile survival.

Our preliminary findings suggest that the use of agricultural fields during the summer had a positive influence on body fat and body mass across all age classes for males, but had no effect on females. Additionally, in areas where cropland is available, we have found that lactating females use cropland more than non-lactating females. Overall, survival is high and stable, and adult male and female survival does not appear related to use of cropland.

Establishing an adaptive management plan for mule deer in the Panhandle will prove crucial as habitat changes continue. Our research will provide information needed to improve the management of mule deer in Texas.

Cooperative funding provided by Texas Parks and Wildlife Department, Boone and Crockett Club, and the Mule Deer Foundation.

Cattle - White-tailed Deer Interactions on the East Foundation Ranches

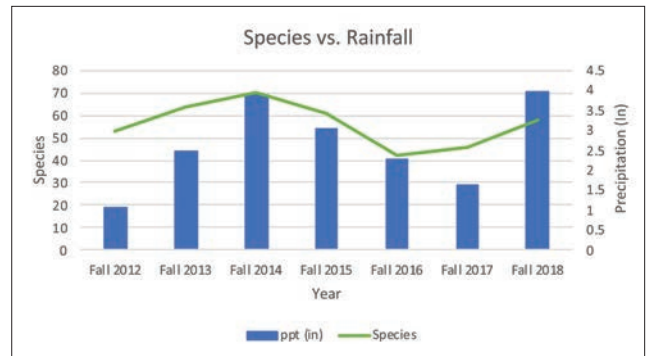
Dillan J. Drabek, J. Alfonso Ortega-Santos, Timothy E. Fulbright, David B. Wester, David G. Hewitt, and Tyler A. Campbell

Cattle ranching has had cultural and economic value for years in southern Texas. Rangeland managers often consider the interactions between cattle and white-tailed deer. Cattle grazing has been used as a tool to improve habitat, but it can also damage valuable



© Randy DeYoung

Cattle grazing has been used to improve rangeland habitat for white-tailed deer.



Plant species richness was affected by rainfall during the autumn months of 2012–2018 in South Texas.

habitat for wildlife if incorrectly used. Although grazing herbivores primarily consume grasses, vast amounts of forbs are eaten as well. Previous studies reporting findings of grazing effects on grasses and forbs in a semiarid climate have been mixed.

Our objectives are to determine how grazing impacts affect forb standing crop production for white-tailed deer and to determine plant species richness on the study sites. We hypothesize that although grazing intensity varies among the study sites, it has no effect on an increase in forb productivity; however, abiotic factors (i.e., rainfall) aid in the plant’s production.

Six 6,183-acre study sites are being used on the East Foundation ranches in South Texas. There are 50 16-ft² grazing exclosures randomly located on the study sites that are being monitored. Forage standing crop will be determined by collecting grasses, preferred forbs, and non-preferred forbs.

Preliminary results show that autumn plant species richness increases when rainfall increases during the autumn months. This study will provide a better understanding of how cattle affect forage standing crop and plant species richness on cattle/wildlife operations in South Texas.

Cooperative funding provided by the East Foundation.

Mule Deer Movement Patterns and Habitat Use in an Agricultural Landscape

Levi J. Heffelfinger, Laura S. Warner, David G. Hewitt, Shawn S. Gray, Warren C. Conway, Timothy E. Fulbright, Randy W. DeYoung, Aaron M. Foley, and Louis A. Harveson

Conversion of native rangeland to row crop farming is one of the largest forms of habitat fragmentation. One area in which agricultural expansion is expected

to increase is the Texas Panhandle. Historically, Texas mule deer were most common in the Trans-Pecos, but population numbers have dramatically increased in the Panhandle. Little is known about mule deer habitat use and movement in this area of extensive fragmentation.

We delineated 3 study sites of varying agriculture densities throughout the Panhandle and placed GPS collars on 42 adult mule deer per study site. We are evaluating home range sizes, proportion of individuals using agriculture, and habitat use.

Male home range size was large and variable regardless of site, averaging 12–16 mi². Female home range size was smaller and less variable regardless of study site, averaging 3.5–4.5 mi². The proportion of marked deer that used agriculture appeared dependent on cropland density. The high and moderate density cropland sites had 85% while the low cropland density site had 15% of deer using cropland. In terms of habitat use, mule deer averaged 7% of their time in agriculture during spring and summer and 21% during the autumn and winter months.

The increased cropland use by mule deer during the cooler months is likely because of crop type and the result of decreased use of shrubland and grassland

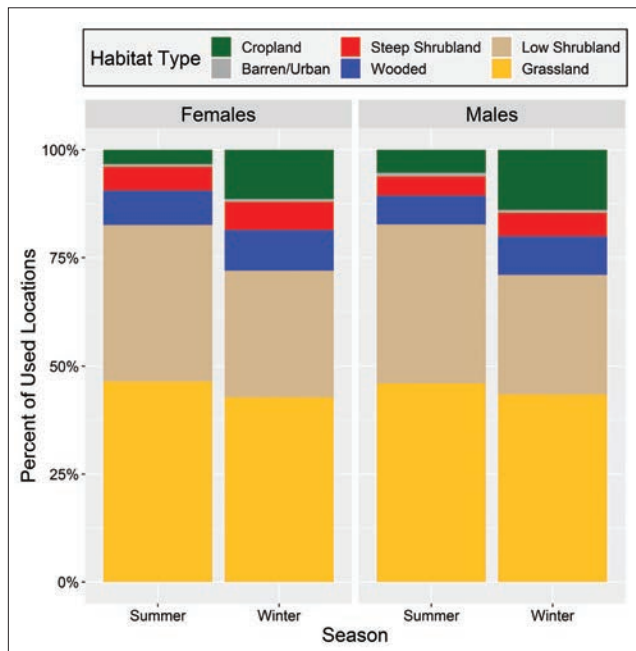


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A collared buck (Blue 5) is part of an ongoing study evaluating the influence of agriculture on mule deer in the Texas Panhandle.

habitats. These findings help to define the management scale for mule deer in the Texas Panhandle and other regions where extensive agriculture and mule deer coexist.

Cooperative funding provided by Texas Parks and Wildlife Department, Boone and Crockett Club, and the Mule Deer Foundation.



Graph showing habitat use by GPS-collared adult mule deer throughout the Texas Panhandle. Sampling of mule deer occurred across study sites with variable amounts of agricultural land use. Habitat use was calculated as the proportion of GPS fixes in each habitat type relative to the total fixes in other habitat types. Habitat use of adult females (left pane) and adult males (right pane) was calculated separately. Seasons were delineated based on typical crop growth cycles. Winter is defined as October–March and summer is defined as April–September.

Using Capture Locations of White-tailed Deer to Index Home Range

Seth T. Rankins, Jacob L. Dykes, Timothy E. Fulbright, J. Alfonso Ortega-Santos, Aaron M. Foley, David G. Hewitt, Randy W. DeYoung, Landon R. Schofield, and Tyler A. Campbell

The helicopter net-gun technique is the safest and most efficient way to capture large animals. In the South Texas region, helicopter and net-gun are routinely used to capture white-tailed deer for research and management purposes. Pilots herd deer into open areas, an onboard gunner shoots the net over the deer, which becomes entangled in the netting and is restrained by a ground crew.

Previous research suggests that deer are reluctant to venture beyond their home range when pursued. Because deer prefer to hide from predators, they may remain in familiar areas.

We have captured deer on 4 East Foundation ranches in South Texas for 8 years. The capture information has revealed differences in body and antler

size associated with soil and vegetation communities within and among ranches. We are using locations from recaptured deer to determine if capture locations are a reasonable index of a deer’s home range.

Our preliminary results indicate that the deer on our study sites had high site fidelity. Ninety percent of recaptures were within 2 miles of their original capture location. From these data, we can demonstrate that recapture locations were contained within a smaller area than the average home range size for white-tailed deer in South Texas.

Overall, our findings suggest that deer probably use circuitous escape routes within their home range while trying to avoid capture. This indicates that capture locations can be used as a proxy for habitat use at a home range scale for future studies.

Cooperative funding provided by the East Foundation.

Habitat Use by White-tailed Deer After Brush Management

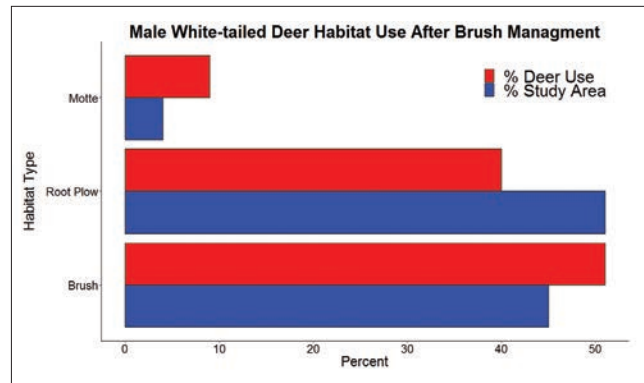
Jacob L. Dykes, Randy W. DeYoung, Timothy E. Fulbright, J. Alfonso Ortega-Santos, and Dean W. Wiemers

Habitat selection by wildlife is influenced by the availability of forage and the perceived risk of predation to obtain that forage. White-tailed deer are faced with the trade-off between quality forage and protective cover. The effects of such trade-offs become more apparent after large-scale habitat alterations. Brush management is commonly used in the South Texas region to increase herbaceous vegetation, manage



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Opening up areas of thick brush is often necessary for improving white-tailed deer habitat, but such actions reduce usage until the vegetation returns to the right stage.



Proportion of study area and male white-tailed deer use of 3 habitat types: motte, root plow, and brush following strip-motte root plowing to manage brush encroachment in South Texas. Deer were monitored using GPS tracking collars set to record locations at 30-minute intervals for 10 months following root plowing. Deer use was calculated by comparing the number of GPS points occurring in each habitat type.

undesirable plant species, and alter wildlife habitat, but it causes dramatic changes to the availability of resources needed by wildlife.

In summer 2008, we root-plowed a 1,087-acre block of dense re-growth mesquite in a strip-motte pattern on a ranch in South Texas. Mottes and brush outside the root-plowed strips were left undisturbed. The post-treatment landscape was comprised of 46% brush strips (approximately 280 ft wide), 51% root-plowed strips (approximately 311 ft wide), and 3% brush mottes (approximately 0.25–1 acre). We evaluated use of mottes, brush, and the root-plowed area by 10 GPS-collared male white-tailed deer from October 2008 to August 2009.

Preliminary results indicate that mottes were selected 4 times more often than brush, although mottes comprised only 3% of the study area. Deer selected brush (46% of the study area), but avoided the root-plowed area. This is likely a response to both cover and vegetation regrowth. Land managers are often presented with the task of balancing objectives and cost when manipulating the landscape. Motte creation is time-consuming and makes follow-up treatments more difficult. Understanding use of wildlife after brush management is important when developing management strategies.

Cooperative funding provided by the USDA Natural Resources Conservation Service, Jack R. and Loris J. Welhausen Experimental Station, and Exxon-Mobil Corporation.

Consumption of Feed Containing Ground Juniper by Deer and Feral Pigs

Jessica L. Glasscock, David G. Hewitt, Travis R. Whitney, Fred C. Bryant, and Susan M. Cooper

Junipers are native, invasive shrubs that occur on millions of acres of rangelands throughout the United States. Dense juniper reduces rangeland production for livestock and alters wildlife habitat.

Research shows that ground juniper can be used as a source of fiber in feedlot diets for cattle, sheep, and goats without adverse effects to animal health. Juniper contains potentially toxic plant compounds (e.g., condensed tannins and terpenoids) that act as a defense to herbivory, but white-tailed deer and mule deer eat juniper at different times throughout the year. Ruminant species such as deer have adaptations for coping with toxic compounds, but non-ruminant species (e.g., feral pig) may not tolerate these compounds and thus, reduce juniper consumption.



(A) Blueberry juniper has been chipped, dried, and ground and is ready to be mixed into animal diets as a fiber ingredient. (B) A deer pelleted supplement that includes ground juniper. Photos © Jessica Glasscock.

The goals of this research project are to evaluate preference and intake of supplemental pellets containing ground blueberry juniper by free-ranging white-tailed deer and feral pigs. Four supplements were designed that differed by source and percentage of roughage in the diet: alfalfa 15%, alfalfa 30%, blueberry juniper 15%, and blueberry juniper 30%. To evaluate consumption, we used trail camera video data at 4 supplemental feeding sites on the Welder Wildlife Refuge in Sinton, Texas.

Data collected from our study sites are being analyzed. Results from this project will help in designing white-tailed deer supplemental feed that is not consumed by non-target species, which will reduce supplementation costs.

Cooperative funding provided by Texas A&M AgriLife Research and the Rob and Bessie Welder Wildlife Foundation.

Long-term Study of Deer Captures on East Foundation Lands

Aaron M. Foley, David G. Hewitt, Randy W. DeYoung, Timothy E. Fulbright, J. Alfonso Ortega-Santos, Kory R. Gann, Michaela F. Rice, Seth T. Rankins, Landon R. Schofield, and Tyler A. Campbell

Long-term studies are invaluable for understanding natural systems because they can include a range of environmental conditions and present ample learning opportunities for undergraduate and graduate students. The East Foundation has sponsored a long-term deer capture project on 4 of their South Texas ranches since 2011. Student volunteers from Texas A&M University-Kingsville, Texas A&M University-College Station, Sul Ross State University, Tarleton State University, Texas State University, Texas Tech University, and Stephen F. Austin State University get an opportunity for real-world, hands-on learning and exposure to field research methods.

Volunteers collect body weight, age, antler size, blood, and tissue from each deer to help answer researcher questions about recruitment, age structure, stress, genetic structure, and the influence of age, rainfall, soil, and plant communities on body and antler size. The value of conducting research on East Foundation lands is that the deer are unmanaged, and thus serve as a baseline to compare with intensive management programs.

During 8 years, we captured 586, 813, 1,124, and 2,046 deer on the Santa Rosa, Buena Vista, El Sauz,

and San Antonio Viejo ranches, respectively. Further, 741 deer were recaptured, including several that were captured 6 times. One-third of deer captured were 6.5 years old or older. Of the 200 deer that were recaptured and were 6.5 years old and older, 27 were captured 3 times, 7 were captured 4 times, and 2 were captured 5 times. This indicates that some deer were probably 11 years old or older. Our long-term dataset provides a wealth of information that is needed to help us better understand white-tailed deer ecology in natural, unmanaged habitats.

Cooperative funding provided by the East Foundation.



© Randy DeYoung

Effects of the Major Histocompatibility Complex on Antler Development

David Navarro, Randy W. DeYoung, Charles A. DeYoung, Don A. Draeger, and Masahiro Ohnishi

Development of secondary sex characters (i.e., antlers and horns) is costly and is thought to be an honest signal of a male's quality. Antler development is influenced by age, nutrition, and genetics. Thus, below-average antler growth may be from poor body condition or pathogens instead of poor genes. The major histocompatibility complex (MHC) is part of the immune system that recognizes pathogens. The immunocompetence handicap hypothesis suggests that the immune system competes for resources with sexually selected ornaments. If true, a weak immune system should affect antler growth.

Genetic diversity at the MHC has been associated with antler growth in white-tailed deer and other species of cervids. Individuals with genetically diverse MHC alleles can respond to a wider range of pathogens, thereby devoting more resources to antler growth. This increased pathogen resistance may be especially important during rut, when high testosterone levels suppress the immune system of bucks. If the MHC is influencing antler development, selective harvest may affect the distribution of genetic variation in a population.

As part of a long-term study on the effects of culling white-tailed deer on antler development at the Comanche Ranch in Dimmit and Maverick counties, Texas, we are characterizing MHC diversity in relation to antler size. We will use repeated antler records for individual bucks and established parent-offspring relationships to study the relationship between antler development and MHC variation. Our findings will

CKWRI researchers are studying relationships among antler development, genetics, and environmental variables.

improve our understanding of factors that affect antler development in wild white-tailed deer and will have important implications for harvest programs.

Cooperative funding provided by the Comanche Ranch.

BOBWHITES AND OTHER QUAILS

Evaluation of Aerial Survey Techniques for Bobwhites on South Texas Rangelands

Zachary J. Pearson, Leonard A. Brennan, Humberto L. Perotto-Baldivieso, Fidel Hernández, and David DeLaney

Precise and reliable population estimates are needed to meet wildlife management goals and objectives. For northern bobwhites, landowners have relied on a variety of survey methods to estimate the distribution and abundance of this species. Such methods have ranged from morning covey-call counts and strip transects to distance sampling.

Helicopters have been found to be a practical platform to survey large areas of rangeland for wildlife. Over the last decade, winter (late November to early December) helicopter distance sampling surveys have been conducted annually on portions of the Santa Gertrudis and Norias divisions of the King Ranch to estimate bobwhite abundance with the goal of being able to set spatially explicit harvest quotas. Distance sampling from a helicopter to estimate bobwhite population density comes with many challenges. This study will continue working with the distance sampling methodology to create reliable and precise abundance estimates for bobwhites.

Advances in technology have made drones more common in natural resource management and research. This new and emerging technology offers the potential to safely sample bobwhite populations. Another objective of our study is to explore the usefulness of drones fitted with thermal imaging cameras to detect bobwhites. Drones are an evolving technology that is rapidly gaining popularity. With increased affordability, drones will be readily available for wildlife managers in the near future.

Cooperative funding provided by King Ranch, Inc. and South Texas Chapter of Quail Coalition.

Influence of Rainfall and Management on Northern Bobwhite Populations

Alec D. Ritzell, Fidel Hernández, Eric D. Grahmann, John T. Edwards, Dale Rollins, and Humberto L. Perotto-Baldivieso

Rainfall is a strong driver of quail populations on southwestern rangelands. Populations dramatically increase during wet periods and drastically decrease during drought. Quail managers have tried to regulate

these boom-and-bust fluctuations using grazing, supplemental feeding, predator control, and other practices. Given that rainfall can account for 70 to 90% of the variability in quail abundance, the effectiveness of quail management has been questioned. Our objectives are to (1) evaluate the effects of rainfall and management on bobwhite density and (2) determine if management can stabilize populations on rangelands that have variable rainfall.

We are building on current research to create a 5-year dataset (2014–2018) of bobwhite density on Texas rangelands. The dataset will be used to assess whether management can sustain quail density and reduce its variability. Helicopter surveys were conducted in the Rio Grande Plains and Rolling Plains of Texas during winter of 2017 and 2018 to determine bobwhite numbers at 10 sites. We will quantify bobwhite management on the study sites via landowner surveys and record rainfall. We will use bobwhite density, management intensity, and rainfall to evaluate their importance in maintaining densities. Our study will provide information that can be used to develop solutions for bobwhite conservation and management on Texas rangelands.

Cooperative funding provided by Texas A&M AgriLife Extension Service's Reversing the Decline of Quail Initiative, South Texas Chapter of Quail Coalition, and The Richard M. Kleberg, Jr. Center for Quail Research.

Testing Sustainable Harvest Prescriptions for Northern Bobwhites in South Texas

Donal A. Woodard, Leonard A. Brennan, Fidel Hernández, Humberto L. Perotto-Baldivieso, and Neal Wilkins

Over the past century, various harvest rates have been recommended for northern bobwhites. These rates have ranged from 0 to 70% of fall populations. The current recommendation for South Texas is a 20% harvest, which includes crippling losses. However, the feasibility of implementing a 20% harvest and the sustainability of remaining spring populations have not been tested.

The goal of this project is to implement and test the 20% harvest recommendation for northern bobwhites in South Texas. This study is taking place on East Foundation properties in Jim Hogg County. Two study areas have been designated: hunted (15,030 acres) and non-hunted (10,813 acres). The study areas are 12

miles apart and comprised of similar soils, vegetation, grazing pressure, and bobwhite densities (2017–2018 = 0.256 ± 0.03 (mean \pm standard error) quail per acre versus 0.248 ± 0.03 quail per acre). Line-transect distance sampling using a helicopter is being conducted to estimate bobwhite density on both areas. Surveys take place prior to hunting (November), every 35 days during the hunting season (mid-December, late-January), and after the hunting season (March).

In 2018–2019, a 20% harvest quota (422 quail) was designated for the hunted area based on the November survey results. The quota was reached after 59 hunts. Surveys indicated an initial population increase in December on both sites, followed by declining trends through March. The resulting spring densities were 0.156 ± 0.02 quail per acre on the hunted area and 0.158 ± 0.02 quail per acre on the non-hunted area. Preliminary results support the hypothesis that quail harvest is a defensible element of quail management in South Texas.

Cooperative funding provided by the East Foundation, The Richard M. Kleberg, Jr. Center for Quail Research, and South Texas Chapter of Quail Coalition.

Habitat Use by Northern Bobwhites in the Gulf Coast Prairie

Kelly M. Redmond, Nicole A. Hansen, William L. Lutz, Andrew P. Nicholson, Taylor R. Shirley, Fidel Hernández, Eric D. Grahmann, Leonard A. Brennan, Timothy Anderson, Michael E. Morrow, and Kirk Feuerbacher

Northern bobwhites have declined throughout their geographic range. Declines can be attributed mostly to the loss, fragmentation, and degradation of their habitat. Extensive information exists on the habitat requirements for the species. However, the Gulf Coast Prairie of Texas is a unique region for which conflicting information exists regarding bobwhite habitat use. Biologists often question whether the general attributes that characterize bobwhite habitat across Texas apply to this region. Our objective was to quantify habitat-suitability bounds of bobwhites in the Gulf Coast Prairie and compare these bounds with known attributes for the species in Texas.

Our study is occurring on 3 ranches (2,471-acre units on each) in Goliad and Refugio counties. We used radio telemetry to determine exact locations of bobwhites from April–August 2017 and 2018. We collected vegetation data at a subsample of bobwhite locations and at paired, random locations for

comparison. We estimated percentages of woody cover, grass cover, and forb cover. Using these data, we created continuous selection functions to identify habitat-suitability bounds for bobwhites.

Preliminary data analyses suggest that bobwhites selected areas with woody cover greater than 38%, grass cover less than 72%, and forb cover greater than 43%. These habitat-suitability bounds are within those found for bobwhites in other regions of Texas. Therefore, bobwhites in the Gulf Coast Prairie region of Texas do not appear to be unique in their habitat requirements. This study will provide important information to help guide bobwhite habitat management in the Gulf Coast Prairie.

Cooperative funding provided by the Coastal Bend Bays and Estuaries Program, U.S. Fish and Wildlife Service, Steve and Jon Lindley, D Bar J Ranch, Dunn O'Connor River Ranch, and JF Welder Heirs' Vidaaurri Ranch.

Spatial Analyses of Northern Bobwhite Hunting Dynamics

Donal A. Woodard, Leonard A. Brennan, Fidel Hernández, Humberto L. Perotto-Baldivieso, and Neal Wilkins

The recommended harvest strategy for northern bobwhites is based on sustained yield harvest theory. Under this strategy, total harvest is prescribed from a fall abundance estimate to meet what is considered a sustainable spring density. Testing these prescriptions requires additional data on the spatial dynamics of harvest and associated hunting pressure.



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Quail hunting is a popular sport in the rangelands of South Texas that generates thousands of dollars to landowners via hunting leases.

The aim of our study is to analyze the spatial aspects of bobwhite hunts in South Texas. This study is taking place on 15,030 acres of East Foundation property in Jim Hogg County. Monthly harvest quotas are prescribed based on the November survey, and quail hunting continues until quotas are met. Spatial hunting distributions are collected using GPS units on hunt trucks and hunting dogs, along with detailed hunting logs from each hunt.

A total of 59 hunts (167.6 hours) took place during the 2018–2019 quail hunting season. Hunting parties encountered 9.1 ± 0.4 (mean \pm standard error) coveys per morning and 4.5 ± 0.5 coveys per afternoon. Morning hunts covered 218 ± 7.9 acres at a rate of 67.1 ± 1.8 acres per hour. Evening hunts covered less acreage, averaging 109.0 ± 8.7 acres per hunt at 61.0 ± 4.2 acres per hour. Hunting pressure was applied to 6,271 acres. However, 46% of those acres were hunted on multiple occasions (see figure).

Analyses of spatial distributions from the first year of the study suggest that hunters target acreage with optimal hunting conditions (e.g., brush densities less than 20%) and higher bobwhite densities (e.g., greater than 0.25 quail per acre). Findings of our research will help wildlife managers strategically plan bobwhite

harvest and hunting pressure across properties according to sustained yield harvest prescriptions.

Cooperative funding provided by the East Foundation, The Richard M. Kleberg, Jr. Center for Quail Research, and South Texas Chapter of Quail Coalition.

Influence of Juniper on Montezuma Quail in the Edwards Plateau of Texas

Kristyn G. Stewart, Fidel Hernández, Eric D. Grahmann, Leonard A. Brennan, Humberto L. Perotto-Baldivieso, and Robert M. Perez

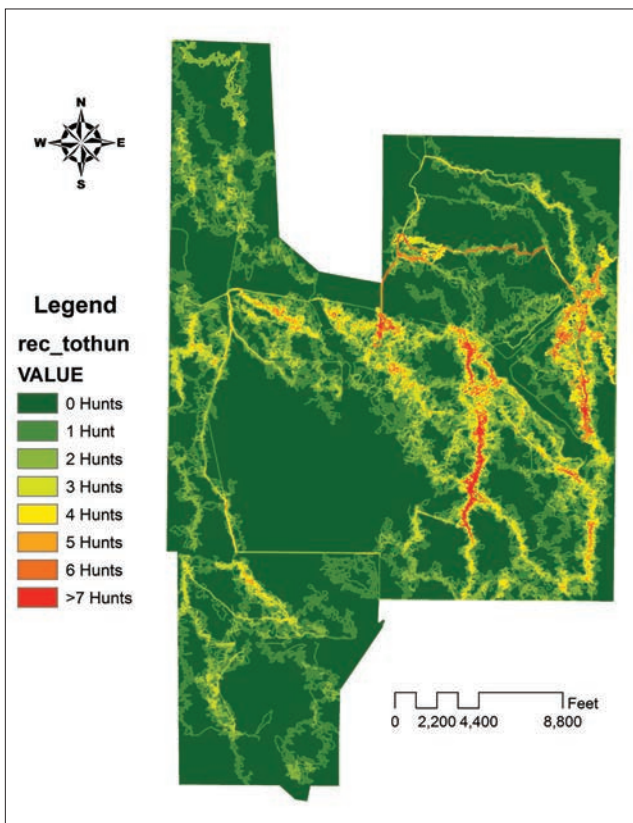
Montezuma quail inhabit the pine-oak and oak-juniper woodlands of Arizona, New Mexico, and Texas. In Texas, they are most common in the Davis Mountains. Over the years, fire suppression, overgrazing, and juniper encroachment have extirpated the species from most of the region. However, there is a remnant population in the Edwards Plateau. Recent clearing of juniper resulting from a change in land-ownership and increase in recreational use of the landscape have resulted in increased sightings of Montezuma quail.

Few studies have focused on the Montezuma quail population inhabiting the Edwards Plateau. Thus, there is a lack of information about Montezuma quail in this ecoregion. Our objective will be to quantify the influence of juniper encroachment on the distribution and habitat use of Montezuma quail in the Edwards Plateau region.

This study is being conducted at Kickapoo Cavern State Park and 2 ranches in Edwards and Kinney counties. We are placing GPS transmitters on Montezuma quail to monitor their movements, survival, reproduction, and habitat use during spring–autumn 2018 and 2019. We are also collecting vegetation data on Ashe juniper (density, percent cover, and height) and other habitat variables at both used and random locations.

Data will be used to determine habitat suitability and thresholds at which Montezuma quail exhibit habitat use or avoidance to certain areas. This research will provide needed information that can be used to guide juniper management in the Edwards Plateau that will benefit Montezuma quail.

Cooperative funding provided by the Texas A&M AgriLife Extension Service's Reversing the Decline of Quail Initiative, The Richard M. Kleberg, Jr. Center for Quail Research, South Texas Chapter of Quail Coalition, and Hill Country Chapter of Quail Coalition.



Total hunting pressure distribution for 59 quail hunts during the 2018–2019 hunting season on Buena Vista Ranch, Jim Hogg County, Texas.

Summer Insect Availability to Foraging Northern Bobwhites in South Texas

Nicole J. Traub, Tessa M. Green, Horacio Rodriguez, and Alan M. Fedynich

The northern bobwhite is one of the most extensively studied avian species in Texas. Bobwhites are primarily granivorous. Nevertheless, insects compose more than 80% of the diet of newly hatched chicks during their first 2 weeks of life and are an important protein source for hens. The downside in eating insects is that they can transmit helminth parasites. Thus, a better understanding of insect availability and abundance is needed.

We have been using sweep nets to collect insects on several South Texas ranches during the summer months of 2018 and 2019. The 3 most abundant insects by taxonomic order in the 2018 summer field collections were Orthoptera (grasshoppers, crickets, and locusts), Hemiptera (true bugs: aphids, leaf-hoppers, cicadas, and shield bugs), and Lepidoptera (butterflies and moths). In 2019, the 3 most abundant insect orders were Orthoptera, Hemiptera, and Coleoptera (beetles). We are presently identifying the insects collected and counting them to assess relative densities.

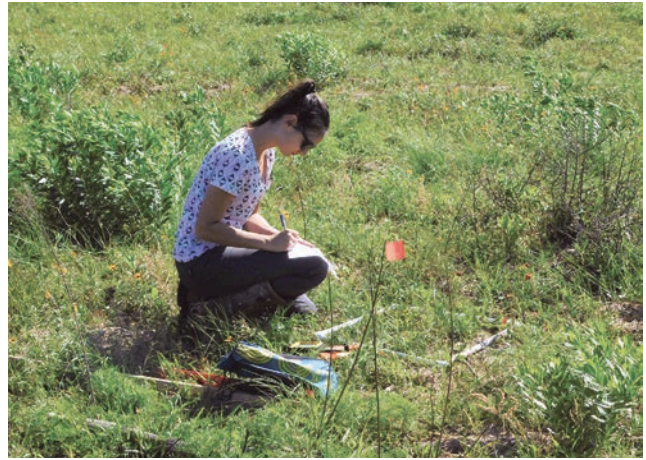
By gaining a better understanding about the insects available to foraging bobwhites, natural resource managers will be able to better manage habitats that promote insect abundance. Such management strategies will ultimately provide a needed food resource for bobwhite populations in South Texas.

Cooperative funding provided by the Rotary Club of Corpus Christi (Harvey Weil Sportsman Conservationist Award).

Gamebird Response to Control of Red Imported Fire Ants

Kelly M. Redmond, Nicole A. Hansen, William L. Lutz, Andrew P. Nicholson, Taylor R. Shirley, Fidel Hernández, Eric D. Grahmann, Leonard A. Brennan, Timothy Anderson, Michael E. Morrow, Kirk Feuerbacher, and Jay Kelso

Red imported fire ants have been considered a possible factor responsible for population declines of upland gamebirds on the Texas Coast. A recent treatment showing promise in the control of fire ants is the aerial application of Extinguish Plus (0.25% s-methoprene and 0.36% hydramethylnon). When fire ants decline there is an increase in native insects



© Brian Martinson

Graduate student Kelly Redmond is sampling vegetation and counting fire ant mounds at bobwhite locations.

(food resource for gamebirds), which may translate to greater survival of northern bobwhites and Attwater's prairie chickens in the Coastal Prairie of Texas. However, this benefit remains unclear. The objective of this research is to determine the efficacy of this aerially applied insecticide in (1) reducing fire ant numbers and (2) increasing gamebird demographic performance and density.

Our study is on 3 ranches in Goliad and Refugio counties. Each ranch contains 2 paired experimental units: a treatment and a control (1,235 acres each). The treatment unit received an aerial application of fire ant bait (Extinguish Plus) in April 2018, while the other unit remained untreated.

Pasture-wide estimates of fire ant abundance and mound density will be determined using baited cup traps and counting fire ant mounds. Bobwhite densities will be estimated using helicopter surveys. Adult bobwhite and prairie-chicken survival, brood survival, and nest success will be monitored using radio telemetry. We will also calculate fire ant mound density at each nest and radio location site.

Preliminary analyses indicated that bobwhite survival and density did not differ between the control site and the treated site either pre-treatment (2017) or post-treatment (2018), which indicated there was no benefit from the fire ant treatment. However, these results are preliminary and more detailed analyses are being conducted.

Cooperative funding provided by the Coastal Bend Bays and Estuaries Program, U.S. Fish and Wildlife Service, Steve and Jon Lindley, D Bar J Ranch, Dunn O'Connor River Ranch, and JF Welder Heirs' Vidaurri Ranch.

Publication of the Eagle Ford Shale Restoration Management Bulletin

Forrest S. Smith, David B. Wester, Anthony D. Falk, and Keith A. Pawelek

Restoration of native habitats affected by the production and transport of Eagle Ford Shale (EFS) oil and gas resources is an important conservation issue. Since 2008 when the production potential of the EFS was discovered by Petrohawk, effects of energy exploration on wildlife habitat have been significant. Landowners and many in the energy industry have placed emphasis on minimizing impacts to native habitats and wildlife, and on restoring native plant communities. Since the early days of exploration and infrastructure development in the EFS, the *South Texas Natives* Project and the Caesar Kleberg Wildlife Research Institute have played an important role in conducting research to provide restoration solutions.

In 2019, we began to summarize this body of research into a management bulletin. This bulletin will provide information to landowners and industry operators in an easy-to-use format. It outlines typical restoration scenarios in the EFS and provides concise actions based on objective research. This management bulletin will be updated as new knowledge is generated by ongoing projects.

We hope the publication of this bulletin will provide common sense solutions and be a source of common ground between operators and landowners from which to implement native plant restoration that will benefit South Texas wildlife. Restoration of EFS disturbances will be a critical conservation topic for decades to come. Online publication of the bulletin is scheduled for early 2020.

Cooperative funding provided by Peter and Fran Swenson and donors to the South Texas Natives Project.

Update on Progress and Accomplishments of the South Texas Natives Project

Anthony D. Falk, Keith A. Pawelek, Robert Obregon, Liisa L. Hewitt, John Reilley, Shelly D. Maher, and Forrest S. Smith

South Texas Natives (STN) has been a leader in native seed source development and restoration methodology research for the past 19 years. STN continues working on seed releases, addressing new restoration

challenges, and refining our knowledge of restoration ecology in South Texas.

In the past year, STN focused on increasing inventory of seed stocks of our past releases. This was needed to provide seed for commercial growers to maintain and expand production capacity. Many early seed releases are nearing the end of their initial 7-year production cycle. As a result, we have re-established seed increase fields of 12 releases to produce needed foundation seed. Limits on stand life of releases in commercial seed production are adhered to so as to prevent genetic shifts of selected plant material in response to growing location. STN tracks seed generations closely and maintains high quality seed of each selection using plants grown from the original wild seed collection.

Another important function of STN is providing seed mix and restoration guidance. Over the last year, we have provided over 25 seed mix recommendations to landowners and made seed mix recommendations for more than 500 miles of pipeline built in South Texas. Because of the generosity of our many sustaining supporters, STN plans to continue facilitating commercial supplies of locally adapted native seed, conduct needed restoration research, and assist constituents with restoration recommendations for years to come.

Cooperative funding provided by Robert J. Kleberg, Jr. and Helen C. Kleberg Foundation, Lee and Ramona Bass Foundation, Joan and Herb C. Kelleher Foundation, A.E. Leonard Family Giving Council, ConocoPhillips, Peter and Fran Swenson, Enbridge, Inc., Caesar Kleberg Partners Program, and numerous donors to the South Texas Natives Project.

Managing Tanglehead with Prescribed Fire and Herbicides

David B. Wester, Sandra Rideout-Hanzak, Megan K. Clayton, and Dustin A. Golembiewski

Tanglehead is a native warm-season grass common on sandy-textured soils throughout the Coastal Sand Prairie. Tanglehead has increased throughout this region since the late 1990s. It often forms monocultures whose habitat quality is less than optimum for wildlife. We have investigated the combined effects of prescribed fire, herbicidal application, and discing as a control treatment to reduce tanglehead abundance. Previous results have shown promise. The

soil disturbance caused by discing, however, has the potential to stimulate tanglehead seedling emergence from the soil seed bank.

In spring 2019, we initiated a study of the combined effects of burning and herbicidal control on tanglehead and other perennial grass mortality. We burned study plots in tanglehead-dominated areas in Jim Hogg County in spring 2019. In early summer, we applied glyphosate, glyphosate plus a pre-emergent herbicide, or imazapyr to plots that had been burned. We are monitoring perennial grass density in plots that were burned only, burned and sprayed, or not treated either with fire or herbicides. With this research, we hope to further document perennial grass response in tanglehead-dominated areas to certain land management practices aimed at improving wildlife habitat quality.

Cooperative funding provided by Ford Smith, the Invasive Grass Program of CKWRI, and Texas A&M AgriLife Extension.

A Photographic Guide to the Vegetation of the South Texas Sandsheet

Dexter Peacock and Forrest S. Smith

The South Texas Sandsheet is an area of critical importance to wildlife and native plants. Inherent botanical diversity along with a high degree of endemism makes plant identification in this region a challenge. Because of the value of the region to hunters, outdoor recreationists, and ranchers, there is interest in identification of the flora in the region. However, no specific resources have been published that encompass the common plants found in the region within a single volume. Available plant identification books focus on adjacent regions or deal only with specific groups of plants such as forbs, grasses, or woody plants.

In 2017, we began work on a photographic guide to the common vegetation of the South Texas Sand Sheet. One goal was to include plants from all vegetation types in a single volume for ease of use. Another goal was to provide descriptions of the plants in laymen's terms and high-quality photographs organized by visual appearance to ensure the book was easily usable by those without formal training in botany. Over 200 plant species are included.

The resulting book is to be published by Texas A&M University Press titled *A Photographic Guide to the Vegetation of the South Texas Sandsheet*. It is scheduled to be available for purchase in late 2019.

This photographic guide book should help landowners, managers, and recreational users of the Sand Sheet to identify the common plants easily and accurately and aid in the appreciation and conservation of this unique region.

Cooperative funding provided by Rowan Companies, Caesar Kleberg Partners Program, and the Texas A&M University-Kingsville Perspectives on South Texas Book Series.

Collection, Development, and Release of Native Seed Resources for Texas

Forrest S. Smith, Keith A. Pawelek, Rob Ziehr, John Reilley, Robert A. Shadow, Brandon Carr, Douglas L. Jobes, Tyler C. Wayland, John R. Bow, Samuel R. Lutfy, Colin S. Shackelford, and Anthony D. Falk

Commercial native seed sources are an important resource for restoration of native plant communities in Texas. Interest in rangeland restoration through federal conservation programs using ecotypic native seeds is growing. This has resulted in high demand for seed sources. The *Texas Native Seeds* Program (TNS) and USDA Natural Resources Conservation Service (NRCS) Plant Materials Centers (PMC) in Kingsville, Nacogdoches, and Knox City are cooperating to address these needs through a Cooperative Ecosystem Studies Unit Grant.

Objectives include identifying species for NRCS conservation programs in each region of the state, making seed collections, and cooperating with the PMCs to select, increase, and release germplasm for



© Colin Shackelford

Native seed collection efforts are being conducted across Texas by staff of the *Texas Native Seeds* Program.

large scale production by commercial seed companies. TNS and PMC personnel are also collaborating on establishing research and demonstration seeding plots. This will help us learn more about native plant establishment dynamics and management requirements associated with rangeland restoration. Providing science-based guidance to NRCS staff, field offices, and landowners on the selection of suitable native plant seed mixes for restoration projects is also a function of the project.

In 2018, 734 native seed collections were made across Texas and placed in the PMC Program inventory because of this collaboration. In spring 2019, we began evaluations of 7 native plant species for future commercial release. In partnership with PMC staff, we hope to finalize release of 6 native seed releases for Texas by the end of 2019.

Cooperative funding provided by a Cooperative Ecosystem Studies Unit Grant from the USDA Natural Resources Conservation Service-Texas and donors to the Texas Native Seeds Program.

Determining Crude Protein in Tanglehead Using Unmanned Aerial Vehicles

Rider C. Combs, J. Alfonso Ortega-Santos, Humberto L. Perotto-Baldivieso, Sandra Rideout-Hanzak, David B. Wester, Douglas R. Tolleson, Michael T. Page, Alexandria M. DiMaggio, and Justin P. Wied

Use of the unmanned aerial vehicle (UAV) for data collection in scientific research has been increasing in recent years. UAVs have been applied to many



© Rider Combs

Graduate student Michael Page flying an unmanned aerial vehicle for mapping tanglehead.

disciplines of the scientific community. The crop science industry uses UAVs to monitor quality of plants to make adjustments to improve production. We will be testing UAVs to improve production in rangelands and cattle operation efficiency. Our objective is to determine the relationship between crude protein in tanglehead and the imagery collected using a UAV.

Three flights will be conducted on a 10-acre prescribed burn plot in Jim Hogg County, Texas. Prior to each flight, individual tanglehead plants will be marked. These individual plants cover the different growth stages of grass. The distribution will be 20 plants only growing new leaves, 20 plants producing new stems, and 20 plants producing seed heads.

Using the UAV to collect aerial imagery, we will obtain a greenness color value of the individual marked plants. After the flight is complete, each plant will be clipped, individually bagged and sent off to a forage lab for percent crude protein analysis. Through statistical analysis and building on other research, we aim to develop a method to obtain crude protein per acre for animal nutritional recommendations.

Cooperative funding provided by the Jones Ranch.

Commercial Seed Production of Texas Native Seeds Program Seed Releases

Keith A. Pawelek, Forrest S. Smith, Anthony D. Falk, Dean N. Williams, and Nick Bamert

Texas Native Seeds (TNS) plant releases have been in high demand in 2018–2019. This has been in large part because of demand for native seeds for pipeline right-of-way restoration. This growing source of demand has stretched commercial seed supplies thin, and has spurred increased interest from commercial seed companies. Commercial growers also reported increased interest from private landowners seeking to restore or diversify habitat on their properties. In total, commercial producers harvested over 54,000 lbs of native seed developed and released by TNS in the 2018 growing season. Almost all of this seed was produced as Texas Department of Agriculture Certified-Selected Texas Native Germplasm.

Commercial production of Cibolo Germplasm little barley, a cool season annual grass, was started in fall 2018. The largest anticipated use of this seed selection is for cool season erosion control plantings by the Texas Department of Transportation along highways during construction. Several upcoming grass

releases adapted to West and Central Texas were planted in spring 2019 to begin commercial production, including purple threeawn and whiplash pappusgrass. Continued strong demand for native seeds is anticipated for the immediate future. This is in large part because of reclamation needs associated with proposed pipeline construction. We continue to strongly encourage consumers to preorder native seed for their large projects to guarantee availability.

Cooperative funding provided by the numerous donors to the Texas Native Seeds Program and through seed production license agreements with Amigo Genetics, Bamert Seed Company, and Douglass W. King Seed Company.



© John Bow

Central Texas Native Seed Project Collection, Evaluation, Increase, and Release

John R. Bow, Forrest S. Smith, Keith A. Pawelek, Anthony D. Falk, Colin S. Shackelford, James P. Muir, and Chase A. Murphy

The goal of the *Central Texas Native Seed Project* (CTNSP) is to develop locally adapted native seed sources for the central portion of Texas. This is accomplished through collecting, evaluating, selecting, increasing, and eventually releasing native plant seeds that can be commercially produced. The CTNSP collects native seed from over 67 counties encompassing several ecoregions. Evaluations are conducted at the Texas A&M AgriLife Research and Extension Center at Stephenville, the USDA Natural Resources Conservation Service James E. “Bud” Smith Plant Materials Center at Knox City, and the Sandbrock Ranch near Aubrey.

Sideoats grama and seep muhly were established at all 3 locations in 2018. Data collection includes growth measurements, plant characteristic rankings, seed production potential, and seed quality. Collections in 2018 were focused on Indiangrass and gayfeather. In May 2019, new evaluation plots of these species were established from greenhouse transplants. These evaluations consisted of 60 populations of Indiangrass and 22 populations of gayfeather.

Evaluations completed in 2018 resulted in 2 grass species being selected for release: hairy grama and tall grama. Transplants of these selections were established in isolated field plots to increase seed at the Stephenville location. Seed harvested will be released as a select native germplasm by *Texas Native Seeds* in 2020. These future releases and 3 releases being grown (little bluestem, silver bluestem, and meadow

Sideoats grama and other native grasses are currently being evaluated for future release in Central Texas.

dropseed) will provide much needed seed sources for reclamation and restoration in Central Texas.

Cooperative funding provided by the Texas Department of Transportation, USDA Natural Resources Conservation Service, Stillwater Foundation, Sandbrock Ranch, Rod Sanders, and Texas A&M AgriLife Research and Extension Center at Stephenville.

Long-term Response of Tanglehead to Prescribed Burning and Cattle Grazing

Alexandria M. DiMaggio, J. Alfonso Ortega-Santos, Humberto L. Perotto-Baldivieso, Chase H. Walther, Sandra Rideout-Hanzak, and David B. Wester

Tanglehead is a perennial bunchgrass native to South Texas. It has invasive tendencies and is known to create dense monocultures. Our study is a continuation of a 2-year study that has been monitoring the effects of prescribed fire and cattle grazing on (1) the composition of a plant community dominated by tanglehead and (2) cattle and wildlife use of tanglehead-dominated areas treated with prescribed fire.

A 246-acre pasture dominated by tanglehead was chosen in Jim Hogg County, Texas for study. Nine experimental plots are being used, which consist of 3 control plots and 6 plots that are treated with a prescribed burn (November 3rd, 2016 and February 3rd, 2019). This site has been continuously grazed at a stocking rate of 0.25 animal units per acre per year. Three grazing exclosures are set in each of the 9 plots and an area of vegetation inside and outside of the

grazing enclosure is sampled every 35 to 90 days to estimate forage standing crop (FSC) use. The foliar cover percentage of each species is recorded, and all vegetation within the sampling frame is clipped and bagged to determine dry FSC. Tanglehead coverage, forage use, species richness, total plant cover, and FSC will be calculated for each of the 9 plots.

This study will likely show plant species richness will increase by reducing the cover of tanglehead through concentrated cattle grazing in the burned plots. Land managers may be able to use burns to increase grazing use on rangelands dominated by tanglehead.

Cooperative funding provided by the Jones Ranch.



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TxDOT Native Plant Integration Program for Texas

Forrest S. Smith, Keith A. Pawelek, Anthony D. Falk, Tyler C. Wayland, Douglas L. Jobes, John R. Bow, Colin S. Shackelford, Shyla E. Rabe, Liisa L. Hewitt, Dennis K. Markwardt, and Travis Jez

The Texas Department of Transportation (TxDOT) is one of Texas’ largest landowners and right-of-way managers. Revegetation to meet federal mandates for cover and erosion control on roadsides is a major activity overseen by the agency. TxDOT needs native plants, but commercial supplies of locally-adapted seed to meet the agency’s needs are inadequate in some regions of the state.

In September 2019, we began a project to address these limitations. The project is similar to work done with TxDOT’s support in South Texas from 2001–2011 and West and Central Texas from 2012–2018. We are now addressing native seed supply limitations impacting TxDOT in East Texas, the Coastal Prairie, and Permian Basin/Panhandle regions. Our goals are to collect, select, increase, and commercialize locally-adapted native seed sources for each region.

Upon successful commercialization of new seed selections, we will assist TxDOT in revising their standard seeding specifications for erosion control. This will result in greater native plant use by TxDOT. We are also working to increase commercial supplies of past seed releases, and on improving the availability of native pollinator plant seed for use by TxDOT.

Our efforts should have beneficial impacts on the use of native plants for revegetation throughout Texas. It will be especially beneficial on over 1 million acres of road right-of-ways managed by TxDOT. Supplies

Cibolo Germplasm little barley has been developed for use as a cool-season annual cover crop on road right-of-ways through the TxDOT Native Plant Integration Program.

of seed commercialized through the project will also benefit large scale restoration efforts by private landowners, the energy industry, and other agencies.

Cooperative funding provided by the Texas Department of Transportation.

Release of Hooded Windmillgrass and Sand Dropseed Ecotypes for Central Texas

John R. Bow, Forrest S. Smith, Anthony D. Falk, Keith A. Pawelek, Brandon Carr, James P. Muir, and Chase A. Murphy

The *Central Texas Native Seed* Project, USDA Natural Resources Conservation Service James E. “Bud” Smith Plant Materials Center at Knox City and Texas A&M AgriLife Research and Extension Center at Stephenville are releasing Burnet Germplasm hooded windmillgrass and Taylor Germplasm sand dropseed. Each release is a blend of 4 populations collected from native populations in the Edwards Plateau, Rolling Plains, Cross Timbers, and Blackland Prairies.

Sand dropseed and hooded windmillgrass are early seral, warm season, perennial grasses. Both grasses have excellent early establishment features. These seed releases should be useful for prairie restoration, highway right-of-way revegetation, energy exploration site reclamation, and rangeland seeding mixes. Selections of populations in each release were made based on plant performance data collected over 3 years at evaluation sites in Stephenville and Knox City.

Selected seed populations were increased from the original seed collections and grown in isolated fields at the Texas A&M AgriLife Research and Extension Center at Stephenville. They are then blended for release. Each of these releases has been licensed to Amigo Genetics, Bamert Seed Company, and Douglass W. King Seed Company for commercialization.

Seed of Burnet Germplasm hooded windmillgrass and Taylor Germplasm sand dropseed should be commercially available for purchase by 2020. These releases will aid in the restoration of native plant communities within Central Texas.

Cooperative funding provided by the Texas Department of Transportation, USDA Natural Resources Conservation Service, and donors to the Central Texas Native Seed Project.

Native Plant Demonstration Garden in Downtown Midland

Samuel R. Lutfy, Colin S. Shackelford, Anthony D. Falk, Jesse Wood, Keith A. Pawelek, and Forrest S. Smith

The Permian Basin is the largest oil and gas producing region in the United States, and Midland is a center of operations for many companies in the oil and gas industry. Concho Resources, Inc. partnered with the Permian Basin and Panhandle Native Seed Project (PBPNSP) to establish and maintain a native plant and restoration demonstration garden in Midland in 2018 to help inform the oil and gas industry about our efforts. This garden showcases native plant species that can be used in habitat restoration projects throughout the region.



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A native plant demonstration garden has been established in Midland in partnership with Concho Resources, Inc.

Located near Concho's headquarters, the garden contains plantings of 5 species of native wildflowers and 21 species of native grasses found in the region. Commercial seed of some of these species is available for use. Seed supplies of others used in the project are being developed by the PBPNSP. Each species is displayed in a 10 ft x 10 ft plot with 5 ft walking rows in-between to give visitors easy access for viewing and to showcase the variety of growth habits and aesthetics associated with native plants of the region. In addition, a quarter-acre of land adjacent to these plots was seeded in spring 2019 with an experimental native seed mixture to show the positive impact of restoration seeding efforts.

Interpretive signage describing the plantings and the PBPNSP was added in 2019. This demonstration garden has facilitated meetings with industry professionals and public organizations that support our desire to educate people about the benefits of native plant restoration and conservation in the Permian Basin.

Cooperative funding provided by Concho Resources, Inc.

East Texas Natives Project Collections and Evaluations

Tyler C. Wayland, Robert A. Shadow, Jacob L. Sparger, Keith A. Pawelek, and Forrest S. Smith

Native plant restoration is in high demand throughout the East Texas region. This is due to land use changes, increased highway and pipeline construction, energy production and transfer, and efforts to offset habitat fragmentation caused by urbanization and development. However, in East Texas, there are few regionally adapted or ecotypic native seed sources available commercially to meet these demands. To solve this problem, *Texas Native Seeds* expanded into the East Texas region in February 2018.

We have made over 370 native seed collections of 46 species across 57 East Texas counties. Seed collections were made along county roads and on private and public lands and National Forests.

Indiangrass and silver bluestem were selected as the first species to be evaluated for seed source development in the region. In May 2019, we established the project's first evaluation plots at the USDA Natural Resources Conservation Service East Texas Plant Materials Center in Nacogdoches and at Daisy Farms near Paris. These sites will be used to evaluate adaptation and performance of native populations of these

species collected from East Texas for selection of suitable ecotypes for commercial seed production.

The *East Texas Natives* Project should help improve supply of locally adapted native seed of a large variety of native plants. Over time, this will result in the availability of native seed mixes for use in a wide range of applications.

Cooperative funding provided by Ellen Temple, Texas Department of Transportation, USDA Natural Resources Conservation Service, U.S. Forest Service, Joan and Rufus Duncan, Amanda Haralson and Thomas Livesay, Susan Temple, the Pineywoods Foundation, TransCanada Pipeline Company Charitable Fund, and the East Texas Communities Foundation.

The Rate of Spread of Tanglehead under Prescribed Burning and Cattle Grazing

Rider C. Combs, J. Alfonso Ortega-Santos, Humberto L. Perotto-Baldivieso, Sandra Rideout-Hanzak, and David B. Wester

Tanglehead is a native perennial bunchgrass that is found throughout South Texas. This native grass is a drought tolerant warm season grass, which has been drastically increasing its distribution over the past 15 years. As tanglehead matures the stems become coarse and unpalatable to cattle for grazing. The reduction in grazing pressure and the aggressive nature of the plants allow it to dominate South Texas rangelands.

The objective of our study is to determine the rate of spread of tanglehead under 4 treatment combinations. The study area is located south of Hebronville, Texas on the South Texas Sand Sheet and is dominated



© J. Alfonso Ortega-Santos

Prescribed fire stimulates new growth of tanglehead, thereby increasing its palatability for cattle.

by tanglehead. Three 10-acre prescribed burns were implemented on a 236-acre pasture in February 2019. Ten head of cattle are in the pasture and allowed to continuously graze on the non-burned areas (control) and the patch burns. Sixty individual tanglehead plants will be monitored over the course of 2 years. Half of the plants will be excluded from grazing by fencing off each plant. The percentage of bare ground, litter, tanglehead foliar cover, and foliar cover of other species will be recorded. Tanglehead seedlings, seed-head per plant, and plant basal circumference will also be documented.

We aim to supply information on how fast tanglehead can increase from the time when spotty tanglehead plants may be considered proper nesting cover for grassland birds to the time it becomes a monoculture, thereby reducing native plant species richness and causing habitat degradation.

Cooperative funding provided by the Jones Ranch.

Restoration of Monarch Habitat on the Valley Crossing Pipeline

Anthony D. Falk, Forrest S. Smith, Keith A. Pawelek, Devin Hotzel, and William R. Murphy

The installation of pipelines has the potential to damage native habitats. If restored prudently, new right-of-ways can be an opportunity to improve habitat for some wildlife. We are working with Enbridge, King Ranch, and Kenedy County landowners to study native plant restoration to benefit monarch butterflies along the Valley Crossing Pipeline (VCP).

Beginning in 2017, we began working with seed producers and landowners to design a native plant seed mix that includes nectar plants used by monarchs for planting on the Kenedy County portion of the VCP. The planting area of the right-of-way was approximately 200 ft wide by 56 miles long and was adjacent to U.S. Highway 77 through Kenedy County. The right-of-way was planted between September 2017 and July 2018 with a mix of 19 locally-adapted native grasses and forbs developed by the *South Texas Natives* Project.

In autumn 2018, we began monitoring vegetation on and directly adjacent to the right-of-way. This provided data on the restoration effort and allowed us to determine the success of establishing nectar plants for monarchs. Early results are similar to those seen at other sandy restoration sites in the Sand Sheet, with

volunteer forbs dominating the site. Overall, seeded species densities in less than 1 to 2 years since planting were greater than 0.5 seeded species per ft², indicating successful short-term revegetation of the right-of-way. We will continue to collect vegetation data twice annually for the next 2 years to determine long-term results.

Cooperative funding provided by Enbridge, Inc. and King Ranch, Inc.

Licensing the Commercial Seed Production of Native Seed Releases

Keith A. Pawelek and Forrest S. Smith

Commercial seed production is perhaps the most important step in making ecotypic native seed available to consumers. Ultimately, the goal is to have an ecosystem-level positive impact on native habitat restoration in Texas.

After almost 20 years of attempting to commercialize native seed germplasm releases, *Texas Native Seeds* (TNS) has tried many processes to commercialize seed and incentivize commercial growers to meet market demand. After much disappointment in voluntary production of our seed releases, TNS followed the direction of crop developers and started to license production rights to commercial growers in 2008. This change has been successful from a seed production standpoint, and it continues to motivate commercial production of seed releases made by the program. In recent years, licensing agreements have helped to ensure that seed availability to consumers occurs within 2 years of germplasm release. In addition, seed



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Santiago Germplasm silver bluestem is being licensed to commercial seed companies for large scale production.

supply has generally been maintained throughout the life of the agreements.

In recent years, we began to request bids for licensed production of each release. This has enabled all commercial producers to have an equal opportunity to produce our releases as well as enabling us the ability to license multiple growers if deemed advantageous. In 2010, we licensed production of 10 upcoming native grass releases to 2 to 3 companies. In addition to spurring commercial production, a tenant of each of these licenses is that all seed must be produced under the Texas Department of Agriculture’s Certified Seed Program. This helps ensure high quality and cleanliness of the seed produced.

Cooperative funding provided by the numerous donors to the Texas Native Seeds Program.

Texas Native Seeds Program releases that were licensed to commercial seed companies for production in 2018–2019.

Species	Release name	Growers
Little barley	Cibolo Germplasm	Douglass W. King Seed Co., Bamert Seed Co., Amigo Genetics
Silver bluestem	Santiago Germplasm	Douglass W. King Seed Co., Bamert Seed Co., Amigo Genetics
Hooded windmillgrass	Burnet Germplasm	Douglass W. King Seed Co., Bamert Seed Co., Amigo Genetics
Sand dropseed	Taylor Germplasm	Douglass W. King Seed Co., Bamert Seed Co., Amigo Genetics
Purple threeawn	Menard Germplasm	Douglass W. King Seed Co., Bamert Seed Co.
Purple threeawn	Loma Germplasm	Douglass W. King Seed Co., Bamert Seed Co.
Whiplash pappusgrass	Permian Germplasm	Douglass W. King Seed Co., Bamert Seed Co.
Slim tridens	Bexar Germplasm	Douglass W. King Seed Co., Bamert Seed Co.
Rough tridens	Brystal Germplasm	Douglass W. King Seed Co., Bamert Seed Co.
Sideoats grama	Brewster Germplasm	Douglass W. King Seed Co., Bamert Seed Co.

Woody Cover Classification Using Very-High Resolution Imagery

Michael T. Page, Humberto L. Perotto-Baldivieso, David B. Wester, and Alison R. Menefee

Recent studies have shown that woody cover structure can be used as thermal refuge for various wildlife species. Quantifying thermal refuge over large scales can greatly improve our ability to assess wildlife habitat. Including woody cover structure into wildlife habitat models is also needed for developing better habitat management strategies.

The aim of this study is to develop new methods and approaches to quantify woody cover structure on South Texas rangelands. The objectives are to (1) capture, process, and quantify woody vegetation cover from unmanned aerial vehicle (UAV) imagery, (2) combine UAV information with very-high resolution imagery to develop a spatial model for woody cover structure, and (3) evaluate these over large areas of South Texas rangelands.

We are using the Tio and Janell Kleberg Wildlife Research Park and South Pasture Research Area as study sites. At each location, we are flying a Phantom 4 Pro UAV 100 ft above ground level in a double grid pattern. We are processing the data to generate 1-inch resolution imagery. We will evaluate other areas of South Texas once our model is developed.

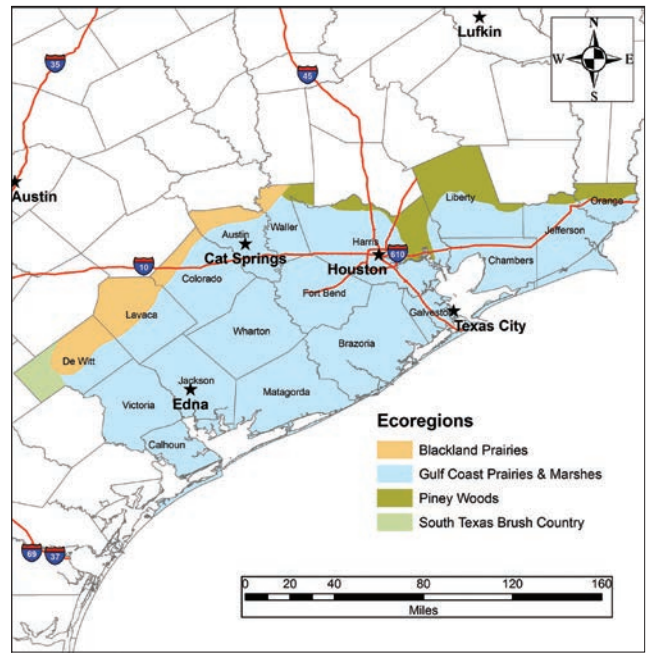
This project will improve our understanding of how woody vegetation structure can be modelled at large scales for habitat attributes such as thermal refuge. It will also provide insight about using spatially based methodologies for habitat assessment.

Cooperative funding provided by the Texas A&M University-Kingsville Research Award and the USDA Natural Resources Conservation Service.

Ecotypic Seed Source Development in the Coastal Prairies Region

Douglas L. Jobs, Forrest S. Smith, Keith A. Pawelek, Anthony D. Falk, Aaron D. Tjelmeland, Garry S. Stephens, and James W. Willis

Seed collections from remnant prairie sites within the Coastal Prairies and Marshes ecoregion are a major focus of the *Coastal Prairies Native Seed Project*. We made 175 seed collections of various native species of grasses and forbs throughout the region in 2018. Our



Coastal Prairies Native Seed Project area of focus in southeast Texas (image produced by the CKWRI Wildlife Technologies Lab).

focus is on species of interest for restoration identified by collaborating partners, seed industry contacts, and our regional technical committee.

Most seed collection efforts are seasonal and opportunistic. Collection sites typically are where major soil disturbances have not occurred and the sites have limited manipulation of vegetation. While private property is a good source for collections, other areas including railroad right-of-ways, roadside fence lines, and county roads provide some of the best seed collection opportunities.

Soil types are an important consideration for developing locally adapted native seed sources. Therefore, we selected evaluation sites for collections that would be representative of sandy and clay prairie sites, which are the predominant soils of the region. Data are being collected on second-year collections of little bluestem and knotroot bristlegrass. Once the evaluations are complete a decision should be made for possible seed increase of these species in 2020. In addition, we began new evaluation studies for collections of Indiangrass and silver bluestem in summer 2019.

Cooperative funding provided by Texas Department of Transportation, USDA Natural Resources Conservation Service, Rotary Club of Corpus Christi (Harvey Weil Sportsman Conservationist Award), Henderson-Wessendorf Foundation, Lavaca Navidad River Authority, and donors to the Coastal Prairies Native Seed Project.

Railway Ranch Re seeding Research to Benefit the Permian Basin Region

Samuel R. Lutfy, Colin S. Shackelford, David Dick, Anthony D. Falk, Keith A. Pawelek, and Forrest S. Smith

Oil and gas activity in the Permian Basin region continues to increase. Consequently, tens of thousands of acres of rangeland are negatively impacted. These disturbed areas would greatly benefit from native habitat restoration.

Our program works to develop new plant materials using locally-adapted seeds for restoring native habitats. We are also researching the utility of available native seeds for immediate restoration needs and to better understand the limitations to successful re seeding projects. These efforts will help guide seed source development work and will provide knowledge needed to develop technical recommendations for restoration plantings.

At the Railway Ranch near Odessa, we have installed a restoration research project to learn more about seed adaptation to common soil series, effects of planting season on establishment, influence of rabbit herbivory on establishment, and the utility of 2 commonly used seeding implements. In both fall 2018 and spring 2019, we established 5 acres of trial fields using native seed mixes that contained 20 species. Three replicate plantings for each period were made using a Trillion broadcaster seeder and a Truax no-till drill. Within these treatments, rabbit exclosures were built to assess the impact of herbivory.

First-year data are currently being collected and analyzed. The sites will be monitored for several years, and results will be used to guide seed source



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Restoration of native grasses and forbs is being studied at the Railway Ranch in the Permian Basin.

development and refine recommendations for Permian Basin re seeding projects.

Cooperative funding provided by Railway Ranch.

Sandbrock Ranch Native Grassland Restoration Research Project

John R. Bow, Jamie Miller, Forrest S. Smith, Anthony D. Falk, and Keith A. Pawelek

The *Central Texas Native Seed Project* (CTNSP) in 2018 began a collaboration with Sandbrock Ranch near Aubrey. The goal is to improve knowledge on restoration techniques in converting former cropland in the Blackland Prairie to native grassland. The objectives are to plant seed and collect data on 100 acres of restored land for 3 years and establish transplant evaluation plots of plants used in the restoration. CTNSP is providing technical support for seed mixtures, assisting with planting and management, collecting data on species performance, and evaluating plant establishment.

To compliment restoration efforts and research, CTNSP established evaluation plots on the ranch. This new location provides a much-needed evaluation site in the Blackland Prairies. Data on plant performance of accessions are collected monthly and compared to data from evaluations at Knox City and Stephenville.

Establishment of the restoration and evaluation projects has greatly extended the geographic extent of the *Texas Native Seeds Program*. We hope to use the projects in education and outreach efforts to stimulate greater awareness of the importance of native grasslands in North Texas. Our research will aid landowners, agencies, and the public who are interested in native plant restoration within this region.

Cooperative funding provided by Rod Sanders and Sandbrock Ranch.

Restoration of Native Plant Communities in the South Texas Sand Sheet

Anthony D. Falk, Keith A. Pawelek, Bart Dupont, Jimmy Rutledge, and Forrest S. Smith

The South Texas Sand Sheet is one of the best strongholds for native plant communities and wildlife in South Texas. Native plant communities have proven



© Anthony Falk

Restoration of diverse native plant communities following disturbance is a desire of many landowners in the South Texas Sand Sheet.

difficult to restore after disturbance due to sandy soils, narrowly adapted plant ecotypes, and invasion of non-native grasses. *South Texas Natives* (STN) is working with El Coyote Ranch to address these challenges and develop strategies to improve restoration outcomes in the South Texas Sand Sheet. Over the past few years, we have begun restoration studies on degraded range sites, former drilling pads, and an electric transmission line right-of-way. Data are being collected on restoration outcomes to assess our efforts.

Factors evaluated include seed mix composition, non-native grass control techniques, and planting methodology. Preliminary results indicate that high percentages of early seral grasses in Sand Sheet seed mixes are needed for success. Repeated, multi-season application of glyphosate herbicides prior to seeding can be effective for controlling non-native grasses on disturbed sites. Without such efforts, initial establishment of native plants can be difficult.

Analysis of exclosure data suggests that the use of livestock grazing within months after seeding can help suppress the reinvasion of non-native grasses. This is especially true for Guinea grass, though some negative effects on late seral native plant establishment are likely. We have also examined the use of 2 seeding tools, a Truax flex II drill and a Trillion drop seeder, and documented similar establishment using both implements. STN personnel will use results from these projects to refine and improve restoration recommendations for the Sand Sheet.

Cooperative funding provided by the Lee and Ramona Bass Foundation and El Coyote Ranch.

Soil Organic Carbon Effects on Rangeland Productivity

Douglas J. Goodwin, J. Alfonso Ortega-Santos, Humberto L. Perotto-Baldivieso, Stephen L. Webb, and William E. Fox

The health of the soil has received considerable attention recently. Soil systems are critical to grazing land productivity and are thought to mitigate climate change. However, few studies have outlined the relationships with soil organic carbon on soil dynamic properties, plant production, and plant species richness on grazing lands in the southern Great Plains. Besides quantifying relationships among soil and productivity, robust tools and techniques are needed to measure soil metrics quickly, affordably, and accurately.

A method used to mitigate cost concerns of studying soil resources is spectroscopy. Spectroscopy measures the reflectance of light in specific wavelengths and is used to estimate chemical and physical properties. Our objectives are to (1) determine the effectiveness of estimating soil organic carbon using visible, near, and mid-infrared spectroscopy and (2) understand soil organic carbon's influence on metrics that affect grazing land production, such as soil water holding capacity and plant productivity.

Our study will determine the above relationships on 14 similarly managed grazing land operations in southern Oklahoma and northern Texas. Soil and vegetation metrics will be measured at these locations and the data analyzed. This study will reveal potential soil carbon relationships and determine if emerging spectral technologies can provide the same level of resolution and accuracy as standard soil tests.

Cooperative funding provided by the Noble Foundation.

West Texas Native Seed Project Native Seed Source Development

Colin S. Shackelford, Louis A. Harveson, Keith A. Pawelek, Anthony D. Falk, and Forrest S. Smith

Significant progress is being made toward development of locally adapted native seed sources for the Trans-Pecos region of Texas. In 2019, one new plant material release for West Texas was planted in seed increase plots in Alpine. This future release of hooded windmillgrass was established in May. In addition, 12 species desired for grassland restoration in West Texas are in various phases of seed increase.

Three of those species (whiplash pappusgrass, silver bluestem, and sideoats grama) are now licensed to 3 growers for commercial production. Additional species being increased include black grama, blue grama, Hall’s panicum, sand dropseed, cowpen daisy, Gregg’s mistflower, skeletonleaf goldeneye, and Tahoka daisy.

New evaluation plantings of 38 accessions of hairy grama and 11 accessions of narrowleaf globemallow and advanced evaluations of 10 accessions of tobosa grass were installed at both the Sierra la Rana Research Facility at Alpine and the Railway Ranch Facility near Odessa in June 2019. Data collection for these species will continue through 2020 before selected accessions are planted in seed increase fields for commercial release. In total, evaluations of 23 species have now been completed or are underway for West Texas.

Seed collections from West Texas are also ongoing to support future plant evaluations for the region. To date, nearly 1,300 collections were made across West Texas. Collections for Arizona cottontop, Canada wildrye, rayless Gallardia, huisache daisy, and prairie coneflower are nearing completion. Evaluations are planned for these species beginning in 2020.

Cooperative funding provided by the Texas Department of Transportation, Caesar Kleberg Foundation for Wildlife Conservation, USDA Natural Resources Conservation Service, Concho Resources, Inc., Faye L. and William L. Cowden Charitable Foundation, Alfred S. Gage Foundation, CF Properties and the Sierra la Rana development, Stan Smith, and Railway Ranch.

Native Grassland Restoration: Diversity and Stability of Wildlife Communities

Geron G. Gowdy, Brandon J. Palmer, Ellart J. Vreugdenhil, Javier O. Huerta, Fidel Hernández, Eric D. Grahmann, Timothy E. Fulbright, Forrest S. Smith, and Michael W. Hehman

Non-native, invasive species are a global conservation concern because they negatively affect biodiversity. The southwestern U.S. contains several non-native, invasive species. One species is buffelgrass. This species has a major ecological impact on southwestern rangelands. Buffelgrass was introduced from Africa to the United States in the early 1900s. Since then, millions of acres have been planted or invaded by this species. Buffelgrass is a prolific seed disperser that displaces native plants and forms dense monocultures. These monocultures can reduce diversity of birds, small mammals, and butterflies. Because

high biodiversity generally is associated with high community resilience, restoration of native plant communities has received increased attention.

The objective of our study is to assess changes in the diversity and stability of bird, small mammal, and butterfly communities in an area being restored to a native plant community. The restoration site was formerly dominated by buffelgrass. We are conducting surveys for breeding birds (June), wintering birds (December), small mammals (March), and butterflies (October) on 3 study sites (restoration site, a non-native grassland site, and a native thornshrub site). Data obtained will be used to compare how diversity and stability changes through time. Our findings will provide insight on how wildlife communities respond to a native plant community after a buffelgrass monoculture has been removed.

Cooperative funding provided by the Hixon Ranch and Texas Parks and Wildlife Department.

The Texas Native Seeds Program Pipeline Prairies Initiative

Forrest S. Smith, Shyla E. Rabe, Keith A. Pawelek, Anthony D. Falk, Colin S. Shackelford, John R. Bow, Samuel R. Lutfy, Tyler C. Wayland, and Douglas L. Jobes

Restoration of native plants on new oil and gas pipeline right-of-ways is of increasing importance to landowners and the pipeline industry. Many new pipelines are projected to be built across Texas. There is a need for science-based recommendations on native seed mixes following construction. Regional seed



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Texas Native Seeds Pipeline Prairie Initiative will provide seed mix recommendations for right-of-way revegetation.

mix recommendations that consider commercial seed supply are critical for successful native plant reseeding efforts at the scale of pipeline construction.

Texas Native Seeds (TNS) is uniquely poised to compile the needed information on seed mix composition and commercial seed supply the pipeline industry needs at the statewide scale. Through relationships with pipeline companies, seed companies, and landowners and using the results from demonstration, research, and evaluation efforts, we are compiling recommended native seed mixes by general soil texture and county for the entire state. These recommendations will be available on a *Pipeline Prairies Initiative* web page on the TNS website. Recommendations will be updated frequently based on commercial seed supply changes, new research findings, and commercialization of new seed sources.

Equipping landowners and the pipeline industry with information about native seed use should have major positive impacts on seed markets and the success of restoration efforts. This effort will have a positive impact on native habitats and wildlife throughout the state of Texas.

Cooperative funding provided by donors to the Texas Native Seeds Program.

Quail Ranch Native Grassland Restoration Research Plantings

Samuel R. Lutfy, Colin S. Shackelford, Anthony D. Falk, Jesse Wood, Keith A. Pawelek, and Forrest S. Smith

There has been relatively little native seeding research in the Permian Basin over the last 30 years. Our efforts are changing that situation, and we are focusing on developing and releasing new native seed sources for the region. We are also working to determine the utility of available seeds for immediate use and to test various hypotheses why restoration seeding has historically been difficult in this region.

We established 20 acres of research plantings on 2 soil series at Concho’s Quail Ranch in Upton County. On each soil series, we planted 10-acre plots on degraded rangeland where brush was removed and significant soil disturbance had occurred. We no-till drilled a mix of commercially available native seeds containing 15 species thought to be adapted to this region. Half of each planting site was enclosed with rabbit-proof fencing to determine the effect of rabbit herbivory on the plants.



© Samuel Lutfy

Native grass seedling establishment dynamics are being studied at Concho’s Quail Ranch in the Permian Basin.

At 1 of the 2 sites, data indicated acceptable adaptation of 2 seed varieties in terms of early establishment: Nueces Germplasm sand dropseed and Van Horn green sprangletop. Eight other native grasses also had some first-year establishment. In the rabbit enclosure, native grasses reached 20% cover, whereas the non-exlosures had almost no native grass establishment, and non-native Lehman lovegrass dominated. At the second site, very poor establishment was measured in the first growing season. Future research and second-year data will help us better understand the relationships between seed adaptation to various soil series in the Permian Basin and better understand the effects of rabbit herbivory on reseeding success.

Cooperative funding provided by Concho Resources, Inc.

Native Plant Development and Restoration for Trans-Pecos and Permian Basin

Colin S. Shackelford, Samuel R. Lutfy, Louis A. Harveson, Keith A. Pawelek, Anthony D. Falk, and Forrest S. Smith

The National Fish and Wildlife Foundation (NFWF) recently provided substantial funding to support restoration efforts in West Texas through the Pecos Watershed Conservation Initiative (PWCI). The PWCI is a partnership between NFWF, 11 major oil and gas producers in West Texas, and the USDA Natural Resources Conservation Service.

The NFWF has recognized that conservation of native grasslands is a high priority for the region.

Addressing inadequate locally-adapted commercial seed supplies will be a major focus. The grant to *Texas Native Seeds* was 1 of 11 grants made by the NFWF for conservation work focusing on restoring grasslands and riparian areas in the Pecos River Watershed.

The grant will boost efforts to develop ecotypic seed sources for habitat restoration. This will support farm operations for new plant material evaluations and seed production, thereby enabling commercialization of new plant releases. NFWF funding will provide partial support for assistant director positions in West Texas and the Permian Basin. It will support a technician for project partners at Sul Ross State University and Borderlands Research Institute. The grant will also help establish 20 new restoration research plantings over the next 2 years. This will greatly help in the development of best practice recommendations for West Texas restoration projects. Our partnership with the NFWF will have a major positive effect on grassland habitat restoration in West Texas.

Cooperative funding provided by the National Fish and Wildlife Foundation Pecos River Conservation Initiative and Concho Resources, Inc.

Martindale Army Airfield Pollinator Planting Demonstration

Anthony D. Falk, Keith A. Pawelek, Forrest S. Smith, and Aaron R. Gilfillan

South Texas Natives (STN) and the Texas Military Department are working on a 100-acre Blackland Prairie restoration project at the Martindale Army



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Pollinator habitat has been established at the Martindale Army Airfield near San Antonio.

Airfield near San Antonio. The goal is to establish native vegetation that is low maintenance and provides pollinator habitat. The restoration site was historically used for cropland and is representative of soils and land use common to the Blackland Prairies ecoregion.

The project began in the spring of 2017 with the application of herbicides to control agricultural weeds, especially Johnsongrass. Throughout 2017 and the spring of 2018, applications of herbicides were made in an attempt to exhaust the weed seed bank that had developed during years of agricultural use. The seedbed was prepared, and the site was seeded with a mix of 37 commercially produced native plant species. This mix included locally adapted grasses and forbs and commercially available native pollinator plants.

The first sampling after sowing seed was completed in the spring of 2019. Data showed excellent establishment of a number of seeded pollinator plants. Best performing seeded species include plains coreopsis, mealy blue sage, and pink evening primrose. We will continue monitoring the site through 2020 to evaluate plant community establishment and changes over time, quantify the performance of a wide range of native seed sources, and determine the potential for success of restoration efforts. Information obtained in this study will be valuable in aiding similar efforts throughout the Blackland Prairies ecoregion of Texas.

Cooperative funding provided by the Texas Military Department.

Permian Basin and Panhandle Native Seed Project Collections and Evaluations

Samuel R. Lutfy, Colin S. Shackelford, Anthony D. Falk, Jesse Wood, Keith A. Pawelek, and Forrest S. Smith

Energy development and associated activities in the Permian Basin and Texas Panhandle create a major demand for native seeds in restoration and remediation projects. A critical part of providing native seeds is the development and commercialization of locally adapted native germplasm, which is needed to ensure planting success. Obtaining wild seed collections from the specific geographic region, evaluating them for important traits, followed by selection and seed increase of desired populations helps make locally adapted seed available to consumers that has a high rate of successful establishment.

Since November 2017, we have made over 300 collections of 24 forbs and 26 grasses from the Permian

Basin and Texas Panhandle region. Collections were made on private and public lands in cooperation with numerous ranches, energy companies, and agencies. The collections will be planted at the Railway Ranch at Odessa and the USDA Natural Resources Conservation Service Plant Materials Center at Knox City for evaluation and future selection. An additional evaluation site is also being sought.

In 2018, populations of hairy grama, tall grama, sideoats grama, seep muhly, and hooded windmill-grass from the region and adjacent ones were evaluated at the evaluation locations. In 2019, we established new evaluations of hairy grama, tobosa grass, and narrowleaf globemallow at Odessa, and gayfeather and Indiangrass at Knox City. Collection, development, and release of locally adapted native seed sources should greatly improve restoration and reclamation outcomes in the region.

Cooperative funding provided by Concho Resources, Inc., USDA Natural Resources Conservation Service, and Texas Department of Transportation.

Detecting Invasive Grasses Using Remote Sensing Platforms

Justin P. Wied, Humberto L. Perotto-Baldivieso, April A. Torres Conkey, and Leonard A. Brennan

The expansion of invasive plants can alter the function and productivity of native ecosystems. These disruptions can create feedback loops that favor invasive species at the expense of native species. Such threats can create long-term negative effects on wildlife.



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Undergraduate student doing a final pre-flight review before unmanned aerial vehicle takes off.

Old World bluestems were introduced to Texas in the first half of the 20th century for forage production and erosion control. Forage production of Old World bluestems and other grasses may be desirable for livestock production. However, these species may decrease wildlife habitat and reduce food resources.

Plant species have distinct spectral signatures in the electromagnetic spectrum. These properties have been used to quantify the amount and spatial distribution of tanglehead, an invasive, native grass species in South Texas, using satellite imagery. But, there is still no research that has been conducted to assess the distribution of Old World bluestems.

We are developing remote sensing approaches to identify spectral signatures of Old World bluestems on South Texas rangelands. We are comparing 3 satellite platforms: PlanetScope (9-ft resolution), RapidEye (15-ft resolution), and Sentinel-2 (30-ft resolution). We are also using aerial imagery from the USDA National Agriculture Imagery Program (3-ft resolution). Imagery collected using a DJI Phantom Pro 4 unmanned aerial vehicle (1-inch resolution) and ground control points acquired with a Trimble Juno GPS unit are being used to perform accuracy assessments on the satellite and aerial images.

This study will allow us to rank the performance of each platform and the processing techniques in detecting Old World bluestem spatial distribution. Findings can be used to better manage South Texas rangelands.

Cooperative funding provided by South Texas Chapter of Quail Coalition.

Testing Efficacy of Stock-piling Topsoil for Ecological Restoration

Dustin A. Golembiewski, Sandra Rideout-Hanzak, Veronica Acosta-Martínez, and David B. Wester

Prior to beginning oil and gas extraction, it is commonly recommended that topsoil stock-piles be created to aid in the re-establishment of plant communities at a site when the energy-related activity is completed. Topsoil is collected using heavy machinery, piled at a nearby location, and re-applied when the extraction process is completed, often years later. Stock-piles can be large, depending on site surface area, reaching several yards in depth.

Our study area, a retired fracking pond in Dimmit County, Texas was restored in 2017 with stock-piled topsoil collected prior to construction. We segregated

the existing stock-pile into 3 layers that were 4.5 ft in thickness and distributed these layers (along with a fresh topsoil surface and a non-amended surface) in separate strips over the pond. Each of the 5 surfaces was seeded with a mixture of (1) 13 native grasses, (2) 13 native grasses plus an annual warm-season grass cover crop, or (3) non-seeded (control plot).

Our assessment of restoration success began with first-year plant density and species composition. First-year results indicate there were more than 3 seeded plants per yd² on all soil surfaces, and more native plants in seeded plots than in the control. Additional assessments will quantify foliar coverage and above ground biomass. We will collect topsoil samples for seed bank trials and analysis of soil chemistry and microbial community structure.

Our assessments will be compared to similar data collected from the stock-pile between 2012 and 2015. Our goal is to quantitatively assess the common recommendation of stock-piling topsoil following soil disturbance in semiarid regions and explore the efficacy of current methods.

Cooperative funding provided by Alston and Holly Beinhorn.

Native Seed Development for U.S. Forest Service Restoration in East Texas

Tyler C. Wayland, Thomas C. Phillips, Robert A. Shadow, Keith A. Pawelek, and Forrest S. Smith

The U.S. Forest Service (USFS) manages over 675,000 acres in Texas. These public lands are divided into 4 National Forests and 2 National Grasslands within 15 East Texas counties. The USFS is expecting land disturbance from oil and gas activities to reach upwards of 20,000 acres in Texas over the next 20 years. These trends highlight the need for commercial production of regionally adapted native seed sources to meet future restoration and revegetation needs in East Texas.

In 2018, *East Texas Natives* joined a cooperative effort of the USFS and the USDA Natural Resources Conservation Service East Texas Plant Materials Center to develop regionally adapted seed sources of native understory species. These species are needed for restoration projects on the National Forests and other public and private lands throughout East Texas. The focus is on seed collections of priority native species on National Forest lands, the commercialization of previous USFS ecotype selections of 3 species,



© Tyler Wayland

Local ecotypes of pinehill bluestem collected by the U.S. Forest Service are being increased at the East Texas Plant Materials Center in collaboration with *East Texas Natives*.

and the evaluation of seed collections to identify and select more locally adapted germplasms for commercial production.

Regionally adapted seed sources will be released to commercial producers for large scale seed production to support federal, state, and private restoration efforts. These efforts should ultimately increase the quality of longleaf and shortleaf pine savannas and blackland prairie habitats, and provide adapted native species for use on disturbed lands in East Texas.

Cooperative funding provided by the U.S. Forest Service, USDA Natural Resources Conservation Service East Texas Plant Materials Center, and numerous donors to the East Texas Natives Project.

Pollinator Management: Restoration at Camp Bowie Training Center

John R. Bow, James P. Muir, Forrest S. Smith, Anthony D. Falk, and Keith A. Pawelek

In June 2019, the *Central Texas Native Seed Project* (CTNSP) began a pollinator habitat restoration project in cooperation with the Texas Military Department at Camp Bowie Training Center in Brown County. The objectives of the project are to reduce the density of Texas wintergrass and increase biodiversity by establishing native forbs and legumes. This will be accomplished by planting a native seed mix designed specifically for the site.

Eighty-five acres of the grassland will be prepared for seeding by combinations of mowing and herbicide application. The native forb and legume seed mix will be planted using a no-till seed drill. Monitoring of treatment effects will include species performance related to soil type, planting date, planting technique, site preparation, geographical location, and seed mixture composition. Sampling will occur during the spring and fall for several years to capture the variation in cool and warm season species. Analyses will also be conducted on the performance of individual species to evaluate how each species compares to its relative percentage of the seed mix.

Results of this project will be reported to inform landowners and natural resource managers on native seed mix components that are best suited for pollinator habitat restoration in the Central Texas region. Native plant restoration is a growing priority within the region, which should result in a variety of benefits to wildlife, rangelands, and pollinator species.

Cooperative funding provided by the Texas Military Department, Texas A&M AgriLife Research and Extension Center at Stephenville, and donors to the Central Texas Native Seed Project.

Native pollinator seed mix to be planted and evaluated at the Camp Bowie Training Center in Brown County, Texas.

Common Name	Scientific Name	Seed Variety	Percent of Seed Mix (by PLS*)
Velvet bundleflower	<i>Desmanthus velutinus</i>	Hondo Germplasm	5
Illinois bundleflower	<i>Desmanthus illinoensis</i>	Sabine	5
Engelmann daisy	<i>Engelmannia pinnatifida</i>	Eldorado	5
Partridge pea	<i>Chamaecrista fasciculata</i>	Comanche	5
Purple prairie clover	<i>Dalea purpurea</i>	Cuero	5
Awnless bushsunflower	<i>Simsia calva</i>	Venado or Plateau	5
Orange zexmenia	<i>Wedelia hispida</i>	Goliad Germplasm	5
Clammyweed	<i>Polanisia dodecandra</i>	Rio Grande	5
Maximillian sunflower	<i>Helianthus maximilliani</i>	Aztec	5
Prairie acacia	<i>Acacia angustissima</i>	Rio Grande or Plains	5
Redseed plantain	<i>Plantago rhodosperma</i>	STN-496	4
American basketflower	<i>Centurea americana</i>	-	3
White prickly poppy	<i>Argemone sanguinea</i>	-	3
Texas thistle	<i>Cirsium texanum</i>	-	3
Black-eyed susan	<i>Rudbeckia hirta</i>	-	2
Yellow neptunia	<i>Neptunia lutea</i>	-	2
Blue sage	<i>Salvia azurea</i>	-	2
Dotted gayfeather	<i>Liatris punctata</i>	-	2
Spider milkweed	<i>Asclepias asperula</i>	-	3
Cowpen daisy	<i>Verbesina enceloides</i>	-	2
Texas bluebonnet	<i>Lupinus texensis</i>	-	2
Huisache daisy	<i>Amblyolepis setigera</i>	-	2
Indian blanket	<i>Gaillardia pulchella</i>	-	5
Plains coreopsis	<i>Coreopsis tinctoria</i>	-	1
Mexican hat	<i>Ratibida columnifera</i>	-	5
Prairie verbena	<i>Verbena bipinnatifida</i>	-	1
Greenthread	<i>Thelmesperma filifolium</i>	-	5
Standing cypress	<i>Ipomopsis rubra</i>	-	2
Lemon mint	<i>Monarda citridora</i>	-	1

* PLS = pure live seed

Associations between Old World Bluestems and Soil Microbial Communities

Sandra Rideout-Hanzak, David B. Wester, and John Reilley

Plant communities and the microbial communities that occupy the soil beneath them coexist in a delicate balance of shifting relationships. There are many factors that affect these relationships. Important influences include climatic variability and change in species composition associated with invasive grasses.

In recent years, we have reported results of studies of soil microbial communities associated with tanglehead, a native grass with invasive behavior. In particular, we have found higher saprophytic fungi-to-bacteria ratios in invaded sites, an effect that was detectable in each of 3 years that varied in rainfall amounts received at the study site.

We are initiating a similar study focusing on soil microbial communities associated with Old World bluestems. We will identify study sites that differ in the length of residence time of Old World bluestems—some sites have been recently invaded, others have supported bluestems for a longer period of time. We will assess soil microbial community characteristics (e.g., soil microbial nitrogen, carbon, and fungi) and relate them to residence time of Old World bluestems. We will also assess soil seed banks in our study sites.

Our findings will help us in understanding how to restore native rangelands that have been affected by invasive grasses. This information can be used to better inform those individuals involved in future restoration efforts.

Cooperative funding provided by the USDA Natural Resources Conservation Service.

Grassland Restoration in Northeast Texas – The Riverby Ranch Project

Tyler C. Wayland, Anthony D. Falk, Forrest S. Smith, and David B. Wester

The *Texas Native Seeds* Program has been successful over its 20-year history at the Caesar Kleberg Wildlife Research Institute (CKWRI) because it is based on ecologically-sound principles. For example, because plants are locally-adapted to their environment we can custom-fit particular varieties of species to specific restoration needs. We are applying this approach in East Texas with *East Texas Natives*,



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***Texas Native Seeds* personnel are cooperating with RES Texas Mitigation to conduct research on prairie restoration at the Riverby Ranch Mitigation Area in northeast Texas.**

a regional component of the statewide *Texas Native Seeds* Program of the CKWRI. *East Texas Natives* is a collaborative initiative that is currently developing regionally-adapted native seed sources for habitat restoration on private and public lands in East Texas.

The Riverby Ranch, located in the Oak Woods and Prairies ecoregion of Fannin County, has been selected as part of the Bois d'Arc Lake mitigation project in the North Texas Municipal Water District. Overall project goals include long-term and sustainable restoration of about 15,000 acres associated with future water development for northeast Texas.

We will apply the expertise developed in the *Texas Native Seeds* Program to identify locally-adapted native species and site-specific restoration strategies that will achieve overall project goals. Replicated large-plot evaluation trials will be established throughout 3,200 acres of grassland on the Riverby Ranch. We will test plant species varieties and seed mixtures and monitor plant performance in long-term trials to document vegetation establishment and plant community dynamics.

Information obtained in this project will be used to develop current and future restoration efforts at this site. Our findings will also provide the basis for developing restoration guidelines that can be applied throughout East Texas.

Cooperative funding provided by RES Texas Mitigation, LLC.

Assessment of the Annual Mottled Duck Breeding Survey

Vijayan Sundararaj, Daniel P. Collins, and Bart M. Ballard

The mottled duck is a nonmigratory species that inhabits coastal marshes of the western Gulf Coast, primarily in Louisiana and Texas. This species has experienced a long-term decline, and since it is a hunted species, requires annual monitoring to help inform biologists in making hunting recommendations.

A range-wide breeding survey was designed and implemented in 2008 to track mottled duck population levels. This aerial survey is scheduled during peak nesting and has been conducted each year since its initiation. Since there are 12 years of survey data, our goal is to analyze the data and investigate ways to improve the survey design. Extent of surveyed area, allocation of transects, and implementation of visibility correction factors will be assessed based on variation in current estimates, as well as the availability of new, and possibly improved, geospatial datasets.

We will involve an array of conservation partners in the decision-making process to help guide our analyses. Our research will improve the efficacy of the annual mottled duck breeding survey and improve estimates of population abundance that are used in habitat planning and harvest regulations.

Cooperative funding provided by U.S. Fish and Wildlife Service, Region 2.

Influence of Migration Strategy on the Breeding Status of White-fronted Geese

Jay A. VonBank, Mitch D. Weegman, Kevin J. Kraai, Paul T. Link, and Bart M. Ballard

The breeding success of migratory species is influenced by many factors. These may include body condition, body size, and competition for resources. Other factors may include behavioral choices, such as the timing of migration, number of times stopping during migration, and length of stay at stopover sites. Environmental conditions such as temperature, snow cover, and food availability can also influence breeding success.

In recent years, greater white-fronted geese have changed their major stopover locations used during spring migration. They also have changed the timing

of their spring migration. This makes predicting and assessing habitat quality throughout migration difficult. We may gain a better understanding of the annual changes in size of migratory bird populations by determining behavioral choices made during spring migration and the resulting influences on breeding success.

During winters 2015–2017, we captured adult white-fronted geese in Texas and Louisiana and attached tracking devices equipped with sensors that allow us to measure their behavior. We tracked their movements and behaviors throughout the spring migration and breeding periods.

Our sample of white-fronted geese nested across their entire breeding range throughout Alaska and Canada. They arrived to breeding areas between April 20th and June 2nd in 2016, and between May 11th and 24th in 2017.

We will associate white-fronted goose behaviors made during spring migration to individual migration characteristics and breeding status, and assess the impact with which the stopover landscape influences breeding success. Understanding this connection can help conservation planners recognize the role that spring stopover sites have on reproductive success, prioritize efforts on spring stopover sites, and predict impacts of future changes in habitat quality and quantity at spring stopover sites.

Cooperative funding provided by Texas Parks and Wildlife Department and Louisiana Department of Wildlife and Fisheries.

Spatial Analysis of Wild Turkey Habitat in South Texas

Alison R. Menefee, Humberto L. Perotto-Baldivieso, William P. Kuvlesky, Jr., J. Alfonso Ortega-Santos, Leonard A. Brennan, Michael T. Page, Jaclyn D. Robles, and Darrion M. Crowley

Telemetry data collection has been used in wildlife studies to assess animal locations and the habitat resources used. However, triangulation errors can occur due to observer error and distance effects. Previous research has used confidence ellipses to assess inaccuracies in triangulations. When combined with landscape metrics, we can use these ellipsoids to describe land cover spatial structure to provide insight into how species use their habitat. It would be useful to analyze decades of telemetry data to gain a historical perspective of landscape level habitat use by the

species under study. Our objectives are to (1) identify the type of ellipsoids adequate for landscape level studies and (2) quantify landscape structure within ellipsoids derived from telemetry data. We are focusing our study on the breeding and wintering seasons.

We used telemetry data from a study conducted on female wild turkey home ranges on the King Ranch in 2004 and 2005. We then classified National Agriculture Imagery Program imagery to assess landscape structure.

Preliminary results indicate wild turkeys are using woody areas during the wintering season and more open areas during the breeding season. This may be a direct result of their behavior. Wild turkeys tend to use open areas for mating and brood-rearing and woody cover for roosting and for foraging when insects and seeds may be less plentiful. Our results will provide insight for wildlife managers to ensure habitat is available, which may increase wild turkey populations.

Cooperative funding provided by Las Huellas Association of South Texas, Hoffman HC 30 Ranch, El Veleno Ranch, and the Bass ranches.

Modeling Foraging Habitat for Shorebirds in the Laguna Madre

Mikayla M. House, Selma N. Glasscock, Humberto L. Perotto-Baldivieso, Mitch D. Weegman, and Bart M. Ballard

Habitat requirements of shorebirds on migratory and wintering areas have been largely ignored. There is little information regarding shorebird ecology in the Laguna Madre, particularly during migration.

The Texas coast is experiencing major population growth and development. Consequently, understanding the needs of shorebirds and the availability of their habitats is important for conservation planning.

Our goal is to develop a model that predicts when and where foraging habitat is available during spring migration in the Laguna Madre of Texas. This lagoon has the largest amount of foraging habitat for migrating shorebirds in the Western Hemisphere. Thus, it is a high priority area for conservation efforts.

Information needed for modeling availability of shorebird habitat includes water depths across the entire lagoon, tide fluctuations, weather variables, and benthic substrate characteristics. Most tidal fluctuations in the Laguna Madre result from tides driven by wind. Thus, we plan to include weather variables such as wind direction, wind speed, and duration of wind

events in our model. We will use a portion of each dataset to develop the model and retain a portion of the data to assess model performance.

Our findings will aid in understanding when and where foraging habitat is available during spring migration. This information can be used to prioritize conservation efforts and reduce impacts from future development throughout the Laguna Madre.

Cooperative funding provided by the Rob and Bessie Welder Wildlife Foundation and Coastal Bend Audubon Society.

Movements and Energy Expenditure in White-fronted Geese

Jay A. VonBank, Mitch D. Weegman, Kevin J. Kraai, Paul T. Link, Daniel P. Collins, and Bart M. Ballard

Greater white-fronted geese historically wintered in the Gulf Coastal marshes of Texas and Louisiana. However, they have moved inland following agricultural expansion during the 1940s. During the last decade, white-fronted geese have shifted their main wintering range northeastward into the Mississippi Alluvial Valley. This shift is probably influenced by large-scale landscape changes and climate change.

Several regions still support large greater white-fronted goose populations throughout their historical wintering range. However, movements among regions are largely unknown. Also, because land use can greatly vary among wintering regions, there may be additional energetic costs to wintering in some regions over others. Our research aims to estimate the probability of movement and energy expenditure



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Flock of greater white-fronted geese foraging in a harvested corn field during winter in South Texas.

among regions to understand the effects of the shift in winter distribution.

We placed tracking devices on 97 greater white-fronted geese captured in Texas and Louisiana during winters 2016–2017 and 2017–2018. Daily movement distance was greatest in early winter and decreased as winter progressed in both winters. Daily movement was not influenced by daily minimum or maximum temperatures. Among geese captured in Texas during winter 2016–2017, 31% moved among wintering regions, and 17% moved between the Central and Mississippi flyways. Geese marked before December 1st, 2016 moved among regions (50%) and between flyways (83%) more frequently than geese marked later in winter. Addressing the role of movement and energy expenditure following a large-scale distribution shift will aid in the future management and conservation of greater white-fronted geese.

Cooperative funding provided by Texas Parks and Wildlife Department and Louisiana Department of Wildlife and Fisheries.

Use of Constructed Roosts by Wild Turkeys in South Texas

Alison R. Menefee, Humberto L. Perotto-Baldivieso, William P. Kuvlesky, Jr., J. Alfonso Ortega-Santos, Leonard A. Brennan, Brandon S. Mitchell, Darrion M. Crowley, and Joshua Vasquez

The Rio Grande wild turkey is an important upland game species in South Texas. Roost sites are critical to maintaining wild turkey populations. Constructed



© Humberto Perotto-Baldivieso

Constructed roost sites are being evaluated to understand preferences of Rio Grande wild turkeys in a South Texas.

roosting structures have provided an alternative when roost trees are sparse. These may be designed specifically for wild turkeys, though many are an indirect result of power lines, windmill towers, grain storage tanks, and large buildings.

Little is known about the use of constructed roosts, and even less on their relationship with wild turkeys in South Texas. Therefore, our goal is to determine landscape features that will provide a basis for recommendations on locations to build constructed roosts for use by wild turkeys. The objectives of this project are to (1) quantify vegetation composition and richness around used roost sites and (2) assess landscape spatial structure around roost sites.

Sampling was conducted during the middle of the breeding and wintering seasons in 2018 and 2019. We identified roost use by looking for droppings and feathers under the roost. We measured ground canopy cover and height of visual obstruction, and identified plant species. Very-high resolution (spatial and temporal) satellite imagery has been used to quantify landscape structure around roost sites.

Our research of landscape structure and vegetation composition will allow us to identify roost site characteristics that are preferred by wild turkeys. Wildlife managers can use this information to aid wild turkeys in South Texas landscapes.

Cooperative funding provided by Las Huellas Association of South Texas, Hoffman HC 30 Ranch, El Veleno Ranch, Bass ranches, and Zacatosa Ranch.

Using Behavior to Understand Habitat Use in White-fronted Geese

Jay A. VonBank, Stephanie A. Cunningham, Toryn L. J. Schafer, Mitch D. Weegman, Kevin J. Kraai, Paul T. Link, Christopher K. Wikle, Daniel P. Collins, and Bart M. Ballard

Throughout the 20th century, greater white-fronted geese mostly wintered in Texas and Louisiana. However, over the last 2 decades they have shifted their main wintering distribution northeastward into the Mississippi Alluvial Valley. Changes in land use, climate, and resource availability are likely causes of the shift in distribution, yet the degree to which these causes affect the shift is unknown. Our research aims to further understand several aspects of white-fronted goose winter habitat use and behavior.

We captured 56 adult white-fronted geese during winters 2015–2017 in Texas and Louisiana and fitted

them with tracking devices that provided information on locations as well as their behaviors. We used location information to determine specific habitats used by white-fronted geese and used information on their behaviors to further inform us about habitat use. We combined 53,502 locations with identified behaviors, along with regional and environmental variables to determine influences on habitat use throughout their wintering range.

Findings indicate that habitat use by our marked geese changed monthly and by ecoregion, where differences in land use vary considerably. We found a trend of agricultural waste grain use in early winter, changing to green vegetation in late winter. Freshwater unconsolidated shore/bottom and woody wetland types were used most often. Behaviors varied with region and time of winter, and in relation to habitat types. Foraging increased in early winter, decreased mid-winter, and increased again before the start of spring migration. Understanding the use of habitats and patterns of behavior and energy expenditure will aid in determining future management practices throughout the range of white-fronted geese.

Cooperative funding provided by Texas Parks and Wildlife Department.

Spring Migration Strategies of Northern Pintails in North America

Georgina R. Eccles, Bart M. Ballard, Daniel P. Collins, Kevin J. Kraai, and Mitch D. Weegman

Northern pintails remain below their population management goal. This occurred despite 3 decades of favorable conditions on breeding areas. In contrast, most other duck species have experienced record abundance over the same period. This suggests factors during migration and winter may be having a negative impact. Pintails winter across a broad geographical range. Thus, they are subject to site-specific stressors, survive at different rates, and migrate through different landscapes.

We began this study to learn more about spring migration strategies of pintails originating from different wintering areas. We will determine the connection between migration strategies and reproductive success, assess the contribution of stored body fat and protein to reproduction for pintails using different regions and migration strategies, and identify critical migration stopover areas. We will attach tracking



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A pair of northern pintails use a freshwater wetland to drink after foraging in the Laguna Madre.

devices to adult females during winters 2019–2022. Capture locations will be at major wintering areas (Louisiana coast, Texas coast, Texas Panhandle, New Mexico, Arizona, and central California).

Expected outcomes include (1) identification of important migratory stopover sites, (2) understanding how behavior and habitat use during migration influence body condition and reproductive success, and (3) understanding differences in migration strategies within and among wintering regions and their effect on reproduction. Results of this study will increase our knowledge about the migration ecology of pintails. Our findings can be used to develop better management strategies for pintails.

Cooperative funding provided by Texas Parks and Wildlife Department, U.S. Fish and Wildlife Service, and Ducks Unlimited, Inc.

Does Formation of Growth Rings Occur in Occipital Spines of Texas Horned Lizards?

Javier O. Huerta and Scott E. Henke

Little is known about the age of Texas horned lizards. Past mark-and-recapture data suggest that Texas horned lizards can live at least up to 5 years. However, other members of the genus *Phrynosoma* have been known to live as long as 20 years in the wild.

Age is an essential component for analyzing the population dynamics of Texas horned lizards. Currently, Texas horned lizards are classified as either hatchlings (less than 1 inch), juveniles (1–2.7 inches), or adults (greater than 2.7 inches). Our hypothesis is that occipital spines grow throughout the life of horned lizards and horned lizard growth is greater during summer and slowed during periods of hibernation. If true, then it is possible that occipital spines, which are keratinized, develop growth rings that could be used to age horned lizards.

We plan to (1) gather the remains (specifically the cranium) of deceased Texas horned lizards from the field, (2) determine if growth rings occur vertically or horizontally in the parietal bone or keratinized layer of the occipital spines using microscope and staining techniques similar to the cementum annuli process, and (3) determine if rings are associated with yearly growth using captive raised Texas horned lizards. This study will aid in future research that addresses the life history of this threatened reptile.

Latrine Ecology of Nilgai Antelope in South Texas Rangelands

Lisa D. Zoromski, Randy W. DeYoung, John A. Goolsby, Aaron M. Foley, J. Alfonso Ortega-Santos, David G. Hewitt, and Tyler A. Campbell

The nilgai antelope is an exotic species that has expanded into much of South Texas since their introduction. Unlike most native ungulates, nilgai make latrines (dung piles) by repeatedly defecating in the same place. Presently, there is little information about nilgai latrines or their social significance.

We are studying the number and distribution of latrines on 3 South Texas ranches using camera monitoring systems. We are assessing frequency, time, sex, and age of nilgai that use latrines. We will also use

genetic markers to determine how many individual nilgai use each latrine by analyzing DNA from feces.

Preliminary data revealed that latrines were abundant, about 1 latrine every 3 acres. Latrine activity increased from December–March, corresponding to the breeding season. Latrines were 30% more abundant in spring versus autumn. Latrines were used mainly by adult bulls that visited about once a week, typically at night. We observed no defecations by sub-adult bulls, but cows (adult female nilgai) and calves occasionally defecated at latrines. We are genotyping fecal samples to determine how many individual nilgai use each latrine. Several photos captured bulls showing flehmen responses after smelling latrines recently used by cows. We recorded 2 mating events and a fight between 2 bulls at latrine sites.

Our results suggest that latrines function as important sites for social communication and dominance displays, and that cows using latrines are likely in estrus. This is the first study on nilgai latrine use and provides knowledge about the importance of latrines for nilgai social behavior.

Cooperative funding provided by the Las Huellas Association of South Texas.

Crop Impacts on Pronghorn Home Range and Movements

Anthony P. Opatz, Gary Mizer, Timothy E. Fulbright, Randy W. DeYoung, Humberto L. Perotto-Baldivieso, Warren C. Conway, and Shawn S. Gray

Conversion of native grasslands to agricultural lands is a major threat to wildlife. Currently, over 617,000 mi² (17.5%) of the United States land mass is cropland. Studies have documented pronghorn eating winter wheat and alfalfa in the winter, but the agricultural landscape of Texas contains many other crops such as cotton, corn, and potatoes.

Little is known about pronghorn preference for crop growth stage and crop type. Crop preferences could impact pronghorn movements and home range size at certain times of the year. The objective of this study is to determine the impact of agriculture on home range size and identify crop type and growth stage preference.

In February 2017, we attached satellite GPS collars to 64 pronghorns in study areas near Dalhart and Pampa, Texas, with 32 collars evenly distributed

between sexes. We estimated utilization distributions to determine areas of high use by pronghorns using agriculture. We created home ranges and estimated impacts of crop type, growth stage, and presence on the size of core areas and total home range.

Preliminary results suggest pronghorns prefer winter wheat over other crops. Winter wheat is the primary crop planted in the winter when native prairie forage quality is limiting for pronghorns. All crop types are used more at earlier growth stages. Home ranges increase in size to incorporate agricultural areas during the winter months (October–April). When native forb availability is low, winter wheat in early growth stages influences pronghorn movements in the Texas Panhandle.

Cooperative funding provided by Texas Parks and Wildlife Department.

Determining the Cause of Darkening Jaw Patches on American Alligators

Scott E. Henke, Cord B. Eversole, Javier O. Huerta, Tiffany L. Pope, Andrew Lowery, Brian Loflin, and Clayton D. Hilton

Skin coloration changes are known to occur in reptiles. Speculation regarding why color changes occur has included communication of dominance, aggression, reproductive status, and thermal regulation.

The lower jaw of American alligators has the ability to darken and lighten in color. The reason for this behavior is unknown. We propose this skin color change is a result of either a need for heat dissipation due to hot conditions or a signal of stress and aggression via hormone levels. We will test these hypotheses by comparing pigmentations of the lower jaw through time of individual alligators when exposed to a heat source or to stress.

American alligators have been hand-reared since hatching 4 years ago. For the heat dissipation study, alligators will be exposed to heat lamps and alligator internal and external temperatures will be monitored. Serum will also be collected every 5 minutes from the initiation of exposure to 30 minutes and used to test corticosterone levels. A camera will photograph the same location on the jaw every 5 minutes. Photographs will be quantified to determine the amount of red, blue, and green pigmentation of the jaw. During the hormone experiment, alligators will be given a dose of adrenocorticotropic hormone. Blood samples, body temperature, and photos will be collected every 30 minutes as

previously described. By conducting this study, we will increase our knowledge of the physiology and behavior of this iconic reptilian species.

Monitoring Birds and Small Mammals within Large-scale Impact Studies

Andrea Bruno, Jeremy A. Baumgardt, Faith Hardin, Leonard A. Brennan, and Michael L. Morrison

We are monitoring the response of birds and small mammals to a 18,000-acre grazing demonstration called the Coloraditas Grazing Research and Demonstration Area (CGRDA) and a 11,000-acre burn study in partnership with the East Foundation. We collected monitoring data on the grazing and burn study areas from 2014–present. The first phase of the monitoring project (2014–2017) was also used to establish sampling protocols and determine the sampling effort needed for monitoring vertebrate populations.

The CGRDA is on the East Foundation’s San Antonio Viejo Ranch and consists of 4 grazing treatments. We monitored small mammals on 20 grids in the CGRDA and 10 grids in control sites from February–April. We conducted point counts and measured nesting productivity for breeding birds on 10 transects in the CGRDA and 15 transects in the control sites from April–July. The burn experiment is on the El Sauz Ranch and consists of 15 plots categorized into 4 burn treatments. We burned 3 plots in January and February 2019 and followed with small mammal surveys and breeding bird surveys on 12 treatment plots and 3 control plots.



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Researchers are monitoring rodent populations on the East Foundation’s San Antonio Viejo Ranch.

Based on data collected from 2014–2018 and pooled across all study sites, we have captured 14,426 individual small mammals representing 14 species. For breeding birds, we have observed over 60,000 individuals representing 114 species.

We plan to continue the monitoring project beyond 2020 to develop a long-term dataset of the abundance of small mammals and breeding birds. This information will also provide insight about density, distribution, and productivity in response to this large-scale impact study.

Cooperative funding provided by the East Foundation and The Richard M. Kleberg, Jr. Center for Quail Research.



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Influence of Agriculture on Pronghorn Movements, Survival, and Diet

Gary Mizer, Anthony P. Opatz, Timothy E. Fulbright, Randy W. DeYoung, Humberto L. Perotto-Baldivieso, Warren C. Conway, and Shawn S. Gray

Pronghorns occur in 27 of the 56 counties in the Texas Panhandle Wildlife District. Pronghorn movements, survival, and diet can be influenced by natural and anthropogenic landscape features. Little is known about how agriculture plays a role in these factors. We are studying movements, home range, and response to the rangeland-agricultural landscape using satellite GPS collars placed on pronghorns in 2 study areas for 2 years. Pronghorn survival is obtained from 2 sources: the Known Fate model in program MARK and Kaplan-Meier analysis.

Preliminary results show yearly survival of 79% and 67% in year 1 and year 2, respectively, while seasonal survival ranges from 100% across multiple seasons to 66% during the breeding season. In addition, we are examining a dietary component using DNA metabarcoding of fecal samples. This will allow us to more closely identify how pronghorns are using habitats from a nutritional perspective.

Eighty-four fecal samples, 34 from native rangeland, 47 from croplands, and 3 from unknown sources collected during 13 sampling periods have been analyzed. From the 84 samples sent to Northern Arizona University for analysis, 80 plant genera were detected, of which 5 contained possible agricultural crops. We will analyze the differences between diet and food habits between males and females (44 samples from males, 35 from females) to more clearly identify how pronghorns use food resources in both landscapes.

CKWRI researchers are studying the impact of agriculture on pronghorns in the Texas Panhandle.

These data will be useful in identifying plant species or genera that appear most frequent in pronghorn fecal samples, which can help guide regional pronghorn management decisions.

Cooperative funding provided by Texas Parks and Wildlife Department, Dallas Safari Club, and the Rumsey Research and Development Fund at Texas Tech University.

Genetic Structure and Diversity of Nilgai Antelope in Texas

Lisa D. Zoromski, Randy W. DeYoung, Masahiro Ohnishi, John A. Goolsby, Aaron M. Foley, J. Alfonso Ortega-Santos, David G. Hewitt, and Tyler A. Campbell

Nilgai antelope were released onto private ranches in Texas during the period spanning the 1920s–1940s. Nilgai expanded rapidly and now occupy coastal South Texas from Kingsville to the Rio Grande Valley. The population in Texas is estimated at over 30,000 nilgai. Although nilgai were introduced over 80 years ago, little is known about their ecology and population genetics in either Texas or their native range in India, Nepal, and Pakistan.

We screened 20 genetic markers and identified 7 that had enough genetic variation to identify individuals and assess genetic structure. We are analyzing 249 nilgai tissue samples from Kleberg, Kenedy, Cameron, and Willacy counties, representing the range of free-roaming nilgai in Texas. So far, we have not detected any unique genetic groups or population boundaries.

Nilgai were weakly structured over the entire region. Geographic distance was the main factor in genetic differentiation among sites. Subpopulations appeared to be genetically non-independent over distances of about 480 miles. We are finding no evidence of founder effects on the nilgai population. Findings also indicated that Highway 77 did not cause genetic isolation of the nilgai populations.

Collectively, our results imply that long-distance movements of both sexes are common. Furthermore, standard livestock fences are unlikely to limit interchange of nilgai between ranches. We conclude that nilgai in South Texas have a high potential for spreading disease or parasites, such as the cattle fever tick. This is the first population genetics analysis of nilgai, and it will serve as a reference for future genetic studies and provide information for nilgai population management in South Texas.

Cooperative funding provided by the Las Huellas Association of South Texas.

Movements of Feral Pigs in Response to Control Efforts

Bethany A. Friesenhahn, Nathan P. Snow, Bruce R. Leland, Michael J. Bodenchuk, Randy W. DeYoung, and Kurt C. VerCauteren

Feral pigs are an invasive species, and their population numbers are rapidly increasing across the United States. Pigs are omnivorous, which means they eat both animal and plant material. Thus, they are a pest in crop and rangeland environments, where they cause



© Bethany Friesenhahn

Feral pigs in the United States cause 1.5 billion dollars in agricultural and environmental damage each year.

billions of dollars in damage annually. Management strategies, such as shooting and trapping, are widely used, but their effects are typically short-lived and local in scale. Our objective is to monitor feral pig movements relative to crop and rangeland resources and their movements relative to control efforts.

We trapped 30 feral pigs in an agriculture area in Delta County, Texas during January 2019 and fitted each with a satellite GPS collar. The collars record a GPS point every hour.

We will monitor pigs during January to September, spanning the planting, growth, and harvest periods for corn. We will determine agricultural resources available in the area via crop information, such as planting dates, seed varieties, and harvest dates. We will visit non-crop areas used by GPS-collared pigs, such as woodlands, riparian areas, and rangeland to determine how the pigs are using those landscapes as well as what resources are available to them.

We will use the information obtained in this study to identify pig home ranges, estimate resource selection during the growing season, and monitor pig response to control efforts conducted by Texas Wildlife Services and landowners. Our findings will allow us to better understand movements of feral pigs throughout the year, which can help refine control efforts.

Cooperative funding provided by the USDA Animal and Plant Health Inspection Service National Feral Swine Damage Management Program and the USDA Animal and Plant Health Inspection Service National Wildlife Research Center.

Fence-Line Ecology: Wildlife Use of Fence Crossings in South Texas

Megan M. Granger, Lisa D. Zoromski, Randy W. DeYoung, John A. Goolsby, Aaron M. Foley, J. Alfonso Ortega-Santos, David G. Hewitt, and Tyler A. Campbell

Fences are common throughout southwestern rangelands, but surprisingly, there is limited research on how animals cross fences. Past studies mainly focused on large game animals during long-distance migrations. Wildlife often cross fences at defined locations, and they prefer to go underneath rather than over fences. We defined fence crossings as areas where the bottom fence wires are pushed up or missing, often with a depression of bare soil beneath. The need to investigate fence crossings in South Texas arose because white-tailed deer and nilgai are alternative hosts for cattle fever ticks. These ticks can transmit the deadly *Babesia* protozoan to cattle. Nilgai are

difficult to attract, and crossings may serve as locations to target nilgai with tick acaricide treatments. Non-target species could be exposed to acaricides at crossings as well, and need to be documented.

We are assessing rates of animal movement at fence crossings on 2 ranches in South Texas using camera monitoring systems. During a single year of monitoring, we recorded 15 species and 6,229 attempted crossing events at one ranch and 4,657 at the other. White-tailed deer contributed the most to attempted crossing events at both ranches (44%, 58%), followed by nilgai (14%, 8%), and cattle (6%, 13%). On average, nilgai attempted to cross once every 4 days, whereas about 2 deer crossed per day. Knowledge of contact and movement rates between private landholdings will aid in the creation of disease control measures and help us understand the importance of fence crossings to wildlife movements.

Cooperative funding provided by the Las Huellas Association of South Texas and the USDA Animal and Plant Health Inspection Service National Wildlife Research Center.

Developing an Economic Model of Nature-focused Photography in Texas

Linden S. Eli, David G. Hewitt, April A. Torres Conkey, Benjamin L. Turner, and Bart M. Ballard

Passion for nature photography is nothing new. But, photographers are often looking for places where they can take high quality photos of unique or iconic animals. To meet this demand, some Texas landowners are starting to market their properties as “photography



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Some ranch owners are providing photo blinds to meet the increasing demand for nature photography.

ranches.” These often have photo blinds, water features, and natural areas that attract birds and other wildlife. Photography ranches may be a profitable business by charging access fees, guide fees, and room and board. These fees may increase a landowner’s income and make use of underutilized land, although the status of this market is currently unknown.

We are planning to study the economics of these nature-focused photography operations. Our objectives are to (1) determine the economic impact of nature-focused photography on private lands, (2) measure the financial impact of nature-focused photography on property values, and (3) construct a business model detailing the benefits and costs in creating and operating nature-focused photography operations on public and private lands.

We will interview landholders who advertise their property as a “photography ranch.” Information obtained will include property visitation specifics, property history, diversification of revenue, photography blind construction, and allocation of finances. If there is economic justification, creation of new or expansion of existing photography ranches as a revenue source can benefit landowners, photographers, and the wildlife they both enjoy.

Seasonal Resource Selection of Pronghorns in the Texas Panhandle

Anthony P. Opatz, Gary Mizer, Timothy E. Fulbright, Randy W. DeYoung, Humberto L. Perotto-Baldivieso, Warren C. Conway, and Shawn S. Gray

As croplands continue to replace native rangelands there will be an increase in wildlife-agriculture interactions and a resulting increase in human-wildlife conflicts. Our objective is to evaluate the effects of agriculture on home range placement and within home range selection of pronghorns.

In February 2017, we attached satellite GPS collars with 2-hour fix intervals to 64 pronghorns in study areas near Dalhart and Pampa, Texas. Thirty-two collars were evenly distributed between sexes. We paired 400,000 used locations with random locations to assess habitat selection. We modeled home range and within home range resource selection to evaluate the impacts of agriculture on pronghorn selection.

Pronghorns selected areas that had high plant greenness during winter (based on the Normalized Difference Vegetation Index [NDVI]). Mating behavior in August and September caused both sexes to

avoid areas of high NDVI. Pronghorns selected agricultural areas in the winter and spring, likely to supplement their dietary needs when native prairies had low forb production. Females selected areas farther away from paved roads, while males selected areas closer to paved roads. Paved roads are often lined with fences and act as barriers to movements of male pronghorns.

Pronghorns may use agricultural crops as a supplement to native vegetation to meet energy requirements at certain times of the year. Overall, conversion of rangelands to agriculture reduces pronghorn habitat. This is because agricultural areas are used in proportion to availability or avoided most of the year. In addition, infrastructure, such as paved roads that accompany agricultural development, fragments habitat.

Cooperative funding provided by Texas Parks and Wildlife Department.

Development of an Anesthetic Protocol for American Alligators

Clayton D. Hilton, Scott E. Henke, Cord B. Eversole, Tiffany L. Pope, Javier O. Huerta, and Andrew Lowery

The American alligator was once listed as an endangered species where it occurred within the United States. Populations have rebounded because of research focused on their biology and ecology, which allowed wildlife biologists to develop and implement successful management plans. However, there is a lot we still do not know about the American alligator.

With the increase in university research focused on understanding animal biology and ecology, researchers must first receive permission. Institutional Animal Care and Use Committees (IACUC) ensure that animals are not being harmed or unduly stressed by researchers. IACUCs demand that researchers use the most up-to-date methods, and the researchers are not duplicating already completed work. Often, animals must be anesthetized before being used in an experiment. This is needed so they do not become stressed during the experimental procedure.

A safe and reliable anesthesia protocol has not been developed for American alligators. Ketamine has been used for many years, but it can cause hallucinations, results are not always the same, and the effects of the drug can last for days. Recently, dexmedetomidine has been suggested to work in combination with ketamine. This drug would reduce the amount of ketamine needed for an animal to fall asleep and reduce



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Alligator research may require that the animal be appropriately anesthetized with a safe and reliable drug.

the negative aspects of ketamine. Another advantage is that the effects of dexmedetomidine can be immediately reversed using atipamezole, whereas the effects of ketamine must wear off gradually.

In this study, we plan to give dexmedetomidine and a low-dose of ketamine to American alligators in captivity and monitor their responses to stimuli while asleep. If this combination produces safe and reliable anesthesia then it can be recommended as the protocol of choice for American alligators.

Assessing the Use of Cameras to Identify Individual Nilgai at Latrines

Lori D. Massey, Lisa D. Zoromski, Randy W. DeYoung, John A. Goolsby, Aaron M. Foley, J. Alfonso Ortega-Santos, David G. Hewitt, and Tyler A. Campbell

The nilgai antelope is an exotic species native to Pakistan, India, and Nepal. Nilgai were introduced into the United States as zoo animals and released on ranches in South Texas during the 1920s–1940s. There has been only limited research on nilgai. Presently, there is a need for basic ecological information because nilgai can carry cattle fever ticks (CFT). These ticks can transmit the deadly *Babesia* protozoan to cattle that causes bovine babesiosis.

To effectively control CFT, treatment methods are needed for wildlife hosts of CFT, including nilgai. Nilgai do not use feed or bait, but use latrines, repeatedly defecating at a localized site. The identification of individual nilgai would allow us to estimate the



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A nilgai antelope photographed visiting a communal latrine site on the East Foundation’s El Sauz Ranch.

number of nilgai using latrines. This would provide information that could be used for the proper administration of treatments for CFT.

We are analyzing photos of nilgai visiting latrines on the East Foundation’s El Sauz Ranch. We will use physical features, such as scarring, to determine the proportion of identifiable nilgai.

Based on preliminary analyses, we identified individuals in over half of our pictures that visited repeatedly and a few individuals that visited multiple latrines. Fur patterns on legs and ears and horn shape and size were the best identifiers.

Our results will help us understand nilgai latrine ecology and determine if camera monitoring is an effective tool for the identification of individual nilgai. Also, this study will provide an estimate of the efficacy of latrine sites as locations for treatment of CFT.

Cooperative funding provided by the Las Huellas Association of South Texas and the USDA Animal and Plant Health Inspection Service National Wildlife Research Center.

Seasonal Home Ranges of Pronghorns in the Texas Panhandle

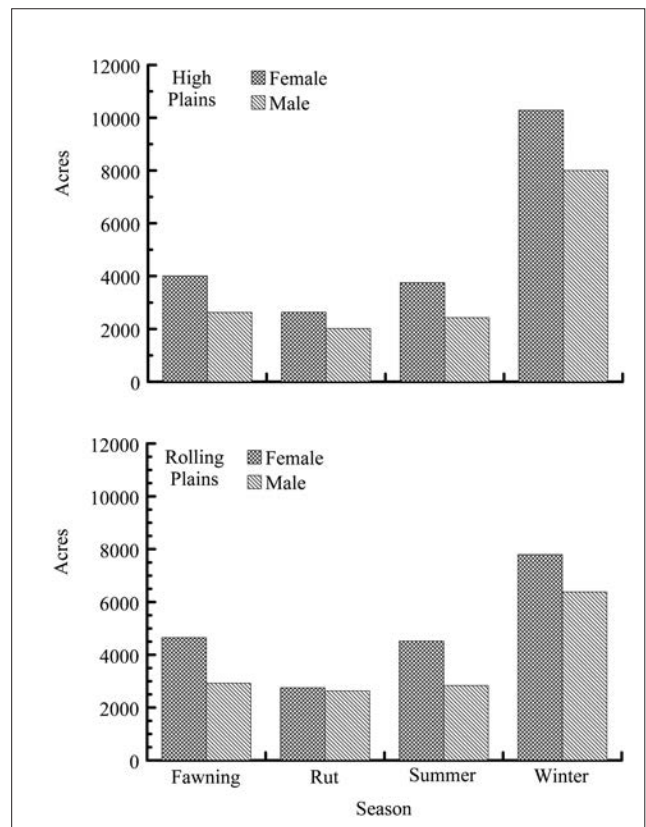
Timothy E. Fulbright, Anthony P. Opatz, Gary Mizer, Randy W. DeYoung, Humberto L. Perotto-Baldivieso, Warren C. Conway, David G. Hewitt, and Shawn S. Gray

Seasonal home range sizes of pronghorns in the Texas Panhandle have not been well documented. This information is needed to better manage this

iconic species. Our objective is to determine seasonal (fawning season, summer, rut, and winter) home range sizes of male and female pronghorns in the High Plains (near Dalhart) and Rolling Plains (near Pampa) ecoregions of Texas.

In February 2017, we attached satellite GPS collars with 2-hour fix (data point collected) intervals to 64 pronghorns in study areas near Dalhart and Pampa, with 32 collars evenly distributed between sexes. We also captured and collared 27 additional pronghorns in 2018, 19 in the High Plains (11 males, 8 females) and 8 in the Rolling Plains (5 males, 3 females), to account for mortalities during the study. We retrieved the collars in February 2019. We used the time-based local convex hull home range estimation method to create home ranges that included 95% of the GPS fix points for each season, for each animal.

Female pronghorns tended to have larger home ranges than males, particularly during the fawning period, summer, and winter. Home ranges of both sexes were largest during winter, averaging about 10,285 acres for females in the High Plains compared to 7,795 acres for females in the Rolling Plains. It appears that pronghorns in the Texas Panhandle require extensive areas of landscape. Habitat for pronghorns



Seasonal home ranges of satellite GPS-collared pronghorns in the High Plains and Rolling Plains of Texas during February 2017–February 2018.

in the Panhandle will decline if barriers to movements such as net-wire fences, highways, urban areas, and cropland increase in the future.

Cooperative funding provided by Texas Parks and Wildlife Department.

Assessing Populations of Birds on the East Foundation Ranches

Delanie E. Slifka, April A. Torres Conkey, Leonard A. Brennan, and Tyler A. Campbell

Climate change, human impacts, habitat manipulations, and landscape use are 4 of the main factors that influence bird populations. For 10 years, breeding and non-breeding bird surveys have been conducted on 3 properties belonging to the East Foundation in South Texas, specifically San Antonio Viejo, El Sauz, and Santa Rosa.

During the months of May and June, breeding bird surveys are conducted to document species occurrence, richness, and abundance using point counts. The non-breeding bird surveys are conducted from August–April to document species occurrence, richness, and abundance using transect surveys.

Since this project has been ongoing for the last 10 years, overall trends can be identified. Wildlife managers can use this information to make informed decisions to preserve bird populations.

Cooperative funding provided by the East Foundation and The Richard M. Kleberg, Jr. Center for Quail Research.

Using Drones to Evaluate Crop Damage by Feral Pigs

Bethany A. Friesenhahn, Randy W. DeYoung, Humberto L. Perotto-Baldivieso, Justin W. Fischer, Nathan P. Snow, and Kurt C. VerCauteren

Feral pig damage to crops has increasingly become a major issue for farmers and ranchers across Texas and throughout the United States. Management control strategies include trapping, shooting, and fencing, but the short- and long-term effectiveness of control efforts is not clear. Furthermore, some management options are costly, and it is difficult to estimate how much crop production is gained from specific management efforts. Our objective is to use drone technology



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An unmanned aerial vehicle is taking off to capture imagery to assess crop damage caused by feral pigs.

and geographic information systems (GIS) to help us understand the cost-to-benefit trade-offs of damage mitigation strategies.

We are flying a drone over 5 corn fields near Delta County, Texas every 3 to 4 weeks from March–August to evaluate damage caused by feral pigs at different crop growth stages. The drone captures high-resolution images that will be stitched together to create a complete image of the individual fields. For each completed image, we will determine how much pig damage occurs in each corn field. We will ground-truth sections of the field to verify that feral pigs caused the damage identified in the images.

Paired drone imagery and ground-truthing at different corn growth stages will allow us to determine why pigs target specific growth stages, corn fields, or particular locations within larger fields. We will measure crop yield at harvest to estimate the economic impact of pig damage and the cost-to-benefit value of control efforts. The results of this study should aid agricultural producers in management decisions regarding feral pigs, including whether to replant, and the timing, choice, and duration of control methods.

Cooperative funding provided by the USDA Animal and Plant Health Inspection Service National Feral Swine Damage Management Program and the USDA Animal and Plant Health Inspection Service National Wildlife Research Center.

Control of Cattle Fever Ticks on Nilgai Using Remote Sprayers

Jeremy A. Baumgardt, Kathryn M. Sliwa, Randy W. DeYoung, J. Alfonso Ortega-Santos, David G. Hewitt, John A. Goolsby, and Adalberto A. Perez de Leon

The cattle fever tick (CFT) can transmit the *Babesia* protozoan to cattle, which can cause bovine babesiosis. The last major outbreak of babesiosis in the United States occurred early in the 20th century and affected 14 southern states. This disease was eradicated from the United States during the 1940s by eliminating CFTs. The CFT management program established a permanent quarantine zone at the Mexican border to prevent reinfestation of the U.S. cattle herd.

Recently, CFTs have been detected in 13 South Texas counties outside the permanent quarantine area. These outbreaks were likely facilitated by the movements of nilgai antelope, which also carry CFTs. Nilgai are native to Asia, and were introduced to South Texas in the early 1900s as an alternative livestock. Presently, more than 30,000 free-ranging nilgai occur in the South Texas region.

In this study, we are evaluating the efficacy of remotely activated sprayers for control of CFTs on nilgai. The sprayers discharge a solution containing nematodes, an effective nontoxic biocontrol for CFTs. We have deployed 120 sprayers on 5 ranches in Cameron County. Sprayers are at sites where nilgai cross under livestock fences. Currently, there are 50 nilgai marked with ear tags and 30 with satellite GPS collars in the study areas. In addition, nilgai activity is being monitored at the sprayer sites with trail cameras. Marked animals will be recaptured after 3 months to compare changes in the number of ticks per animal. The results of this study will have important implications for the control of CFTs in the South Texas region.

Cooperative funding provided by the USDA Agricultural Research Service.

Assessing Potential Insect Intermediate Hosts in Northern Bobwhite Diets

Tessa M. Green, Nicole J. Traub, and Alan M. Fedynich

Insects serve as intermediate hosts for certain helminth parasites in which bobwhites are the final (definitive) host. For these indirect lifecycle parasites,

the final host is where they reproduce and shed eggs back into the environment. For effective transmission the insect must ingest the parasite egg after which the egg hatches into a larval form and then waits for the final host to eat the infected insect.

For helminths of bobwhites occurring in South Texas, it is unclear which insects are involved. To learn more, we examined the crops of 136 hunter-donated bobwhites from the 2016–2017 hunting season and 106 from the 2017–2018 hunting season to determine which insects are being consumed by bobwhites during winter.

Insects were found in 19 bobwhite crops (14%) from the 2016–2017 hunting season and 22 crops (21%) from the 2017–2018 hunting season. Six taxonomic orders were present in the 2016–2017 sample and 8 orders were present in the 2017–2018 sample. However, bobwhite crops contained only insects from 1 to 4 orders each. Order Coleoptera (beetles) was most common (57%) in 2016–2017. In 2017–2018, Blattodea (cockroaches and termites) was most common (69%), followed by Coleoptera (13%).

The next step in our research is to identify the insects to species and examine them for larval stages of parasites. Information obtained in this study is crucial if we hope to understand the relationship between insects and bobwhite helminth lifecycles, and ultimately their effect on bobwhites.

Cooperative funding provided by the South Texas Chapter of Quail Coalition.

Wild Felid Disease Prevalence on East Foundation's El Sauz Ranch

Jason V. Lombardi, Clayton R. Hilton, Michael E. Tewes, John P. Leonard, Maksim Sergeev, and Tyler A. Campbell

Feral cat colonies can be susceptible to outbreaks of diseases such as feline immunodeficiency virus, feline leukemia, and feline distemper. Areas where feral cat colonies abut to wildlands can have negative effects on wild cat populations. This is particularly a concern for threatened and endangered species.

Port Mansfield, Texas is a town that is home to a large feral cat population. Over the last few years, this population has experienced outbreaks of felid-specific diseases. Adjacent to the town is the East Foundation's El Sauz Ranch and surrounding private ranches, which are home to 80% of the known ocelots

in the United States. Although ocelots are not known to occur within 7 to 8 miles of the town due to lack of preferred habitat, risk of transmission between feral cats and bobcats, a sympatric species with ocelots, remains. An outbreak within this small ocelot population could negatively affect its long-term survival. To help assess the prevalence of these felid-specific diseases in ocelot and bobcat populations, we have been collecting and testing blood samples from ocelots and bobcats on the El Sauz Ranch spanning 2011–2019.

This study will allow wildlife managers to gain a better understanding of possible risk factors of feral cats to bobcat and ocelot populations. Findings should help wildlife managers plan strategies that aid in reducing or preventing transmission of contagious disease agents among wild and feral cat populations.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute, Wild Cat Conservation, Inc., East Foundation, Annova LNG and their parent company Exelon Generation, Brown Foundation, Tim and Karen Hixon Foundation, Travis and Bettina Mathis, and Ben F. Vaughan, III.

Nilgai Movements and Habitat Selection in Regard to Cattle Fever Ticks

Kathryn M. Sliwa, Jeremy A. Baumgardt, Randy W. DeYoung, J. Alfonso Ortega-Santos, David G. Hewitt, Humberto L. Perotto-Baldivieso, John A. Goolsby, and Adalberto A. Perez de Leon

The cattle fever tick (CFT) can transmit the deadly *Babesia* protozoan to cattle, which can be devastating to the cattle industry. Although CFTs were eradicated from the United States in the 1940s, ranches along the U.S.-Mexico border are at risk of reinvasion from infested areas in Mexico. Livestock can be monitored and screened for ticks prior to transport. However, wildlife, such as deer and nilgai, may facilitate long-distance movement of CFTs from infested areas.

The nilgai is an exotic ungulate that was introduced to South Texas from India in the early 1920s. Nilgai populations expanded rapidly and presently there are about 30,000 free-ranging individuals in South Texas. Little is known about nilgai behavior, but previous studies have concluded these animals have large home ranges and can make long-distance movements.

In early 2019, we captured 30 nilgai in Cameron County, Texas and fitted them with satellite GPS tracking collars. The collars deliver hourly GPS locations of each nilgai. We will use this information to monitor

movements, determine home range sizes, assess habitat selection, and evaluate the influence of the environment on movement patterns.

Knowledge of nilgai movements and behavior has become increasingly important due to the nilgai's ability to move CFTs over large geographic areas. With the recent outbreaks of CFTs in Cameron County, it is critical to consider nilgai movements, activity patterns, and habitat selection in CFT management efforts. The results of this study will help define the scale for potential treatment options and identify focal areas for targeted nilgai-CFT treatments.

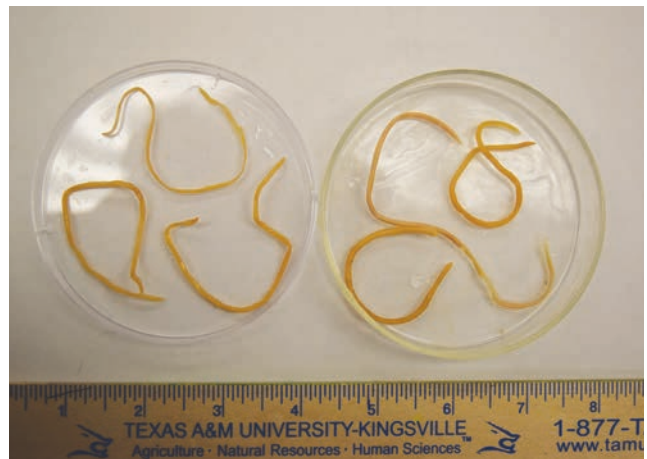
Cooperative funding provided by the USDA Agricultural Research Service.

Fire Effects on Viability of *Baylisascaris procyonis* Eggs in the Environment

Tiffany L. Pope, Scott E. Henke, Sandra Rideout-Hanzak, and Clayton D. Hilton

The raccoon roundworm, *Baylisascaris procyonis*, is a zoonotic parasite found in the small intestine of raccoons. The adult worm does not appear to be particularly harmful to raccoons. However, larvae within intermediate hosts can cause eye and neurologic damage, and can lead to death. Over 150 species of birds and mammals, including humans, have fatally succumbed to the effects of the raccoon roundworm. Therefore, this parasite is a major threat to both public and wildlife health.

Female roundworms can produce millions of eggs per day, which are shed in the feces of raccoons. Upon



© Scott Henke

CKWRI researchers are exploring ways to kill the eggs of the raccoon roundworm to prevent its spread.

feces decay, raccoon roundworm eggs contaminate soil. Due to a protective protein coating that surrounds the eggs, eggs can remain viable in the environment for at least a decade. It has been found that temperatures over 155°F can kill viable eggs.

In this study, we plan to conduct prescribed fires in areas with known viable raccoon roundworm eggs. We will record heat intensity created by the flames and heat transferred to soil at various depths and distances from the flames. This project, if successful, will offer a management strategy to combat the spread of this zoonotic parasite.

Cooperative funding provided by the Texas A&M University-Kingsville Research Award.

Fence Crossings and Management of Cattle Fever Ticks

Jeremy A. Baumgardt, Kathryn M. Sliwa, Randy W. DeYoung, J. Alfonso Ortega-Santos, David G. Hewitt, John A. Goolsby, and Adalberto A. Perez de Leon

It is well known that wildlife cross fences at defined areas. Because animals prefer to go underneath rather than jump, the crossing sites are characterized by a hole or depression under the wire where soil has been removed. In the case of net-wire fencing, wires at the bottom of the fence may be bent upwards or even broken. Therefore, crossings used by large animals, such as white-tailed deer, feral pigs, and nilgai antelope, are easy to identify. Although fence crossings are common in rangelands, there have been no studies on the use of crossings by wildlife.



© Jeremy Baumgardt

Nilgai serve as carriers of the cattle fever tick and their movements are not limited by fences.

The importance of fence crossings and wildlife movements has increased with outbreaks of the cattle fever tick (CFT) in the Lower Rio Grande Valley. The CFT can transmit the *Babesia* protozoan that causes bovine babesiosis. Nilgai and white-tailed deer are important wildlife reservoirs of ticks. Our objective is to quantify the rates of movement among ranches by deer and nilgai and determine the potential for using fence crossings as treatment sites for the CFT.

We deployed 120 cameras at fence crossing sites on 5 ranches in Cameron County, Texas to monitor animals crossing fence lines. We are classifying animal usage of the sites relative to landscape features as well as fence type and size of opening.

So far, we have collected over 1 million photos, including images of white-tailed deer and nilgai, as well as non-target animals such as javelinas, feral pigs, coyotes, bobcats, raccoons, opossums, and armadillos. Understanding the use of fence crossings will be an important step in managing the CFT in South Texas.

Cooperative funding provided by the USDA Agricultural Research Service.

What Makes the Cecal Worm a Successful Parasite in Northern Bobwhites?

Nicole J. Traub and Alan M. Fedynich

Parasitologists often wonder why some nematode parasites are more successful than others. One factor that seems to play a role has to do with how many males and females occur within a host individual. If they are all one sex or the sex ratio is strongly overbalanced, then the opportunity to reproduce is not optimal. This seems to occur in rare nematode species. But, what does the male-to-female ratio look like in a highly successful species? To answer this question, we examined the sex ratios of the cecal nematode (*Aulonocephalus pennula*) that commonly occurs in bobwhites within South Texas.

We used a database containing 174 bobwhites collected during the 2016–2017 hunting season and 106 bobwhites from the 2017–2018 hunting season. Cecal nematode individuals from individual infected bobwhites (called infrapopulations) were placed into 5 groups: 5–30, 50–80, 100–150, 200–300, and 300+ worms, with 5 replicates each. Sex ratios were determined for each host individual and for each group.

We found most host individuals had cecal worm infections with 1-to-1 sex ratios. When each group

was examined individually, 2 of 5 groups in 2016–2017 and 3 of 5 groups in 2017–2018 had 1-to-1 sex ratios. However, 3 of 5 groups in 2016–2017 and 2 of 5 groups in 2017–2018 were female-biased.

Our preliminary results suggest that there are sufficient numbers of males and females present within infected bobwhites for this parasite to be highly productive and maintain its population across the landscape. We plan to add additional years of data to shed light on why this cecal nematode is so successful in its ability to infect bobwhites in South Texas.

Cooperative funding provided by the South Texas Chapter of Quail Coalition.

Allelic Variation in the Prion Protein Gene of White-tailed Deer

David Navarro, Randy W. DeYoung, Aaron M. Foley, Charles A. DeYoung, Don A. Draeger, Tyler A. Campbell, Julie A. Blanchong, and James M. Reecy

Chronic Wasting Disease (CWD) is a fatal neurodegenerative disease, classified as a transmissible spongiform encephalopathy. Caused by misfolded prion proteins, CWD is a major management concern for North American cervids. Currently, there is no cure for CWD. However, some cervids have genetic mutations in the prion protein gene, which confers partial resistance. This resistance delays the progression of CWD. A mutation at codon 96 of the prion protein gene occurs in 5 to 25% of white-tailed deer, and is associated with lower prevalence and slower progression of CWD. However, this period of latency also makes detection of CWD more difficult because infected deer may live longer and continue to spread the misfolded prion proteins.

We amplified and sequenced the prion protein gene from 103 white-tailed deer from Texas, North Carolina, and Iowa. We observed 17 mutations in the prion protein gene, including 7 not previously reported in white-tailed deer. The significance of the newly found mutations is unclear, but some may alter biological function of the gene through amino acid substitutions. Samples from Iowa and North Carolina had frequencies of the codon 96 mutation similar to previous studies, 29% and 17%, respectively. Frequency of codon 96 mutations in Texas white-tailed deer was high, occurring in 54 of 74 individuals (73%).

Our results suggest that the frequency of occurrence of prion gene alleles may vary dramatically



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Chronic wasting disease has become an increasing concern for deer biologists, landowners, and hunters in Texas.

among populations of white-tailed deer. With growing concerns about the impact of CWD on deer populations, we need a better understanding of the genetic variation in the prion protein gene. Such information has implications regarding the detection of CWD as well as future management decisions aimed at controlling the spread of the disease.

Cooperative funding provided by the Comanche Ranch and the East Foundation.

Immune System Variation Found in Nilgai Antelope Occurring in South Texas

Kathryn M. Sliwa, David Navarro, Masahiro Ohnishi, Randy W. DeYoung, Jeremy A. Baumgardt, J. Alfonso Ortega-Santos, David G. Hewitt, John A. Goolsby, and Adalberto A. Perez de Leon

Nilgai were introduced into South Texas beginning in the 1920s as a potential alternative livestock species. Native to India and Pakistan, nilgai fared well in the semiarid Texas climate. There are an estimated 30,000 free-ranging nilgai in South Texas, mainly on contiguous rangelands between Kingsville and the Lower Rio Grande Valley.

Recently, nilgai have been implicated in outbreaks of the cattle fever tick (CTF) in South Texas because they are competent hosts and move long distances, potentially spreading CTFs over a wide area. The ticks can transmit *Babesia*, which is a protozoan parasite that causes bovine babesiosis.

Genetic diversity can aid in defending against pathogens and diseases. Introduced populations often have lower genetic diversity than source stocks. This is due to a small number of founding individuals and random differences in survival and reproduction after introduction. These 2 phenomena are called founder effect and genetic drift. If introduced nilgai have reduced genetic diversity, they may be more susceptible to tick infestations.

Presently, we are analyzing nilgai genetic diversity using the major histocompatibility complex, which is responsible for recognition of pathogens. We will compare immune system diversity to tick loads on nilgai captured in Cameron County, Texas.

The results of this study should help us determine if some individual nilgai are more susceptible to tick infestations because of lower immune system diversity. Our findings will be important for understanding the role of nilgai in CTF outbreaks in South Texas and northern Mexico.

Cooperative funding provided by the USDA Agricultural Research Service.

Zoonotic Pathogens and Antibiotic-Resistant Bacteria in the Microbiome of Raccoons

Molly C. McClurg, Sarah Garza, Jing Wu, Sara D. Lawhon, Scott E. Henke, and Richard C. Laughlin

Raccoons are often found in urban and suburban areas. With an increase in urban sprawl, it will be important to better understand the raccoon's potential for human health risk. Because of the proximity to



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Raccoons harbor a wide range of bacteria and parasites, some of which are harmful to humans.

humans in which raccoons typically reside, we sought to determine what microbiota they harbor, and what risks this might pose to human health.

Previous studies have shown raccoons to be carriers of zoonotic pathogens, such as species of *Salmonella*. However, little has been done to determine the presence of other zoonotic pathogens. While identification of potential human pathogens is important to the study, we further sought to identify the possible presence of antibiotic resistant bacteria that could potentially spread resistance through horizontal transmission to other bacteria.

In our study, the intestines of raccoons from southern Texas are being examined for the presence of potential pathogens. We enriched and selectively cultured samples for species of *Salmonella*, *Escherichia*, and *Enterococcus*. Samples were further identified by mass spectroscopy in collaboration with the College of Veterinary Medicine at Texas A&M University. These 3 genera were selected for their relevance in clinical settings. They were found in nearly all samples. This indicates a potential risk for humans living near raccoons. In addition, we found a vancomycin-resistant enterococcus (VRE). This is a significant health concern in both human and veterinary clinics. Future work will include expansion of sample sizes as well as additional testing of antibiotic resistance to other relevant antibiotics.

Feeder Acceptance by Nilgai: Implications for Cattle Fever Tick Management

Kathryn M. Sliwa, Jeremy A. Baumgardt, Randy W. DeYoung, J. Alfonso Ortega-Santos, David G. Hewitt, John A. Goolsby, and Adalberto A. Perez de Leon

The cattle fever tick (CFT) can transmit the *Babesia* protozoan that causes bovine babesiosis. This is a disease that can have a severe economic impact on the U.S. cattle industry. The ticks were eradicated from the United States in the 1940s after decades of effort. Since that time, a permanent quarantine zone along the U.S.-Mexico border has been maintained to prevent re-invasion of ticks. Although cattle are the preferred host for CFTs, white-tailed deer and nilgai antelope can serve as alternative hosts.

Cattle within the permanent quarantine zone in Texas are monitored and treated for CFTs using acaricides. Wildlife are more difficult to manage. Treatment methods used for deer include medicated corn and topical applications of acaricide at feeder

sites. However, nilgai do not respond to bait and the only current option would be to reduce nilgai numbers. This option is not desirable because the nilgai is a popular game animal.

In this study, we will determine if free-ranging naïve nilgai can be influenced to consume pelleted feed by observing other nilgai that have been habituated to eating supplemental feed. We will transport feed-habituated nilgai from a ranch, where they are accustomed to eating from feeders, to a game-fenced area containing wild deer and nilgai. We will monitor feeder sites using trail cameras to document feeding activities and social interactions between habituated and wild nilgai and white-tailed deer.

If naïve nilgai can be conditioned to eat from supplemental feeders, CFT treatment could be delivered through medicated feed or motion-activated sprayer systems at feeder stations. The results of this study will uncover more information about nilgai behavior and social interactions, and may result in a CFT treatment option.

Cooperative funding provided by the USDA Agricultural Research Service.

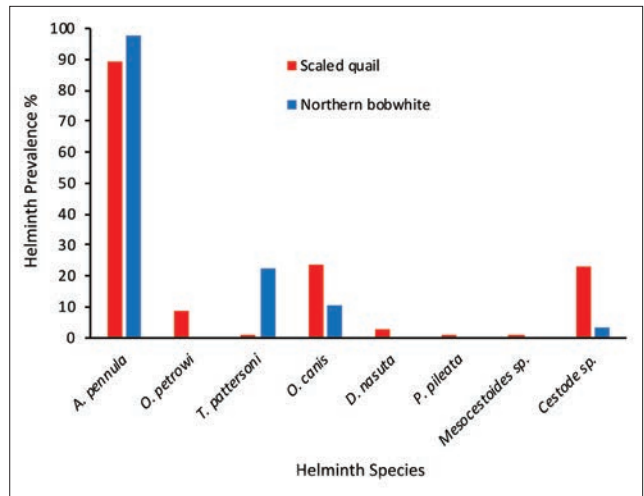
Survey of Helminth Parasites Infecting Regionally Sympatric Quail Species

Nicole J. Traub, Taylor R. Shirley, and Alan M. Fedynich

Northern bobwhites and scaled quail are experiencing a long-term decline throughout Texas. The underlying cause has been attributed to habitat fragmentation and loss. However, despite habitat management efforts, long-term declines have continued in certain areas, thereby indicating other causes.

As part of a long-term parasite study in South Texas, we are wanting to learn more about how infections might vary among regionally co-occurring quail species. We examined 85 bobwhites and 105 scaled quail that were donated during the 2016–2017 and 2017–2018 Texas quail hunting seasons by cooperators at La Mesa I Ranch in Zapata County, Texas and La Mesa II Ranch in Jim Hogg County, Texas.

Bobwhites were infected with 4 species. The cecal worm (*Aulonocephalus pennula*) had the highest prevalence (98% of bobwhites infected) and abundance (7,814 individual worms found; average of 94 worms per bird). The other species (*Tetrameres pattersoni*, *Oncicola canis*, and an unidentified cestode) rarely occurred (each species had less than 25% prevalence).



Graph showing the helminth parasite distribution and prevalence (% of infected hosts) in 85 northern bobwhites and 105 scaled quail donated during the 2016–2017 and 2017–2018 hunting seasons from Zapata and Jim Hogg counties, Texas.

Scaled quail had 8 species. The cecal worm had the highest prevalence (90%) and abundance (1,373 individuals; average of 14 worms per bird). The remaining species (*Oxyspirura petrowi* [eyeworm], *T. pattersoni*, *O. canis*, *Dispharynx nasuta*, *Procyrnea pileata*, *Mesocestoides*, and an unidentified cestode) rarely occurred.

It appears that the helminth community in both quail species is species-poor and numerically dominated by the cecal worm. Interestingly, higher species richness occurred in scaled quail, suggesting exposure to a wider range of parasite species’ infective stages. Overall, most quail were infected with only 1 species (cecal worm) and no quail individual was infected with more than 4 species. Our study is providing additional insight on host-helminth systems occurring within South Texas.

Cooperative funding provided by the South Texas Chapter of Quail Coalition.

Allelic Variation in the Prion Protein of Texas Mule Deer

Gael A. Sanchez, Randy W. DeYoung, David G. Hewitt, Timothy E. Fulbright, Humberto L. Perotto-Baldivieso, Louis A. Harveson, and Shawn S. Gray

Chronic wasting disease (CWD) was detected in Texas mule deer in 2012. Management has focused on containment of CWD. There is no cure or evidence of resistance to CWD, but mutations in the prion protein (Prnp) gene affect susceptibility, incubation time, and the ability to detect the disease. To learn more about allelic variation in the prion protein, we amplified and sequenced the Prnp from a subset of tissue samples collected at CWD check stations in the Trans-Pecos and Panhandle regions of Texas during 2012–2015.

- We observed mutations in the Prnp that change the amino acids, including 6 not previously reported in any species of deer.
- Twenty deer phenotypically identified as mule deer had nucleotide substitutions at codon 96, mutations originally identified in the white-tailed deer Prnp.
- Seven mule deer had mutations at codon 225, resulting in an amino acid substitution associated with CWD prevalence and progression in Colorado and Wyoming populations.
- Our results reveal a diverse set of Prnp alleles in Texas mule deer, possibly due to past hybridization and backcrossing with white-tailed deer, as well as novel mutations with as yet unknown significance to the progression of CWD.
- Genetic variation in the Prnp has implications for detection of CWD and future management decisions aimed at controlling the spread of the disease.

Cooperative funding provided by Texas Parks and Wildlife Department and the U.S. Fish and Wildlife Service Wildlife Restoration Section 4 Grants Program (TXW-169-R-1).

Analysis of CWD-Positive White-tailed Deer in Medina County, Texas

Masahiro Ohnishi, Damon L. Williford, H. Jae Edlin, Randy W. DeYoung, and Mitch A. Lockwood

Chronic wasting disease (CWD) is a fatal neurodegenerative disease detected in white-tailed deer from a captive breeding facility in Medina County,

Texas in 2015. Since that time, more than 58 deer from 4 breeding facilities or their associated release sites tested positive. In January 2017, CWD was confirmed in a free-ranging deer in Medina County. Two additional free-ranging deer tested positive during the 2018–2019 hunting season.

Our objective was to determine whether the free-ranging CWD-positive deer were wild native stock or had ancestry to captive herds. Using genetic markers, we analyzed samples from the free-ranging deer population and 3 captive herds.

- We observed sufficient genetic differences to assign individuals to genetic clusters. Our analyses indicated that the CWD-positive deer were most genetically similar to captive deer.
- Due to the presence of admixture, where individuals were assigned to 2 or more genetic clusters, it is difficult to conclude specific relationship categories based on these data. But, it seems likely that the CWD-positive deer had ancestry to captive deer within the past 1–3 generations.
- We could not unambiguously assign the CWD-positives to any of the sites we sampled nor were we able to determine how these animals occurred in the free-ranging population.
- Due to low prevalence of CWD in free-ranging deer (versus infected deer at captive sites) and the long incubation period, it seems likely that the disease may be traced to CWD-positive captive deer.
- Results underscore the importance for CWD testing and monitoring of captive herds and free-ranging deer near facilities that have CWD-positive deer.

Cooperative funding provided by Texas Parks and Wildlife Department.

Contribution of Northern Stock Sources to the Southeastern United States

Jordan L. Youngmann, Steve Demarais, Randy W. DeYoung, Bronson K. Strickland, Johnathan Bordelon, Chris Cook, and William McKinley

White-tailed deer in the southeastern United States are genetically admixed mainly because of translocations by state agencies during the mid-1900s. These translocations were an attempt to restore those populations that were nearly extirpated. Translocated individuals came from native as well as northern stocks.

However, the adaptive ability of translocated individuals from other geographic regions to withstand different climates and novel diseases is questionable. In addition, little is known about their long-term genetic contribution to current populations.

We sampled free-ranging white-tailed deer populations in Louisiana, Mississippi, and Alabama at sites with known historical translocations of northern deer as well as stock source populations from Iron Mountain, Michigan, Sandhill Wildlife Area, Wisconsin, and the Adirondacks in New York. We assessed genetic relationships among current and stock populations using 14 microsatellite DNA markers.

- Populations were admixed with a clear east to west division along the Mississippi River. Genetic differentiation was not associated with geographic distance between sites.
- Northern deer populations were less differentiated from all southcentral populations than the average differentiation across southcentral populations or average differentiation between the western and eastern groups.
- A weak relationship was found between several southcentral deer populations and the Michigan and Wisconsin populations. It is not clear if this is a result of translocations or the lack of differentiation between northern and southern populations.
- Historical restoration programs had a lasting effect on white-tailed deer populations, but it appears that native stocks fared better than northern deer.
- It is clear that careful consideration must be taken in choosing stock sources for restoration efforts.
- Findings bring to light the potential inefficacy of using white-tailed deer stock from different climates and evolutionary histories.

Cooperative funding provided by Mississippi Department of Wildlife, Fisheries, and Parks, Louisiana Department of Wildlife and Fisheries, and Alabama Department of Conservation and Natural Resources via the Federal Aid in Wildlife Restoration Program.

Influence of the Environment on Body and Antler Size in White-tailed Deer

Masahiro Ohnishi, Randy W. DeYoung, Don A. Draeger, Charles A. DeYoung, Bronson K. Strickland, and Mitch A. Lockwood

White-tailed deer antler development is influenced by both genetic and environmental factors. The effects

of age and body condition on current-year antler growth are well-known. However, conditions early in life may have a permanent affect on growth. To learn more about these topics, we quantified the influence of both annual and early life conditions on antler growth and body mass of white-tailed deer on the Comanche Ranch in Dimmit and Maverick counties, Texas where precipitation is highly variable.

Each autumn during 2010–2018, we captured male white-tailed deer, estimated age, measured gross Boone & Crockett Score (GBC), and determined body mass (weight). We evaluated the influence of environmental conditions on buck fawns at birth and during their first year of life on GBC and body mass later in life (1.5–5.5 years old). We also analyzed the effects of precipitation during the autumn, winter, and antler growth period on yearly GBC and body mass. In this study, there were 1,859 captures of 1,087 known-aged individual bucks.

- For young bucks, precipitation experienced while in utero had biologically meaningful effects: 0.81 GBC and 2.8 lbs body mass per inch of precipitation.
- Bucks eventually out-grew the effects of early environment, as we found no effect of early-life conditions on GBC and body mass of bucks at maturity (4.5–5.5 years old).
- As expected, precipitation during the antler growth period affected current-year antler growth (1.3 GBC per inch of precipitation).
- In South Texas, the randomness of environmental variables may have a profound effect on antler development of young bucks. Thus, phenotypic development may be more from environmental effects than genetic potential.



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CKWRI researchers have been studying the effects of environmental conditions on the expression of antler traits.

- Our findings have important implications for white-tailed deer management and selective harvest programs.

Cooperative funding provided by the Comanche Ranch and Texas Parks and Wildlife Department.

Genetic Differentiation of Captive and Free-Ranging White-tailed Deer

Jordan L. Youngmann, Steve Demarais, Randy W. DeYoung, Bronson K. Strickland, Johnathan Bordelon, Chris Cook, and William McKinley

The captive cervid industry has recently grown in Texas. With the increase of chronic wasting disease there are concerns about introgression of non-native genetic stocks into wild populations. Introgression can occur when non-native deer are released into game-fenced enclosures or escape into the wild.

Little is known about the genetic effects of interbreeding between captive and free-range individuals. However, the potential for disease transmission is real. The ability to detect illegal releases or escaped captives depends on genetic differentiation between native and captive deer.

We estimated genetic differentiation between captive and wild stocks based on F_{st} , which is an index of genetic distance. Values for F_{st} less than 0.05 and greater than 0.15 indicate low and high differentiation. We simulated the multi-generational effects of non-native introgression using genetic data from 6 breeding pen populations of white-tailed deer into



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The captive deer industry has grown over the past several years in Texas, which has prompted concerns about the spread of chronic wasting disease into wild populations.

adjacent wild populations in Louisiana, Mississippi, and Alabama using 14 microsatellite loci.

- Genetic differentiation between white-tailed deer in breeding pens and nearby free-range populations was low-to-moderate (F_{st} ranged from 0.036 to 0.068).
- First generation crosses could be reliably distinguished from parent populations of captive and free-range deer.
- Backcrosses could not be consistently differentiated from either parent or 1st generation individuals.
- Non-native deer released into free-range populations may have a detectable genetic signature.
- Subsequent back-crosses to native deer were difficult to distinguish.
- Results suggest that more genetic markers are needed to enable high statistical confidence in population assignment.

Cooperative funding provided by Mississippi Department of Wildlife, Fisheries, and Parks, Louisiana Department of Wildlife and Fisheries, and Alabama Department of Conservation and Natural Resources via the Federal Aid in Wildlife Restoration Program.

Landscape-Genetic Analysis of Texas Mule Deer

Gael A. Sanchez, Randy W. DeYoung, David G. Hewitt, Timothy E. Fulbright, Humberto L. Perotto-Baldivieso, Louis A. Harveson, and Shawn S. Gray

Chronic wasting disease (CWD) was discovered in free-ranging North American cervids in 1981 and has become a major management concern. The disease was detected in Texas mule deer in 2012, most likely spread to the Trans-Pecos region via natural movements of mule deer from New Mexico. Chronic wasting disease was detected in free-ranging Panhandle mule deer and white-tailed deer in 2015 and 2017, respectively.

Patterns of genetic similarity can reveal how animals use the landscape, and how landscape features influence animal movements. In this study, we analyzed genetic data from mule deer harvested throughout their range in Texas to understand how deer movements may lead to the future spread of CWD.

- Our analyses indicated evidence of hybridization between mule deer and white-tailed deer throughout the Trans-Pecos and Panhandle regions.



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Researchers used genetic methods to see how landscape features influence mule deer movements and the possible spread of chronic wasting disease across the landscape.

- Five percent of mule deer had evidence of recent hybrid ancestry, but most were back-crosses versus 1st generation crosses. We removed all detectable hybrids from the dataset and focused on analyses of mule deer in relation to landscape features.
- Genetic differentiation was low and mostly due to geographic distance among samples.
- We detected few barriers to mule deer movements in the Trans-Pecos.
- We found evidence of restricted gene flow in the more fragmented Panhandle region, and in regions of unsuitable habitat where the High Plains and Edwards Plateau meet the Trans-Pecos.
- The results of our study support the use of geographically extensive monitoring and management units for CWD. Based on our genetic analysis, there appears to be few landscape barriers to mule deer movements and the potential spread of CWD in western Texas.

Cooperative funding provided by Texas Parks and Wildlife Department and the U.S. Fish and Wildlife Service Wildlife Restoration Section 4 Grants Program (TXW-169-R-1).

Vegetation Attributes of Thermal Refugia for Northern Bobwhites in South Texas

Brandon J. Palmer, Timothy E. Fulbright, Eric D. Grahmann, Fidel Hernández, Michael W. Hehman, and David B. Wester

We know that northern bobwhites move to brushy areas when it is hot. What we don't know is if there is a particular combination of vegetation characteristics that is most effective in creating the "cool spots" for birds to avoid potentially lethal temperatures. Wildlife managers need to know how to assess the ability of the habitat to provide thermal refuge for bobwhites.

We determined the combination of vegetation characteristics that reduced temperature the most, and what combination of vegetation characteristics bobwhites chose during midday. We radio-collared 40 bobwhites and located them 2 to 3 times per week from April–August 2017 and 2018. We recorded ground temperature, 'operative temperature' (represents what bobwhites actually feel), percent shade, brush species, canopy density, vegetation height, percent woody and herbaceous cover, and degree of overlap of brush canopies where radio-collared bobwhites were found. We also measured the same variables at random locations for comparison.

- We did not find a specific set of vegetation characteristics that were best at reducing temperatures.
- Bobwhites selected sites with more shade during the middle of the day because these sites had cooler temperatures. These sites typically had tall brush with dense overlapping canopies.
- Bobwhites selected clumps with several brush species rather than any one brush species to escape the summer heat.
- The rule of thumb emerging from our research is that if brush is thick enough to produce deep shade, it's probably good for thermal cover.
- Our results emphasize the need for managers to preserve and enhance dense, mature mixed-brush clusters providing shade and dense canopies needed to minimize bobwhites' exposure to extreme heat.

Cooperative funding provided by the Hixon Family, Texas Parks and Wildlife Department, South Texas Chapter of Quail Coalition, San Antonio Chapter of Quail Coalition, San Antonio Chapter of Quail Forever, Hill Country Chapter of Quail Coalition, Coastal Bend Audubon Society, Rotary Club of Corpus Christi (Harvey Weil Sportsman Conservationist Award Trust), and the ExxonMobil Summer Jobs Program.

Restoring Habitat for Northern Bobwhites in Buffelgrass Dominated Grasslands

Ellart J. Vreugdenhil, Brandon J. Palmer, Geron G. Gowdy, Javier O. Huerta, Benjamin R. Olsen, Timothy E. Fulbright, Eric D. Grahmann, Michael W. Hehman, Fidel Hernández, Keith A. Pawelek, Forrest S. Smith, Tony D. Falk, and David B. Wester

One avenue of northern bobwhite habitat loss results from the invasion of non-native grasses. Buffelgrass and Old-World bluestems tend to form monocultures, thereby reducing bare ground that provides travel corridors, space for forbs to grow, habitat for insects, and herbaceous plant diversity.

In 2008, we initiated a pilot study to determine the best methods for restoring quail habitat in areas dominated by non-native grasses. We found that repeated discing and/or glyphosate application to rid the area of non-native plants and their seed each time the plants emerged, followed by planting diverse native plant seeds, was successful.

The aim of this follow-up study, initiated in 2013, was to assess the effectiveness of quail habitat restoration through the methods above on a large scale. Our large-scale restoration was started in 2014 and the site was planted in 2016.

- Repeated discing and herbicide application reduced non-native grasses to less than 1% cover and has remained at this level for 3 years post-planting.
- Three years post-planting, native forb cover increased to over 70%, native grass cover increased to nearly 30%, and herbaceous plant diversity and plant species richness increased.
- Restoration provided adequate bunchgrass structure for bobwhites to nest within 2 years of the restoration planting.
- Restoration efforts should focus on areas to connect existing patches of habitat or in combination with lower intensity disturbance techniques such as patch burning and grazing to maximize the benefit to bobwhites.
- Habitat restoration methods used in our study could help reverse the quail decline.

Cooperative funding provided by the Hixon Family, Texas Parks and Wildlife Department, South Texas Chapter of Quail Coalition, San Antonio Chapter of Quail Coalition, San Antonio Chapter of Quail Forever, Hill Country Chapter of Quail Coalition, Coastal Bend Audubon Society, and the ExxonMobil Summer Jobs Program.

Developing Wild Turkey Wintering Habitat Suitability Models in Northeast Texas

Darrion M. Crowley, Humberto L. Perotto-Baldivieso, William P. Kuvlesky, Jr., J. Alfonso Ortega-Santos, Leonard A. Brennan, Nicholas R. Kolbe, and Michael T. Page

Habitat suitability models are becoming popular in wildlife management. They can help biologists better understand how land cover across the landscape influences the distribution of species. Our objectives were to (1) develop habitat suitability models for wild turkeys and (2) integrate survey methods with the habitat suitability models. Study sites were on Fort Wolters Training Center in Mineral Wells, Texas and Camp Maxey Training Center in Paris, Texas.

We used 9-ft resolution satellite imagery to analyze the land cover spatial structure. We developed habitat suitability models for food and cover requirements for Eastern and Rio Grande wild turkeys in North Texas. We hypothesized that the amount and distribution of land cover used by wild turkeys can be good predictors of habitat suitability. We integrated data from field surveys and land cover to evaluate our models.

- Road surveys matched with food suitability models, and roost surveys matched with cover suitability models.
- We observed that 89% of road locations were in areas of high suitability for food.
- We found 60% of roosts were in areas of high suitability for cover at Fort Wolters Training Center.
- At Camp Maxey, 92% of road locations were in areas of high suitability for food and 100% of roost locations were in areas of high suitability for cover.
- By analyzing biologically relevant land cover structure, we can provide biologists with information on how land cover influences habitat use by wildlife.

Cooperative funding provided by the Texas Military Department.

Northern Bobwhite Use of an Area Restored to Native Vegetation

Brandon J. Palmer, Benjamin R. Olsen, Timothy E. Fulbright, Eric D. Grahmann, Fidel Hernández, Michael W. Hehman, Forrest S. Smith, and David B. Wester

Habitat loss and habitat fragmentation have been viewed as the leading causes in declining northern

bobwhite populations. However, bobwhite populations have remained relatively stable in South Texas. Unfortunately, non-native grasses, particularly buffelgrass and Old World bluestems, are increasingly invading native plant communities in South Texas, which is reducing habitat for bobwhites. Habitat management strategies are needed to reduce the impact of non-native grass-dominated grasslands and restore these areas to native plant communities.

We attempted to restore a large area (about 300 acres in size) dominated by non-native grasses using disking and herbicides, followed by planting native vegetation. Our objective was to determine if large-scale habitat restoration could increase use by bobwhites. We radio-collared 40 bobwhites per year during summers 2013–2018 and located them 2 to 3 times per week.

- Before restoration treatments were applied (2013), the restoration area comprised nearly 64% of bobwhite home ranges.
- We repeatedly disked and sprayed the area during 2014–2016 to deplete the soil seed bank of non-native grass seeds. This resulted in the proportion of bobwhite home ranges on the study area to decrease to 18%.
- During the 2 years after we had planted a mixture of locally-adapted native grasses and forbs (2017–2018), the proportion of home ranges declined to about 17%.
- We believe that limited use of the area by bobwhites post-planting was due to the mechanical removal of woody vegetation from 25% to 10% (needed to remove woody plants containing non-native grasses underneath their canopies).



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CKWRI researchers evaluated a large-scale native plant restoration project for northern bobwhite habitat.

- Woody cover is an important component of bobwhite habitat as it provides both escape cover from predators and shelter from extreme heat.
- Our results suggest that preservation and enhancement of woody cover should be prioritized when managing and restoring habitat for bobwhites in South Texas rangelands.

Cooperative funding provided by the Hixon Family, Texas Parks and Wildlife Department, South Texas Chapter of Quail Coalition, San Antonio Chapter of Quail Coalition, San Antonio Chapter of Quail Forever, Hill Country Chapter of Quail Coalition, Coastal Bend Audubon Society, Rotary Club of Corpus Christi (Harvey Weil Sportsman Conservationist Award Trust), and the ExxonMobil Summer Jobs Program.

Developing a Survey Methodology for the Wild Turkey in Northeast Texas

Darrion M. Crowley, Leonard A. Brennan, Humberto L. Perotto-Baldivieso, William P. Kuvlesky, Jr., J. Alfonso Ortega-Santos, and Nicholas R. Kolbe

Rio Grande and Eastern wild turkeys are popular gamebirds in Texas that have been declining in areas of North Texas. Identifying the optimal survey methodology to determine accurate wild turkey population densities is a key factor used in deciding management strategies. Unfortunately, there is very little research on survey methodologies for wild turkeys.

We initiated this study to learn more about which survey methods provide the best estimates of turkey population densities in northeastern Texas. The objectives of this project were to (1) identify common and



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Survey methods that provide better population estimates are essential for managing wild turkeys.

useful surveys for wild turkeys and (2) compare survey methods and propose a method or set of methods that can reliably estimate wild turkey abundance.

Eastern wild turkeys were surveyed at Camp Maxey Training Center near Paris, Texas while Rio Grande wild turkeys were surveyed at Fort Wolters Training Center near Mineral Wells, Texas. We compared 3 survey methods: road surveys, point count surveys, and roost count surveys. We visited our study sites between January and March in 2018 and 2019. Our statistical analyses compared the survey methods, time of the day (early morning versus late afternoon), and their interactions.

- Road surveys provided consistently higher detection rates than the other 2 methods in North Texas for 2 subspecies of wild turkey.
- Turkey detections were significantly higher for road surveys in both locations (Fort Wolters 4.96 per hour; Camp Maxey 1.03 per hour) compared to point count (Fort Wolters 0.44 per hour; Camp Maxey 0.14 per hour) and roost surveys (Fort Wolters 1.21 per hour; Camp Maxey 0.35 per hour).
- We found no differences in detection rates between times of day for either study site.
- Understanding which survey technique provides the best abundance estimates is useful to landowners and state and federal wildlife personnel for managing wild turkey populations.

Cooperative funding provided by the Texas Military Department.

Quantifying Thermal Refugia for Bobwhites Using an Unmanned Aerial Vehicle

Brandon J. Palmer, Benjamin R. Olsen, Timothy E. Fulbright, Eric D. Grahmann, Fidel Hernández, Michael W. Hehman, Jinha Jung, Anjin Chang, Junho Yeom, David B. Wester, and Humberto L. Perotto-Baldivieso

Northern bobwhites are sensitive to extreme thermal conditions, especially in the more arid portions of their range. Summer daytime temperatures in these regions often exceed 102°F and are potentially fatal to bobwhites. Unmanned aerial vehicles (drones) may provide a more practical alternative to on-the-ground temperature data collection as they can cover more ground in a time-efficient manner as well as collect high-resolution imagery. We tested the use of a drone to determine the distribution of thermal refugia for bobwhites in South Texas rangelands.

We flew a drone at an altitude of 262 ft above the ground over a 40-acre pasture at 2:00 pm, 4:00 pm, and 6:00 pm on October 5th, 2016. The drone was equipped with a thermal camera taking 122 pictures through the duration of each flight. After processing the images obtained from the drone, we then determined what proportion of the pasture fell below 102°F, the temperature above which bobwhites become increasingly vulnerable to hyperthermia.

- Portions of the pasture falling below 102°F comprised 8%, 27%, and 98% of the pasture during the 2:00 pm, 4:00 pm, and 6:00 pm flights, respectively.
- Our results provide additional evidence that thermal refuge becomes limiting during the early afternoon hours when daytime temperatures are usually at their peaks.
- We recommend that wildlife managers increase woody cover to increase thermal cover.
- Using thermal imagery obtained from drones can be a useful technique for determining the large-scale distribution of thermally suitable conditions on the landscape for bobwhites.
- Information gained from our study can be used to guide brush management decision-making.

Cooperative funding provided by the Hixon Family, Texas Parks and Wildlife Department, South Texas Chapter of Quail Coalition, San Antonio Chapter of Quail Coalition, San Antonio Chapter of Quail Forever, Hill Country Chapter of Quail Coalition, Coastal Bend Audubon Society, Rotary Club of Corpus Christi (Harvey Weil Sportsman Conservationist Award Trust), ExxonMobil Summer Jobs Program, and Texas A&M University-Corpus Christi.

Woody Canopy Cover Attributes Selected by Scaled Quail

Ellart J. Vreugdenhil, Timothy E. Fulbright, Eric D. Grahmann, Fidel Hernández, and Michael W. Hehman

Chestnut-bellied scaled quail have been declining across their range with this decline being most pronounced in South Texas. Some researchers have designated scaled quail as a grassland bird based on research on a different subspecies and this may be misleading management. Unlike Arizona scaled quail, which use desert grasslands, chestnut-bellied scaled quail in South Texas use Tamaulipan thornshrub, which consists of woody shrubs with dense canopies, sparse herbaceous vegetation, and high amounts of bare ground.



© Brian Loffin

Although scaled quail are often thought of as a western Texas bird, the chestnut-bellied scaled quail occurs in the Tamaulipan thornshrub areas of South Texas.

Because scaled quail are often thought of as a desert grassland species, brush is often removed with the intention of improving habitat. However, this may not be beneficial to scaled quail in South Texas. Our goal was to determine selection bounds for percent woody canopy cover for chestnut-bellied scaled quail using radio telemetry data.

- Scaled quail in South Texas selected areas where percent woody canopy cover was 40–85% within 164 ft of points of use.
- Scaled quail selected areas with 2,655–5,311 ft per acre of edge where patches of woody vegetation were less than 9 ft apart.
- Because most undisturbed areas of Tamaulipan thornshrub have less woody canopy cover than the upper selection bound suggested by our findings, brush management would not be beneficial to chestnut-bellied scaled quail and instead would likely add to the population decline.

Cooperative funding provided by the Hixon Family, Texas Parks and Wildlife Department, South Texas Chapter of Quail Coalition, San Antonio Chapter of Quail Coalition, San Antonio Chapter of Quail Forever, Hill Country Chapter of Quail Coalition, Coastal Bend Audubon Society, and the ExxonMobil Summer Jobs Program.

Estimation of Future Native Seed Demand for Trans-Pecos Restoration Projects

Forrest S. Smith, Jon Paul Pierre, Michael H. Young, and Dale A. Devitt

Native seed supply is needed to restore habitats affected by development of energy-related infrastructure such as oil and gas pads and pipelines. In the Trans-Pecos ecoregion of Texas, substantial future impacts are projected because of increases in oil and gas production. Knowing the amount of native seed needed for restoration efforts and the economic potential of its production would be useful to oil and gas operators, seed producers, and conservation planners. We used available information to estimate the future potential impact of projected oil and gas production in the Trans-Pecos under low, medium, and high-intensity development scenarios through 2050.

- By 2050, 0.4 to 2.2% of the Trans-Pecos could be affected by oil and gas pad or pipeline development, such that restoration could be required.
- To conduct seed-based restoration activities on this scale of disturbance, cumulative native seed supply of 247,264 to 1,330,614 lbs of pure live seed (PLS) will be needed over the next 30 years.
- The economic value of this amount of seed, based on current retail prices, could range from \$10–57 million if seed was applied to all impacted sites.
- These estimates provide targets for efforts to increase seed source capacity.
- This also shows that cost-savings to energy producers can occur if surface impacts can be minimized.

Cooperative funding provided by the University of Texas Bureau of Economic Geology and the Cynthia and George Mitchell Foundation.

Estimating Forage Standing Crop Using Unmanned Aerial Vehicles

Alexandria M. DiMaggio, Humberto L. Perotto-Baldivieso, J. Alfonso Ortega-Santos, Chase H. Walther, Karelys N. Labrador-Rodriguez, Michael T. Page, Jose de la Luz Martinez, Sandra Rideout-Hanzak, Brent C. Hedquist, and David B. Wester

The use of unmanned aerial vehicles (UAVs) to monitor and manage rangelands has exponentially increased in recent years. This is the result of

miniaturization of sensors, pictures with high resolution, lower altitude platforms, and the ease of use in remote environments. Our aim was to develop a method to estimate forage standing crop in rangelands using UAV high-resolution imagery.

Field data were collected by clipping quadrants with forage standing crop covering the variability of the range. High resolution orthoimagery and digital surface models were acquired with an UAV at altitudes of 98, 131, and 164 ft above ground level in Duval County, Texas. A linear regression equation was developed to predict forage standing crop using the data collected.

- Volume information from UAV data and forage standing crop have a significant relationship at all flight altitudes with best results at 98 ft and 164 ft.
- Estimation of forage standing crop between these 2 flights and field data were similar. However, with the 164-ft altitude more values of volume are required to increase the precision of the estimation.
- UAV platforms can be used to predict and estimate forage standing crop with a similar precision to traditional sampling methods.
- The use of UAVs allows collection of more samples using a non-destructive and less expensive method to cover the variability of forage standing crop on rangelands and increase the precision of the estimation of available forage for grazing animals.

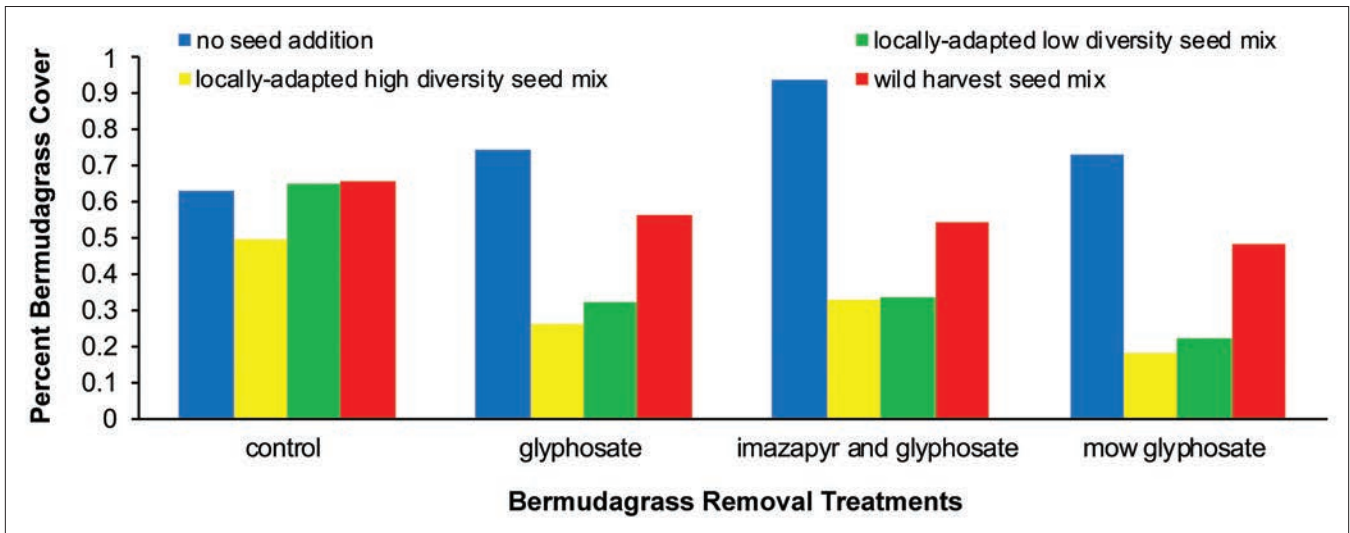
Cooperative funding provided by Duval County Ranch.

Bermudagrass Control and Restoration of Native Prairie

Anthony D. Falk, Keith A. Pawelek, Forrest S. Smith, James P. Muir, Jamie Foster, Leo Herzberger, and William P. Kuvlesky, Jr.

Bermudagrass is a non-native species that has been widely established for livestock forage. The species can form dense stands that prevent native plants from growing. These stands also provide poor habitat for bobwhites. Many landowners desire to convert bermudagrass pastures back to native prairies to benefit quail. However, bermudagrass can be difficult to control or remove. This is because of its extensive above and below ground biomass.

We studied 4 bermudagrass removal techniques, 3 seeding techniques, 4 seed mix types, and 3



Percentage of bermudagrass cover after 3 herbicide and 4 seeding treatments 18 months after installation at Beeville, Texas.

post-planting management techniques in 4 ecoregions that occur in Texas to determine the best methodology for this practice.

- All herbicide techniques were effective in reducing bermudagrass. Mowing followed by repeated applications of glyphosate was the most effective.
- Seed mix choice and removal technique interact with each other in their effect on bermudagrass cover and post-restoration plant species richness.
- The best seed mixes are generally those including locally-adapted native species, with moderate to high levels of plant species diversity.
- Neither seeding technique nor post-planting management affected subsequent bermudagrass cover or restored plant species richness.
- Management plans to restore native prairies to benefit bobwhites will be developed and distributed based on the findings of this study.

Cooperative funding provided by Texas Parks and Wildlife Department.

Release of Starr Germplasm Longspike Silver Bluestem for Use in South Texas

John Reilley, Shelly D. Maher, Keith A. Pawelek, Anthony D. Falk, and Forrest S. Smith

Starr Germplasm longspike silver bluestem was cooperatively released in 2019 as a Texas Selected Native Plant Germplasm by *South Texas Natives* and

the USDA Natural Resources Conservation Service E. “Kika” de la Garza Plant Materials Center. Longspike silver bluestem is a warm season, perennial bunchgrass that is shade tolerant.

Starr Germplasm longspike silver bluestem is recommended for upland wildlife plantings, highway right-of-way revegetation, energy-related reclamation, and inclusion in range seeding mixes. Longspike silver bluestem is a dominant species of many grasslands, and it has shown competitive ability needed to diversify exotic grass stands in South Texas rangelands.

- Starr germplasm longspike silver bluestem is comprised of 5 regional collections from Jim Wells, Kenedy, Kleberg, Atascosa, and Starr counties within South Texas.



© Forrest Smith

Seed increase field of Starr Germplasm longspike silver bluestem that was planted for commercial production.

- Based on collection site locations and evaluations conducted, Starr Germplasm longspike silver bluestem will perform best in the Gulf Coast Prairies and Marshes, Rio Grande Plains, Coastal Sand Plains, Post Oak Savannah, and Blackland Prairies ecoregions of Texas.
- Longspike silver bluestem has been noted to be fair to good livestock forage and provide nesting structure for upland birds.

Cooperative funding provided by the Texas Department of Transportation, USDA Natural Resources Conservation Service, and the multiple donors to the Texas Native Seeds Program.

- We found no difference in gulf cordgrass mortality between winter and summer burning.
- We found that peak fire temperature and duration of heat over 149°F increased gulf cordgrass mortality in both seasons.
- Forage production of gulf cordgrass was similar following both winter and summer burning.
- The reduction of gulf cordgrass from prescribed burning allowed other plant species to increase in abundance and production.
- Burning, regardless of season, will enhance gulf cordgrass rangelands for both livestock use and wildlife habitat.

Cooperative funding provided by the East Foundation.

Season of Burn Effects on Gulf Cordgrass Communities

Jose S. Avila-Sanchez, Victoria L. Haynes, Rebecca R. Zerlin, Sandra Rideout-Hanzak, David B. Wester, J. Alfonso Ortega-Santos, and Tyler A. Campbell

Gulf cordgrass is a warm season bunchgrass that can provide valuable forage for livestock and wildlife when green. However, when gulf cordgrass becomes mature, its leaves and stems are coarse and low in palatability and nutritive value.

Prescribed burning is often used to remove old growth and promote the production of tender, palatable shoots. In this study, we applied prescribed burning in winter and summer in pastures dominated by either gulf cordgrass or seacoast bluestem. Our main objective was to determine the best season for prescribed burning.



© Jose S. Avila-Sanchez

The gulf cordgrass plant community at approximately 15 months after the summer burn occurred in South Texas.

Release of Brewster Germplasm Sideoats Grama for West Texas

Colin S. Shackelford, Keith A. Pawelek, Anthony D. Falk, Forrest S. Smith, Brandon Carr, John Reilley, Shelly D. Maher, and Louis A. Harveson

Brewster Germplasm sideoats grama is the third formal release of ecotypic plant material for use in West Texas by *Texas Native Seeds*. It was developed in collaboration with Sul Ross State University at Alpine, the USDA Natural Resources Conservation Service E. “Kika” de la Garza Plant Materials Center at Kingsville, and the James E. “Bud” Smith Plant Materials Center at Knox City.

Sideoats grama is a warm season perennial bunchgrass found in a wide variety of soil textures and ecological sites. Brewster Germplasm sideoats grama is recommended for upland wildlife plantings, highway right-of-way revegetation, energy-related reclamation seedings, and rangeland seeding mixes. Sideoats grama is a dominant species of many desert grasslands, and it is one of the most important livestock forage plants for the Trans-Pecos.

- Brewster Germplasm sideoats grama is comprised of 2 accessions from an evaluation trial of 37 regional collections from West Texas. The selected accessions originate from Brewster and Terrell counties.
- Based on collection site locations and evaluations, Brewster Germplasm sideoats grama will perform best in the Permian Basin, southern Rolling Plains, southern High Plains, western Edwards Plateau, and Trans-Pecos regions of West Texas.



© Colin Shackelford

Brewster Germplasm sideoats grama has been developed by the *West Texas Natives Seed Project* for use in restoration efforts within the Trans-Pecos.

- Production of Brewster Germplasm sideoats grama has been licensed to Douglass W. King Seed Company and Bamert Seed Company.
- It is anticipated that seed of Brewster Germplasm sideoats grama will be available for purchase by consumers in 2020.

Cooperative funding provided by the Texas Department of Transportation, USDA Natural Resources Conservation Service, Concho Resources, Inc., Caesar Kleberg Foundation for Wildlife Conservation, and donors to the Texas Native Seeds Program.

Growth Dynamics of Hatchling Alligators in Captivity

Cord B. Eversole, Scott E. Henke, Javier O. Huerta, and Andrew Lowery

The American alligator is one of the largest reptiles in North America. They are thought to grow approximately 1 ft per year until sexual maturity at 6-to-7 years of age, after which their growth begins to slow down. Males grow slightly faster than females and obtain size of about 13+ ft, while the average female grows to approximately 9 ft in length.

Alligators become sexually mature at a given size rather than age. Studies found that wild-caught alligators in Texas were not sexually mature until about 13 years old. Our objective was to determine the growth potential of alligators maintained in captivity within 700-gallon tanks and provided with *ad libitum* food.

- Hatchlings averaged 10.5 inches on day of hatching.
- Size differences were noted within 3 weeks of hatching with males being longer than females.
- Growing season for alligators in Texas appears to be May–October, when the greatest growth occurs.
- Alligators nearly doubled in size by the end of the first growing season. Growth rates of both sexes were about 12 inches per year for years 2 and 3.
- Potential growth for captive American alligators can exceed 1 ft per year under ideal conditions.
- Studies are needed to determine what factors (i.e., food, space, etc.) are limiting the growth potential of American alligators in Texas.

Landscape Patterns of Ocelot-Vehicle Collision Sites

AnnMarie Blackburn, C. Jane Anderson, Amanda M. Veals, Michael E. Tewes, Randy W. DeYoung, John H. Young, Jr., and Humberto L. Perotto-Baldivieso

Roads can influence the spatial ecology and population size of species and can be particularly harmful to species of conservation concern. The ocelot is a federally-listed endangered wild felid found in the Lower Rio Grande Valley (LRGV) of South Texas. It occurs in 2 isolated populations of less than 80 individuals.

Ocelots are strongly linked to dense woody vegetation cover. Unfortunately, there is a decreasing amount of available ocelot habitat in the LRGV because this

region is one of the fastest growing population centers in the country. This has also led to an increase in ocelot-vehicle collisions, which represents the highest direct source of mortality.

This study aimed to understand whether the spatial structure of various land cover types was related to ocelot roadway-associated mortality. Using satellite imagery, we examined the amount and distribution of 3 land cover types at 26 ocelot-vehicle collision sites spanning 1984–2017.

- Road sites where ocelots were killed by vehicles consisted of higher percentages of woody vegetation, larger patches of woody cover, and shorter distances between woody patches compared to random road locations.
- Ocelots were struck by vehicles in areas similar to those areas they selected for.
- Areas that contain large patches of woody cover up to 0.6 miles on both sides of a road should be evaluated for placement of ocelot crossing structures.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute and Texas Department of Transportation: Environmental Affairs.

Analysis of Education and Outreach in the Range and Wildlife Profession

Kelley A. Wood and April A. Torres Conkey

Range and wildlife professionals often need to bridge the gap between scientific research and the public. The importance of this will increase as the human population continues to grow and there is a greater need for conserving wildlife and their habitat.

Education and outreach are believed to be important tools in spreading awareness to the public so society will understand, care, and act to conserve natural resources. However, few natural resource professionals are trained in effective education and public communication techniques. The aim of this study is to better understand the impact of education and outreach in various careers of range and wildlife professionals.

- A questionnaire was created and sent by email to 70 range and wildlife professionals across the United States. There were 11 responses (16% response rate): 6 female respondents and 5 male respondents.
- Three respondents were from federal agencies, 2

from state agencies, 3 from non-profits, 2 from private companies, and 1 from a public university.

- Eight of the respondents conducted outreach in rural areas, and 3 of them performed outreach in rural, suburban, and urban areas.
- All respondents agreed that outreach to the public/stakeholders is an important part of their job, with 45% stating that it is vital to their job.
- All respondents, except 1, felt their job influenced the public positively in support of conservation.
- Most respondents (91%) did not have formal training in education or public communication techniques before starting their job, but 73% believed training would have been beneficial to their career.

Raccoon Roundworm as an Occupational Hazard to Wildlife Caregivers

Tiffany L. Pope, Austin A. Killam, Victoria M. Cavazos, Scott E. Henke, Humberto L. Perotto-Baldivieso, and Clayton D. Hilton

Caregivers of captive wildlife such as wildlife rehabilitators and zoo workers are at risk of diseases that can be transferred from animals to people because of their work. One such disease is baylisascariasis caused by the raccoon parasite *Baylisascaris procyonis*. Larvae can cause blindness, paralysis, and death in intermediate hosts and humans.

Infected raccoons can shed millions of eggs in their feces per day. A single infected raccoon scat, upon decay, can contaminate 1 yd² of soil. Thus, an infected raccoon population can quickly contaminate a wildlife facility and expose workers. Our objectives were to (1) determine the prevalence of *B. procyonis*-positive scats and raccoons within the Tio and Janell Kleberg Wildlife Research Park at Texas A&M University-Kingsville, (2) determine the potential exposure to captive wildlife and human caregivers, and (3) determine the most effective method to neutralize potential transmission to humans and captive animals.

- Fifty wild raccoons were captured within the Tio and Janell Wildlife Research Park during a 12-month period from July 2017–June 2018; 23 (46%) were infected with 295 *B. procyonis* roundworms.
- Eighteen of 120 (15%) raccoon scats collected were infected with *B. procyonis*.
- Findings suggest that caregivers can be exposed to *B. procyonis* in their work environment.
- Flaming soil with a propane pear burner followed

by discing and re-flaming the contaminated area was successful in killing the eggs.

- Personnel should wear gloves within wildlife facilities and thoroughly wash their hands upon leaving to reduce their transmission risk to disease agents.

Cooperative funding provided by a Texas A&M University-Kingsville Research Award.

Preliminary Effects of Habitat Restoration on Texas Horned Lizards and Their Prey

Javier O. Huerta, Victoria M. Cavazos, Scott E. Henke, Fidel Hernández, Geron G. Gowdy, Ellart J. Vreugdenhil, Brandon J. Palmer, Eric D. Grahmann, Timothy E. Fulbright, Michael W. Hehman, and Randy L. Powell

Non-native grasses were introduced into the United States from Africa and Asia with the desire to provide livestock with drought-resistant forage and enhance erosion control along roadways. Unfortunately, non-native grasses are highly competitive with native plants. The seeds of non-native grasses have dispersed over large areas and now monocultures of such grasses can be found throughout Texas, which reduce diversity and habitat quality.

Texas horned lizards were once numerous and widely distributed in Texas, but their numbers have drastically declined and their distribution has become patchy. Restoring habitat to native grasses may halt the decline of this state-listed threatened reptile.

In 2013, a 300-acre site on the Hixon Ranch was converted from a buffelgrass dominated area to native plants. The abundance of Texas horned lizards,



© Javier Huerta

Female Texas horned lizards preferred native grass areas to lay their eggs so their hatchlings can find more food.

harvester ants (the main prey), and red-imported fire ants have been monitored on the restoration area and on a nearby non-native grass area for comparison.

- Texas horned lizards were abundant on both the restoration and control areas and had a density of about 1 lizard per 2.5 acres.
- The restoration area had more hatchlings and juvenile lizards while the control area had more adults.
- Harvester ants were more abundant on the restoration area than the control area.
- Female horned lizards may have selected the restoration area as nursery habitat, thereby providing their young with the best possibility for survival.

Cooperative funding provided by the Hixon Family.

Ocelot, Bobcat, and Coyote Coexistence Patterns in South Texas

Jason V. Lombardi, Darryl I. MacKenzie, Michael E. Tewes, Jose M. Mata, Humberto L. Perotto-Baldivieso, and Tyler A. Campbell

Interspecific competition among carnivores has been linked to differences in behavior, morphology, and resource use. Insights into these interactions allow for a better understanding of how species relate to each other. Such information can be used to aid in the recovery of endangered species.

Ocelots, bobcats, and coyotes co-occur over a small geographic range from South Texas to south-central Mexico. Relationships among the 3 species are poorly understood prompting this study.



© Brian Loflin

Researchers have been exploring ecological mechanisms that allow coyotes, bobcats, and ocelots to coexist.

We used camera stations on the East Foundation's El Sauz Ranch in South Texas from 2011 to 2018 to photograph interspecific interactions of ocelots, bobcats, and coyotes. We used a multi-season extension to multi-species occupancy models with 2 or more interacting species. This allowed us to identify the mechanisms of interspecific interactions and examine potential resource partitioning of these species.

- Strong evidence of seasonal coexistence existed between ocelots, bobcats, and coyotes.
- Each species was more likely to occur farther from FM 186, which is a high-speed highway that borders the southern boundary of the ranch.
- Our inability to detect clear evidence of resource partitioning may indicate the niches of the species studied were too discrete or we needed to use a finer temporal scale.
- It appears that bobcats and coyotes may not have a negative effect on the ocelot population. Thus, predator control to benefit ocelots may not be as beneficial as once previously believed.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute, East Foundation, Wild Cat Conservation, Inc., Annova LNG and their parent company Exelon Generation, Brown Foundation, Tim and Karen Hixon Foundation, Travis and Bettina Mathis, and Ben F. Vaughan, III.

Detection of Herpetofauna Models Using Unmanned Aerial Vehicles (UAV)

Javier O. Huerta, Michael T. Page, Victoria M. Cavazos, Scott E. Henke, and Humberto L. Perotto-Baldivieso

Unmanned aerial vehicles (UAV) using mounted cameras have aided in the detection of wildlife. However, the species detected have been large, and are easily seen on video. Technological advances have increased resolution and detail of videos, which might make smaller animals more observable.

We proposed that UAVs could be used to detect small-sized reptiles. To test our hypothesis, we used models made to the scale and coloration of herpetofauna found in South Texas rangelands. Our objectives were to (1) evaluate if UAV technology can detect small herpetofauna models, (2) determine an ideal elevation and speed to identify models, and (3) assess viewer identification and detection of herpetofauna models. We ran 4 test groups that included having non-trained personnel watch the video non-stop,

allowing non-trained personnel to start and stop the video as needed, and the same 2 scenarios except with trained personnel.

- We determined a flight height of 13 ft and a speed of less than 1 mph to detect the herpetofauna models.
- Size, color, placement, and test group influenced what viewers saw on the video. In general, large, brightly colored models placed in the open were readily observed; whereas, smaller more cryptic models were missed by viewers.
- Surveyors observed 23 of 62 models (37%) placed on the road. They correctly identified, on average, 7 (31%) of the models they saw. Consequently, the average surveyor observed and correctly identified only 11% of the models placed on the road.
- Training personnel in reptile identification improved viewers observations by 3-fold.
- Small herpetofauna models can be identified down to individual shape. However, species identification falls short unless personnel are well-trained.

Intake by Feral Pigs of Supplemental Feed Containing Ground Juniper

Jessica L. Glasscock, David G. Hewitt, Travis R. Whitney, Fred C. Bryant, and Susan M. Cooper

Herbivores have adaptations that allow them to consume and tolerate toxins produced by plants as a defense mechanism to herbivory. Non-ruminant species, such as the feral pig, may not be able to consume and tolerate these compounds without adverse effects.

In this study, we evaluated the use of ground blueberry juniper or cottonseed hulls as a roughage ingredient in a supplemental deer pellet on feral pig dry matter intake, growth performance, *in vitro* digestibility and fermentation, and blood serum chemistry.

We captured 24 feral pigs, assigned individual animals to a supplement, and measured feed consumption during 2 periods that differed in availability of a basal diet. Supplements differed by source and percentage of roughage: 20% cottonseed hulls, 20% juniper, 40% cottonseed hulls, or 40% juniper.

- Percentage of roughage in the diet did not affect intake by feral pigs.
- There tended to be a difference in intake for type of roughage by period.
- Ground blueberry juniper tree fiber was essentially indigestible by feral pigs.



© Jessica Glasscock

Feral pig health may be negatively affected by eating supplemental feed that contains ground blueberry juniper.

- There tended to be a roughage effect on blood serum levels of alanine aminotransferase (an enzyme in liver cells), suggesting potential liver damage.
- Our findings could help in developing a supplement to limit consumption by feral pigs or, if consumed, could reduce feral pig health and performance.

Cooperative funding provided by Texas A&M AgriLife Research and the Rob and Bessie Welder Wildlife Foundation.

Can Butterflies be Attracted to Floral Scents of Aerosol Sprays to Entice Pollination?

Scott E. Henke and Cayden S. Henke

Pollinators are vital to the health and economy of the world by propagating flowering plants and crops. However, pollinator species are in decline due to degradation and fragmentation of habitat, reductions in plant diversity, and effects of misused pesticides. The loss of butterflies also impacts bird species that rely on caterpillars and butterflies for food.

Our objective was to determine if butterflies would be attracted to and spend more time in gardens that contained spray misters emitting a jasmine bloom aerosol spray every 15 minutes. Ten gardens with and without spray misters were established with the same species and number of flowering plants. Video cameras recorded butterfly activity.

- Fifteen butterfly species made 215 visits to gardens with and without spray misters.



© Scott Henke

Not all butterfly species were attracted to the aerosol spray mist scent of jasmine.

- Number of butterfly species, number of visits, and total number of minutes butterflies spent on flowers was approximately the same between gardens with and without spray misters. However, butterfly species within a garden type did differ.
- Painted Ladys, Monarchs, and American Ladys occurred most often in gardens without spray misters, while American Snouts, Mexican Silverspots, and Variegated Fritillaries occurred more often in gardens with spray misters. Graphic Crescents and Bordered Patches occurred equally in both gardens.
- On average, butterflies that visited gardens equipped with spray misters spent nearly twice the time per visit compared to butterflies that visited gardens without spray misters.
- Butterflies, like humans, appear to have preferences for certain smells.
- Based on our findings, misters improved time spent in a garden by butterflies, which could potentially improve pollination of plants.

Cooperative funding provided by Flint Hills Resources, Inc.

Flattened Fauna: Spatial Analysis of the Roadkill Patterns in Kleberg County

Kelley A. Wood, Michael T. Page, Tristan Summy, Humberto L. Perotto-Baldivieso, and April A. Torres Conkey

As urbanization increases, animal-vehicle collisions will also increase due to human encroachment on wildlife habitat. This study was conducted to identify

relationships between animal-vehicle collisions, road density, and natural wildlife corridors. We predicted that more wildlife roadkills would occur near corridor areas (waterways and railroad right-of-ways) and in areas of less dense roadways with higher speed limits.

Roadkill carcass records from January 2015 to June 2018 were obtained from the Animal Control Division of the Kingsville/Kleberg County Health Department. We created a geographic information systems (GIS) map of Kleberg County with the roadkill locations, the Texas Department of Transportation road database, and color aerial photos for each year, 2015–2018.

- Locations for 1,968 roadkill carcasses were verified for the 3.5-year period.
- Domestic cats (820 roadkills) and dogs (472 roadkills) represented 66% of the carcasses.
- The Virginia opossum was the most common wildlife species killed (407 individuals; 21% of total). The carcass numbers of the other wildlife species were too few to analyze statistically.
- Proximity to corridors and high speed limits did not have an effect on the locations of roadkills in our sample. However, roadkill locations were related to higher densities of roads (in urban Kingsville).
- Understanding urban roadkill trends could assist animal control departments in identifying neighborhoods for spay and neuter pet programs and education programs on keeping pets indoors or within backyards to reduce pet-wildlife conflicts and animal-vehicle collisions.

Ocelot Colonization-Extirpation Dynamics in South Texas

Jason V. Lombardi, Michael E. Tewes, Jose M. Mata, Humberto L. Perotto-Baldivieso, and Tyler A. Campbell

About 80% of the known ocelot breeding population in the United States occurs on several ranches in Willacy and Kenedy counties, Texas. These ranches support several large, contiguous patches of dense Tamaulipan thornshrub.

Studies have found ocelots in South Texas prefer large patches of extremely dense thornshrub with over 95% canopy cover. Landscape data have been used to explain ocelot habitat use in fragmented areas. However, information is lacking for less-fragmented locations within South Texas. We used camera monitoring surveys on the East Foundation's El Sauz Ranch (2011–2018) to assess colonization-extirpation

dynamics of ocelots relative to climate, microhabitat, and the landscape.

- The initial occurrence of ocelots was positively influenced by cooler temperatures in woody areas than more open areas.
- Colonization-extirpation dynamics were influenced by woody cover density.
- Ocelots were more likely to colonize areas with greater woody plant percentage and patch density.
- Decreasing patch area and increasing patch complexity of woody cover positively influenced extirpation rates.
- As woody patch density increases, these patches will merge over time and form larger patches, which will promote ocelot colonization and persistence.
- Brush management needs to be strategic as patch area and patch complexity are limiting factors for ocelot persistence on private lands.

Cooperative funding provided by the Feline Research Program of the Caesar Kleberg Wildlife Research Institute, East Foundation, Wild Cat Conservation, Inc., Annova LNG and their parent company Exelon Generation, Brown Foundation, Tim and Karen Hixon Foundation, Travis and Bettina Mathis, and Ben F. Vaughan, III.

Evaluation of Scents as Attractants for Baiting Feral Pigs in Texas

Chancie Nuyttens and Scott E. Henke

Scent attractants are frequently used to lure feral pigs to camera monitoring stations for scouting or surveilling feral pig populations or at trap sites to reduce the amount of time for pigs to locate the trap. However, the effectiveness of scents to attract and increase feral pig visitation to camera stations or traps is debatable. Therefore, our objective was to determine if feral pigs were attracted to various scents and whether scents increased feral pig attraction to traps. We used sour corn as our base bait and added the flavors and odors of fruity, orange, and grape as attractants for feral pigs.

- We caught 62 pigs: 10 adult males, 8 adult females, 16 juvenile males, and 28 juvenile females within 24 capture-days.
- We caught feral pigs in 7, 8, 1, and 8 capture-days on sour corn, fruity, orange, and grape odors and flavors, respectively. Bait type did not attract any particular age group or sex more than another.
- We caught 22, 22, 3, and 15 feral pigs on sour

corn, fruity, orange, and grape odors and flavors, respectively.

- No differences were observed among baits in the number of capture-days that caught feral pigs.
- Our research found that adding flavor and odor to sour corn did not improve capture rates of feral pigs. However, orange odor and flavor did reduce the capture rate of feral pigs.

Ocelot Occupancy and Population Density in Sierra Tamaulipas

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Translocations can be used to reintroduce species, restore populations in former ranges, and boost genetic diversity. Ocelots occurring in the Sierra Tamaulipas National Protected Area (STNPA) of northeastern Mexico are genetically similar to those in Texas. They also are a potential source population to genetically rescue ocelots from extirpation in Texas.

The purpose of this study was to assess the genetic diversity of ocelots within the STNPA. We also determined ocelot density, population size, and habitat use from May–December 2009 on Rancho Caracol and Rancho Camotal in Tamaulipas, Mexico.

- A potentially robust ocelot population was found.
- Ocelots in the northern part of the study area occurred in large patches of tropical sub-deciduous forest (1 ocelot per 2.04 mi²).
- Ocelots in the southern half of the study area were more likely to occur in small patches of tropical sub-deciduous forest mixed with Tamaulipan thornshrub (1 ocelot per 2.05 mi²).
- Ocelot occurrence was greatest where tropical deciduous forest was mixed with thornshrub.
- The STNPA likely has more than 870 ocelots with over 600 occurring in the tropical sub-deciduous forest and over 270 in Tamaulipan thornshrub.
- Because of the potentially robust population in the STNPA, there are enough individuals to safely translocate to genetically rescue Texas ocelots.

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PARTING SHOTS



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Graduate students and faculty working for the Caesar Kleberg Wildlife Research Institute spend a lot of time outdoors. They see amazing sights and capture some of these through the lens of a camera. This year we solicited photographs from students and faculty and had them judged by students in the Wildlife Photography Program at Texas A&M University-Kingsville. Enjoy these parting shots.

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