2020 Virtual

June 1-30, 2020

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Welcome to Virtual International Wild Pig Conference!

On behalf of the National Wild Pig Task Force, we hope you are safe and healthy amid the COVID-19 global pandemic.

One of the main missions of the NWPTF is to provide our constituents with the latest information on science, research, and management in the arena of wild pig control. As such, we are still committed to providing a venue for making presentations available to the wild pig research and management community in a timely manner.

The NWPTF hopes that you will enjoy this virtual format. While we cannot replace the face-to-face interaction and networking that a live conference provides, this format retains the educational and informational components of our events, and even more so, because you can peruse the videos and watch them at your lesiure through the entire month of June. Please, interact with our presenters by leaving professional comments and questions under their videos or contact them directly.

At the end of June, you will receive a survey to provide feedback to our conference, we hope you will take a couple minutes to help us evaluate our efforts!

Please plan to join us at our next face-to-face Wild Pig Conference April 2022!

Take Care!

Jim

Dr. James LaCour, Chair National Wild Pig Task Force

2020 International Wild Pig Conference Organizing Staff:

Dr Jessica Tegt, Berryman Institute, Utah State University, 5230 Old Main Hill, Logan, UT 84322-5230, USA. www.berrymaninstitute.org

If you have any questions or issues with the YouTube link, or URL's to the Posters and State Reports, please contact Jessica Tegt at jessica.tegt@usu.edu .

Quick Links:

Conference YouTube Channel: https://www.youtube.com/channel/UCpzNKfCPdg5om8PFmRRNUUA/

Conference Posters: https://www.nwptf.org/wild-pig-conference-posters/

Conference State/Providence Updates: https://www.nwptf.org/wild-pig-conference-state-reports-and-status-updates/

Conference Resources: https://www.nwptf.org/conference-resources/

Presentations at a Glance

Conference Welcome

Dr. James LaCour
Chair, National Wild Pig Task Force

Welcome on Behalf of the National Wild Pig Task Force
Video link: https://www.youtube.com/watch?v=YNuX7CcSlmA

Dr. Raoul Boughton
Ecologist Lead, Mosaic Co.

Welcome on Behalf of the University of Florida Conference Organizers
Video Link: https://www.youtube.com/watch?v=u8duf7uPRTc&t=8s

Conference Plenary

Dr. Ryan Brook
Associate Professor, University of Saskatchewan

Update on the Status and Management of Wild Pigs in Canada
(Plenary Sponsored by Wild Pig Feeder)
Video Link: https://www.youtube.com/watch?v=ZtRwBjXMUKM

Alexine Keuroghlian
Peccary Project

Peccaries and Pigs: Friends or Foes- the situation in central-western Brazil
Video Link: https://www.youtube.com/watch?v=oPWC4IMLnQA

Dr. Jed Sparks
Director, Cornell Isotope Lab, Cornell University

Pigs, the complex problem of ecosystem restoration in Hawaii
Video Link: https://www.youtube.com/watch?v=r_GfV31ntrU

Workshops

Dr. James LaCour
State Wildlife Veterinarian, Louisiana Department of Wildlife and Fisheries

Diseases in wild pigs *(workshop sponsored by Wild Pig Feeder)*
Video link: https://www.youtube.com/watch?v=CqFQHE2rR5g

Russell Singleton
Wildlife Biologist, Wildlife Dominion LLC.

Remote Trapping Techniques
Video link: https://www.youtube.com/watch?v=fIb7qojOtk0

Dr. Keith Carlisle
Research Associate, Colorado State University, Contractor National Wildlife Research Center
USDA-APHIS-Wildlife Services

Dr. Jessica Tegt
Outreach and Engagement Coordinator, Berryman Institute
Utah State University

Human Dimensions and Messaging in a Wild Pig Context
Video link:
Part #1 https://www.youtube.com/watch?v=QZt9o8tj5cs

Part #2 https://www.youtube.com/watch?v=3RUtU0QsfIw

National Feral Swine Damage Management Program

Dr. Dale Nolte
Program Leader, National Feral Swine Damage Management Program
USDA-APHIS-Wildlife Services

National Feral Swine Damage Management Program Overview
Video Link: https://www.youtube.com/watch?v=M7Zqommv-dw&t=18s

Dr. Kurt Vercauteren
Feral Swine and Ungulate Project Leader, National Wildlife Research Center
USDA-APHIS-Wildlife Services

New Book Available! Invasive Wild Pigs in North America
Video Link: https://www.youtube.com/watch?v=9xkDloK6Np8

Discount link for the book, save 20% : https://www.nwptf.org/wp-content/uploads/2020/05/9780367861735-author-flyer.pdf

Mike Marlow
Assistant Program Manager, National Feral Swine Damage Management Program
USDA-APHIS-Wildlife Services

National Feral Swine Damage Management Program Operations Update
Video Link: https://www.youtube.com/watch?v=pwTbKYU85V4

Dr. Vienna Brown
Biologist, National Feral Swine Damage Management Program
USDA-APHIS-Wildlife Services

Feral Swine Disease Surveillance and Target Projects
Video Link: https://www.youtube.com/watch?v=xRG5AJqQJZI

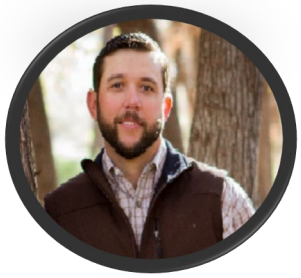
Technical Sessions: Toxicants

James Beasley
University of Georgia, Savannah River Ecology Lab, Warnell School of Forestry and Natural Resources

Evaluation of Kaput® feral hog bait for controlling wild pigs
Video Link: https://www.youtube.com/watch?v=8M51h_EvJvo

Greg Franckowiak
Genesis Laboratories, Inc.

Conditioning and access by feral hogs to bait delivery systems
Video Link: https://www.youtube.com/watch?v=N7qSSauXWQ0



John C. Kinsey
Kerr Wildlife Management Area, Texas Parks and Wildlife Department

Assessment of spilled Hoggone® post toxic bait deployment
Video Link: https://www.youtube.com/watch?v=CpMbS80Pcgc

Nathan Snow
National Wildlife Research Center, USDA-APHIS-Wildlife Services

Movement of Wild Pig Bait Relative to Bait Sites
Video Link: https://www.youtube.com/watch?v=l_TN1Md3RMg

Field Evaluations of HOGGONE® meSN Bait for Controlling Wild Pigs
Video Link: https://www.youtube.com/watch?v=p44EhaI1rM4

Kim Pepin
National Wildlife Research Center, USDA-APHIS-Wildlife Services

Optimal bait-site density for controlling feral swine with toxicant
Video Link: https://www.youtube.com/watch?v=CBmoUi3Ffb4

Technical Sessions: Damage

Arielle Fay
Graduate Research Associate, Auburn University

Impacts of Wild Pigs on Acorns as a Food Source for Native Wildlife
Video Link: https://www.youtube.com/watch?v=TBuWKIjQ8dU

Chris Boyce
Graduate Research Associate, University of Georgia Warnell School of Forestry and Natural Resources, Savannah River Ecology Laboratory

Determining the Timing and Extent of Crop Damage by Wild Pigs to Corn and Peanut Fields
Video Link: https://www.youtube.com/watch?v=Jp6m36DL8u4

Glen Gentry
Louisiana State University Agricultural Center, Bob R Jones Idlewild Research Station

Corn Hybrid Preferences of Feral Swine
Video Link: https://www.youtube.com/watch?v=gGYpaiOcCjY

Sara Bolds
Graduate Research Associate, Auburn University

Impacts of Wild Pigs on Water Quality and Fecal Bacteria in Headwater Riparian Systems
Video Link: https://www.youtube.com/watch?v=IfbpmHX0878

Sarah Chinn
Graduate Research Associate, University of Georgia Warnell School of Forestry and Natural Resources, Savannah River Ecology Laboratory

Understanding Crop Use and Preferences in Agro-ecosystems
Video Link: https://www.youtube.com/watch?v=Pi5LRKGSSo4

Wesley Anderson
Graduate Research Associate, Department of Wildlife Ecology and Conservation, Range Cattle Research and Education Center, University of Florida

Wild Pig Disturbance Reduces Tadpole Abundance within Seasonal Wetlands across a Subtropical Agroecosystem
Video Link: https://www.youtube.com/watch?v=_frCgroh_Gw

Technical Sessions: Management

Amy Davis
National Wildlife Research Center, USDA-APHIS-Wildlife Services

Using Management Data to Evaluate the Impacts of Feral Swine Removal Efforts in Missouri
Video Link: https://www.youtube.com/watch?v=M6LqcxLQylg

Anna Mangan
National Wildlife Research Center, USDA-APHIS-Wildlife Services

Environmental DNA (eDNA) Monitoring in a Novel Ecosystem: A Southern Indiana Case Study
Video Link: https://www.youtube.com/watch?v=QQh7TqHO7cs

Christine Ellis
Veterinary Services, USDA-APHIS-Wildlife Services

Immobilizing Wild Pigs in the Field: A Comparison of BAM™ and MMB
Video Link: https://www.youtube.com/watch?v=1HL3RFD90wA

Risky Business: Using Risk Assessments to Field Biosafety Plans for Handling Wild Pigs
Video Link: https://www.youtube.com/watch?v=e6cnkY4lZt4

Justin Fischer
National Wildlife Research Center, USDA-APHIS-Wildlife Services

Lessons Learned for the Successful Elimination of Wild Pigs in Central Illinois
Video Link: https://www.youtube.com/watch?v=zRR_rYzU_Gg

Michael Bodenchuk
State Director, USDA-APHIS-Wildlife Services Texas Program

Urban Wild Pig Management in Texas
Video Link: https://www.youtube.com/watch?v=FTniUCJlQfc

Stephen Zenas
Graduate Research Associate, Auburn University

Efficacy and Efficiency of a Whole Sounder Removal Program
Video Link: https://www.youtube.com/watch?v=50Bu7JkMcPE

Technical Sessions: Disease

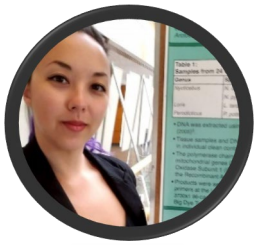
Kim Pepin
National Wildlife Research Center, USDA-APHIS-Wildlife Services

Disease Surveillance and Control in Wild Pigs: Insights for Managing Risks from Influenza A and African Swine Fever
Video Link:
https://www.youtube.com/watch?v=WRvyawyJa28&list=PLOtmBPvHWUBroAkY6W0wNcQonOfd3g52n&index=2&t=1s

Anni Yang
Colorado State University

Effects of Social Structure and Management on Risk of Disease Establishment in Wild Pigs
Video Link:
https://www.youtube.com/watch?v=Q001gS0DgHc&list=PLOtmBPvHWUBroAkY6W0wNcQonOfd3g52n&index=3&t=0s

Technical Sessions: Biology and Ecology



Chelsea Titus
Graduate Research Associate, University of Georgia Warnell School of Forestry and Natural Resources, Savannah River Ecology Laboratory

What is a Sounder: Genomic Relatedness of Wild Pig Social Groups
Video Link:
https://www.youtube.com/watch?v=dfYGVpNyZKE&list=PLOtmBPvHWUBpfwV2cdqhqYJeNj8FhDcmV&index=2&t=0s

Courtney Pierce
Biological Science Technician, National Wildlife Research Center, USDA-APHIS-Wildlife Services

Introduction to Genome-wide Association Studies: Disease in Feral Swine
Video Link:
https://www.youtube.com/watch?v=YVyJX_1kLN8&list=PLOtmBPvHWUBpfwV2cdqhqYJeNj8FhDcmV&index=7&t=0s

James Beasley
University of Georgia, Savannah River Ecology Lab, Warnell School of Forestry and Natural Resources

Wild Boar and the Rewilding of Fukushima's Human Evacuation Zone
Video Link:
https://www.youtube.com/watch?v=Wp3KJbxWD2o&list=PLOtmBPvHWUBpfwV2cdqhqYJeNj8FhDcmV&index=3&t=0s

Lindsay Clontz
Graduate Research Associate, University of Georgia Warnell School of Forestry and Natural Resources, Savannah River Ecology Laboratory

Connecting the Dots: Behavioral State Resource Selection of Wild Pigs in the Southeast, USA
Video Link:
https://www.youtube.com/watch?v=cm58l5H90uY&list=PLOtmBPvHWUBpfwV2cdqhqYJeNj8FhDcmV&index=4&t=0s

Sarah Chinn
Graduate Research Associate, University of Georgia Warnell School of Forestry and Natural Resources, Savannah River Ecology Laboratory

Parental Investment Strategies in a Highly Polytocous Species: Maternal Attributes and Resource Availability Modulate Litter Size and Sex Ratio
Video Link:
https://www.youtube.com/watch?v=w5iPsYCRIhQ&list=PLOtmBPvHWUBpfwV2cdqhqYJeNj8FhDcmV&index=5&t=0s

Timothy Smyser
National Wildlife Research Center, USDA-APHIS-Wildlife Services

Mixed Ancestry from Wild and Domestic Lineages Contributes to the Rapid Expansion of Invasive Feral Swine
Video Link:
https://www.youtube.com/watch?v=OEJl5-fR-Fo&list=PLOtmBPvHWUBpfwV2cdqhqYJeNj8FhDcmV&index=6&t=0s

Technical Sessions: Human Dimensions

John McCall
University of West Alabama

Partners Against Invasive Species: Raising Awareness and Assisting Landowners in West Alabama
Video Link: https://www.youtube.com/watch?v=Uj5QEMIvu_s

John Tomecek
Texas A&M University, Texas AgriLife Extension

Educating the Public About Managing Wild Pigs: The Texas Experience, 30 Years Later
Video Link: https://www.youtube.com/watch?v=pNR6iIG3y04

Matthew Chopp
Florida Fish and Wildlife Conservation Commission

Summarizing Florida's Feral Hog Regulations: An Inter-Agency Exercise
Video Link: https://www.youtube.com/watch?v=uKQfZ5svV4A

Rachael Connally
Graduate Research Associate, Texas A&M University

Human Dimensions of Wild Pig Management: A Typology of Wild Pig Hunters in Texas
Video Link: https://www.youtube.com/watch?v=K-E_-YwYmeY

USA and Ontario State/Provincial Reports:

Jack Mayer, Savannah River National Laboratory, Aiken South Carolina

2020 South Carolina State Report
https://www.nwptf.org/wp-content/uploads/2020/05/2020-South-Carolina-State-Agency-Status-Presentation-002.pdf

Matthew Chopp, Florida Fish and Wildlife Conservation Commission

2020 Florida State Report
https://www.nwptf.org/wp-content/uploads/2020/05/2020-WPC-State-Update_Florida.pdf

(No photo available)
Matthew Brock, Alabama Department of Conservation and Natural Resources

2020 Alabama State Report
https://www.nwptf.org/wp-content/uploads/2020/05/ADCNR-State-Update-IWPC-2020.pdf

Erin Koen, Ministry of Natural Resources and Forestry, Ontario

2020 Ontario Providence Report
https://www.nwptf.org/wp-content/uploads/2020/05/Koen_and_Newton_StateUpdate_Ontario.pdf

Jim LaCour, Louisiana Department of Wildlife and Fisheries

2020 Louisiana State Report
https://www.nwptf.org/wp-content/uploads/2020/05/Louisiana-State-Report-IWPC-5-27-2020.pdf

Alan Leary, Missouri Department of Conservation

2020 Missouri State Report
https://www.nwptf.org/wp-content/uploads/2020/05/Missouri-State-update-for-Internat-Wild-Pig-Conf-2020.pdf

Ricky Flynt, Mississippi Department of Wildlife, Fisheries, and Parks

2020 Mississippi State Report
https://www.nwptf.org/wp-content/uploads/2020/05/MS-Wild-Hog-State-Report-2020.pdf

Michael Bodenchuk, USDA-APHIS-Wildlife Services, Texas Program

2020 Texas State Report
https://www.nwptf.org/wp-content/uploads/2020/05/Status-of-wild-pig-TX.pdf

Conference Posters:

Lizzie Hancock, Auburn University
The impacts of wild pig (Sus scrofa) rooting on soil macroinvertebrate abundance in southeast Alabama
https://www.nwptf.org/wp-content/uploads/2020/05/LizzieH_VirtualConference_Poster.pdf

Bethany Wight, University of Florida
The use of low-cost GPS devices for wildlife studies: Development and deployment on feral swine in Central Florida
https://www.nwptf.org/wp-content/uploads/2020/05/2020-Virtual-Wild-Pig-conference-wight_GPS_poster.pdf

Jack Mayer, Savannah River National Laboratory
The impact of sanitary landfills on wild pigs
https://www.nwptf.org/wp-content/uploads/2020/05/Mayer-et-al-Poster-2020-IWPC-Impacts-of-Landfills-on-Wild-Pigs.pdf

Matthew McDonough, Auburn University
Eastern Wild Turkey population response to the removal of invasive wild pigs
https://www.nwptf.org/wp-content/uploads/2020/05/McDonough_NWPTF_poster_EasternWildTurkeyPopulationResponsetotheRemovalofInvasiveWildPigs.pdf

Brandon Parker, University of Georgia, Savannah River Ecology Lab
Torque teno sus virus 1 (TTSuV1) as a surrogate pathogen for studying foreign animal diseases
https://www.nwptf.org/wp-content/uploads/2020/05/TTSuV1-WildPigPosterFinal-BP.pdf

CONFERENCE ABSTRACTS

Plenary Session

Update on the Status and Management of Wild Pigs in Canada

Ryan K. Brook, Ruth Aschim, Corey Kramer, and Mia Kliewer

Presenter: Ryan Brook
Dr. Ryan Brook is an Associate Professor in the Department of Animal and Poultry Science in the College of Agriculture and Bioresources at the University of Saskatchewan. His applied research program is focused at the wildlife-livestock interface and his team works to mitigate disease and crop damage problems. His group has been studying wild pigs in Canada for ten years.

ABSTRACT:

Wild pigs are not native to North America but were brought to Canada in the 1980s and 1990s to be used for meat production and high fence shoot farms as means of diversifying agriculture and were brought to all provinces and the Yukon Territory. Widespread escapes and purposeful releases through the 1980s to present have introduced and continuously supplemented established free-ranging wild pigs in most provinces, including British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec, with at least one likely sighting in the relatively small coastal Atlantic Provinces. Recent escapes of domestic animals in the Yukon Territory and the presence of wild pigs now <350km from the Northwest indicates ongoing range expansion across large areas of Canada is very likely. Current rate of expansion is 90,000 km^2/year. We predict that by the end of 2020, wild pigs will occupy 1 million km^2 in Canada. This rapid expansion has raised important concerns for northern U.S. states where wild pigs are likely to disperse to over the coming decades. Despite very cold winters and thick winter snow cover normally

from December to March, they are producing 6 young/litter on average and parturition occurs in all seasons. We have documented risks and impacts to large mammal communities and endangered populations of birds (Piping plover) and lizards (Prairie Skink). Wild pigs make extensive use of agricultural crops, most importantly corn. There is no national strategy to address this emerging crisis and only the province of Alberta has a written strategy to address feral swine expansion. Perceptions of risks of wild pigs are primarily determined by the presence of them in the local area; rural people in areas with no wild pigs have low concern and in areas like Saskatchewan that have the most wild pigs, concerns are significantly higher. Over the last decade there have been some small scale efforts to kill wild pigs on the landscape but these vary by province and represent approximately 1% of efforts required to start moving toward population control. There is currently at least one wild pig 'stronghold' in Alberta, Saskatchewan, and Manitoba where eradication is no longer feasible. Ground-based trapping, helicopter capture, and the use of Judas pigs are all proven effective control measures in Canada but these have yet to implemented in a comprehensive approach. On-going research and monitoring is essential and data to inform meaningful population estimates are likely the most important next steps needed as there are currently no existing estimates. Population data and keeping updated the spatial distribution are essential for targeting any management efforts.

Peccaries and Pigs: Friends or Foes - the situation in central-western Brazil

Alexine Keuroghlian,

Presenter: Alexine Keuroghlian

Alexine Keuroghlian, has a PhD from the Ecology, Evolution, and Conservation Biology program from the University of Nevada-Reno. Alexine has more than 20 years of experience studying the ecology of peccaries and other frugivorous wildlife in Brazil. For 12 years, she coordinated the WCS (Wildlife Conservation Society) Pantanal Project, "Improving Ranching Efficiency to Protect Biodiversity in the Brazilian Pantanal". One of the objectives was to investigate the cattle and feral pig impacts on the native forest frugivore community in the Pantanal basin and highlands. Alexine has conducted conservation-related research in a variety of tropical environments. Her other research experience includes studies of primates as part of the "Minimum Critical Size of Ecosystems" project in Amazonas, an investigation of the endangered black lion tamarin in the Atlantic Forest of São Paulo state. Alexine's 25+ years of research on white-lipped peccaries and 15+ years of conservation work in the Pantanal and Cerrado were recognized in 2012 by the IUCN with a Harry Messel Award for Conservation Leadership. Alexine is also the founder and general coordinator of the magazine Pantanal Science- An audience-friendly journal that presents articles by regional researchers on new discoveries, sustainable practices and environmental issues in the Pantanal region.

ABSTRACT:

The Illinois sized Pantanal floodplain and bordering Cerrado highlands in Central western Brazil provide continental scale ecosystem services and contain an extraordinary level of biodiversity. A key landscape species in this region is the white-lipped peccary (WLP). They are the only tropical forest ungulates that form large herds (50-300 individuals), so their effects on forest habitats can be dramatic. The herds strongly affect forest biodiversity via fruit predation and dispersal, as well as forest structure by thinning the vegetation as they trample and turn over the humid soil and litter along their travel routes. WLPs are also important prey for jaguars. Due to their varied ecological roles, extirpation of WLPs, or other peccary species, from a forested area frequently causes habitat alterations and additional biodiversity losses. Unfortunately, local extinctions of WLPs have been reported throughout their vast geographical range. Here, we will present the history of feral pig introductions in the Pantanal and Cerrado of central-western Brazil and discuss some of the pros and cons resulting from their overlap with native peccaries and other wildlife. On the Pantanal floodplain, peccaries and other wildlife have coexisted with feral pigs for over 200 years. The pigs appear well adapted to the largely preserved Pantanal habitats (80% intact) and, in addition to having some negative impacts, may play a positive role in diluting hunting pressure on native wildlife. On the highland plateaus that drain into the Pantanal, nearly 60% of Cerrado forests have been cleared and converted to cash crops (e.g., soy, corn, and cotton) or exotic (non-native) pasturelands during the last 50 years. In this fragmented landscape, feral pig introductions are more recent and may be having more serious negative impacts on native mammal communities. The recent expansion of corn plantations on the Cerrado highlands around the Pantanal floodplain has been accompanied by a growing presence of the much larger and more destructive European Boar. In addition, recently introduced wild boar management may be interfering with conservation of peccaries that are frequently mistaken for the exotic pig. Currently, we have little information on how boar management is impacting peccaries and other wildlife. We will discuss growing concerns about the recent expansion of wild boars and their hybrids with domestic pigs (feral hogs/ feral pigs) in relation to native wildlife, human-wildlife conflict and the Pantanal floodplain, including potential impacts on existing floodplain adapted feral pig populations.

Pig Impacts on Island Landscapes

Jed Sparks

Presenter: Jed Sparks

Dr. Jed Sparks is a Professor of Ecology and Evolutionary Biology and Director of the Cornell Isotope Laboratory at Cornell University. He received a bachelor degree in Biology from the University of Utah in 1994, a Ph.D. in Botany from Washington State University in 1998 and conducted post-doctoral work at the University of Colorado, the National Center for Atmospheric Research and NOAA. He is an Ecologist who uses a variety of methods to study ecosystem function and has published over a hundred peer-reviewed journal articles and book chapters. He was given the Menschel Distinguished Teaching Fellow Award in 2018. He has done extensive work on the management of feral pigs and

ecosystem restoration after their removal in Hawaii. This work has included exploring the origins of pigs in Hawaii using genetic methods, studying the influence of pig removal on ecosystem function, restoration of ecosystems in Hawaii after pig removal and the construction of decision-making models to guide land managers in restoration efforts.

ABSTRACT:

Throughout the Pacific Island region, pigs are hunted recreationally and are considered a cultural asset to many residents. However, pigs are often disproportionately damaging on islands where there is no long-term history of ungulate animals. Often, land managers fence and remove pigs as a first step towards re-establishing desired ecosystem services and management objectives. However, the outcome of animal removal is variable and often does not achieve management goals. Not surprisingly, the trajectory of ecosystem function post animal removal is driven by the underlying ecological processes driving plant community composition, how these processes were influenced by the presence of pigs, and the degree to which there are legacy affects post animal removal. In this study, we have conducted field and greenhouse experiments to investigate how ecosystem processes, especially nutrient regeneration, change after animal removal and have explored strategies to alter ecosystem nutrient availability to promote desired management outcomes. We have established a paired-plot chronosequence of animal removal and examined a suite of soil physical and chemical properties inside and outside of fenced units in wet forests on the Island of Hawaii. Along this chronosequence, pig removal had large impacts on soils that last for >20 years following pig removal. Specifically, pig removal: (*i*) improved soil structure via increased soil aggregation, decreased bulk density, and decreased soil moisture; and (*ii*) enhanced nutrient cycling and availability via increased net N mineralization and increased labile soil carbon and extractable cations in soil solution. We hypothesize that disturbance by feral pigs initially opens the forest understory to invasion by nonnative plants, and that alterations in soil properties facilitates a continued competitive advantage for invasive plants. We have now conducted greenhouse competition experiments assessing the competitive outcome of native and invasive plants over a range of nutrient availabilities. The combined results of these two efforts suggest that management solutions can be best achieved by both the removal of the nonnative animal and techniques (e.g., increasing soil carbon) that slow nutrient regeneration. Further, we have used this information to create decision making models considering both restoration potential and cost to guide land managers in restoration efforts.

Toxicants

Evaluation of Kaput® Feral Hog Bait for Controlling Wild Pigs
James C. Beasley, Lindsay Clontz, Allison Rakowski, Nathan Snow, and Kurt VerCauteren, Savannah River Ecology Laboratory, University of Georgia, Aiken, SC, USA, beasley@srel.uga.edu

To address rapidly expanding wild pig population in the U.S., there is growing interest in use of toxic baits to supplement existing control methods. Here we present results of a comprehensive evaluation of Kaput® feral hog bait, the only toxic bait registered for use in controlling wild pigs in the U.S. We attempted to use a combination of pen and field trials in South Carolina, USA to assess efficacy of Kaput and determine effects to non-targets. During pen trials, all 20 wild pigs that were fed Kaput succumbed to the bait. Mortality averaged ~8 days (range: 5-11) after initial consumption of bait, with the amount consumed having no effect on time until mortality. Wild pigs consuming Kaput exhibited numerous behavioral symptoms characteristic of warfarin exposure including vomiting, bleeding, abnormal breathing, incoordination, and limping. Necropsies further revealed most pigs exhibited internal hemorrhaging and free blood in organs, and blood and swelling in joints. Prior to implementation of field trials, we captured and attached radio transmitters to 96 wild pigs and 92 non-targets (rodents, raccoons, and Virginia opossums) across 3 study sites. Field trials consisted of Hog Hopper® bait stations spaced ~750m apart that were pre-baited with corn, which was replaced after 5 weeks with Kaput upon acclimation by marked pigs. Despite extensive pre-baiting, wild pig use of feeders decreased upon deployment of Kaput, with no pigs consuming more than trace amounts of toxic bait, resulting in no pig or non-target mortalities. Wild pigs were subsequently re-acclimated to feeders baited with corn for several weeks, followed by a second deployment of Kaput, which also resulted in no wild pig or non-target mortality. Collectively, our results suggest wild pigs are highly susceptible to consumption of Kaput, but improvements in bait palatability and feeder accessibility are necessary prior to use by wildlife managers.

Conditioning and Access by Feral Hogs to Bait Delivery Systems
Gregory A. Franckowiak, and Richard Poché, Genesis Laboratories, Inc., PO Box 1195, Wellington, CO 80549, USA, greg@genesislabs.com

Feral hogs are an invasive species that continue to increase in numbers and distribution throughout North America. Toxicants have proven to be a cost-effective tool in reducing feral hog numbers. Currently only one bait, Kaput® Feral Hog Bait, is registered by the USEPA. In this study placebo baits were presented in Hog Stopper® feeders to allow access only by hogs, while minimizing exposure to non-target wildlife. Feral hog visitations and access to feeder contents were assessed using trail camera images. The objective of our research was to evaluate feral hog conditioning to feeder contents over time and monitor access to feeder contents with doors lowered. Data were collected over conditioning and baiting periods. A crack corn formula was compared to a paraffin bait, and a modified commercial hog feeder to the Hog Stopper. Details of the findings will be presented.

Assessment of Spilled Hoggone® Post Toxic Bait Deployment

John C. Kinsey, Justin A. Foster, Nathan P. Snow, Jason Wishart, Linton D. Staples, Janis K. Bush, and Kurt C. VerCauteren, Kerr Wildlife Management Area, Texas Parks and Wildlife Department, 2625 FM 1340, Hunt, Texas 78024, USA, John.Kinsey@tpwd.texas.gov

HOGGONE® has been identified as an effective sodium nitrite-based toxicant against wild pigs (*Sus scrofa*) in Australia, New Zealand, and the United States. Though HOGGONE is highly lethal to wild pigs, it is not species specific. Thus, to protect non-target species that may be attracted to HOGGONE, it must be deployed in a wild pig-specific bait station. Bait stations have effectively minimized non-target access to HOGGONE in both free-range and captive trials, but spillage of bait outside of bait stations caused by feeding wild pigs is a hazard for non-targets. Observations in associated studies have indicated that the method in which HOGGONE is presented in bait stations may affect spill rate. In Phase 1 of this study, we evaluated post-feeding spillage of three bait presentation methods (crumbled, extruded, and trays) against captive groups of wild pigs and conducted double-observer surveys to estimate spillage. Results indicated that the crumbled method produced significantly higher spillage ($p < 0.01$) than the two alternate presentation methods. Though there was no statistical difference in spillage between trays and extruded presentations, differences in manufacturing and operational logistics led to the selection of trays for field use. In Phase 2 we further assessed the risk to non-target species in relation to consumption of spilled HOGGONE delivered in trays via bait stations. Here we estimated spillage across 12 additional replicates (N=16) in which trays were the only presentation method used. Results of Phase 2 maintained that HOGGONE presented in trays decreased total spillage with an estimated mean of 6.39g of spilled HOGGONE per 7 wild pigs per night. Further analyses will assess risk to potential non-target species through consumption of HOGGONE spillage by wild pigs. This study confirms that bait presentation method affects spill rate; and that spillage mitigation is possible and essential for risk management of non-target species.

Field Evaluations of HOGGONE® meSN Bait for Controlling Wild Pigs

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The range and populations of wild pigs (*Sus scrofa*) have been expanding throughout many regions of the world. Wild pigs cause extensive damage to ecological and agricultural resources, and are implicated in the spread of diseases. Current methods for removing wild pigs (e.g., aerial shooting or trapping) are costly or difficult to apply over large areas. Accordingly, an international effort to develop a safe, humane, and cost-effective toxic bait (HOGGONE®) for wild pigs is underway, and recently registered in Australia. We developed a lower-dose formulation of HOGGONE bait for North America to reduce the risk of non-target species that may be exposed. In addition, we developed a presentation method using wild-pig specific bait stations to reduce bait spillage, and revised the baiting strategy to reduce the presence of non-target species at bait sites. We conducted 3 field trials throughout varying climatic regions to evaluate the lethality of free-ranging wild pig and risks to non-target species. Results from the first 2 study areas (Queensland, AU and Alabama, USA) indicated that lethality to the population of wild pigs was high (78-90%) with just one night of toxic baiting. Spilled bait and subsequent non-target risk was minimal. These preliminary results demonstrated good potential for HOGGONE as a new tool for controlling wild pigs. The third trial in Texas, USA is scheduled for Feb-Mar 2020.

Movements of Wild Pigs Relative to Bait Sites

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Wild pigs (*Sus scrofa*) damage agricultural and natural resources throughout their nearly global distribution. Population control activities (e.g., trapping, shooting, or toxic baiting) often involve the deployment of bait to attract wild pigs. A better understanding of how wild pigs respond to bait sites can help maximize efficiency of baiting programs and identify any potential pitfalls. We examined the movement behaviors of wild pigs during intensive baiting programs at multiple sites in Texas and South Carolina, USA. Specifically, we examined the influence of habitat quality, home range size, number of bait sites in the home range, distance to a bait site, and sex on visitation to bait sites. For any bait site visited, the first visit averaged 2.6–8.5 days after deployment, depending on distance from home range centroids. For every 200 m farther away both sexes took ~1 day longer to visit. Wild pigs traveled farther distances to visit bait sites in lower quality habitat. However, we found bait sites needed to be within 1 km of where females were located prior to bait deployment (1.25 km for males) to achieve ≥0.50 daily visitation rate. Deployment of bait increased movement distances and erratic movements for both sexes but did not influence their foraging search area. Home range sizes increased and shifted during baiting, especially for wild pigs on the periphery of the baiting area. After baiting ceased, wild pigs moved away from bait sites and began using new space (i.e., less overlap with prior-to-baiting home ranges), suggesting baiting could facilitate the spread of wild pigs. We recommend baiting programs should be coordinated so that management activities reduce the greatest number of wild pigs possible following baiting. Bait sites should be spaced at 1 bait site/km^2, and should be actively relocated if visitation by wild pigs is not consistent. Uncoordinated and passive baiting for recreational hunting and trapping likely exacerbates the negative consequences of baiting identified in this study, such as expanding the space-use and facilitating the spread and contact of wild pigs.

Optimal Bait-Site Density for Controlling Feral Swine with Toxicant

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Oral baiting is a fundamental method for delivering toxicants to pest species. Planning baiting strategies is challenging because bait consumption rates depend on dynamic processes including space use and demographics of the target species. To determine cost-effective strategies for optimizing baiting, we developed a spatially-explicit model of population dynamics using field-based measures of feral swine space use, bait-consumption, and mortality probabilities. The most cost-effective baiting strategy depended strongly on the population reduction objective and initial density. A wide range of baiting strategies were cost-effective when the objective was 80% population reduction. In contrast, only a narrow range of baiting strategies allowed for a 99% reduction. Cost-effectiveness was lower for low densities of feral swine because of the increased effort for locating target animals. Bait avoidance due to aversive conditioning from sub-lethal dosing had only minor effects on cost-effectiveness when the objective was an 80% reduction, whereas the effect was much stronger when the objective was 99% population reduction. Our results showed that a bait-based toxicant could be cost-effective for

substantially reducing populations of feral swine, but for elimination it may be most cost-effective to integrate additional management techniques following initial toxicant deployment. The interaction of cost-effectiveness, initial population size, and reduction objective also emphasized the importance of considering the dynamics of space use and bait consumption for predicting effective baiting strategies. Although we used data for an acute toxicant and feral swine consumption rates, our framework can be readily adapted to other toxicant characteristics.

Attitudes towards Wild Pig Toxicants: Results from a Large-Scale Survey of Texas Hunters
(no video presentation)
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This study examines attitudes of in-state and out-of-state Texas hunters towards the potential use of a toxicant to control invasive wild pigs (*Sus scrofa*). In 2019, we emailed an online survey link to all licensed Texas hunters with registered email addresses (n = 169,619) and received 37,371 completed surveys. Among other things, survey participants were asked about their motivations for wild pig hunting; annual expenditures associated with wild pig hunting; preferred wild pig population size; experience with wild pig damages; and acceptability of various wild pig control methods, including the use of a toxicant. In addition, we collected qualitative data through the questionnaire concerning respondents' reasons for supporting or opposing a wild pig toxicant. In this presentation, we provide an overview of findings from this study, including the most frequently cited concerns with a toxicant and factors associated with support or opposition to toxicant usage, such as subsistence hunting or experience with wild pig damage. This study provides valuable insight into this critical stakeholder group to inform wild pig control strategies and public outreach efforts.

Damage

Understanding Crop Use and Preferences of Wild Pigs in Agro-Ecosystems
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Wild pigs (*Sus scrofa*) are one of the most successful and detrimental invasive species worldwide. They can alter ecological interactions and ecosystem-level processes, and cost billions of dollars through impacts to agriculture, infrastructure and human health. As ecological generalists, wild pigs quickly adapt to new environments within their introduced range and may take advantage of agricultural forage resources which can be an important driver of population establishment and increase. Understanding context-dependencies such as resource availability, wild pig attributes, and environmental variables can inform how ecological factors influence movement behavior of wild pigs in agro-ecosystems, which can improve predictions of high impact hotspots and inform strategies to mitigate damage across locations

with varying crop types and availability. We linked movement data from 326 wild pigs across different agro-ecosystems in the U.S. to better understand preferences for agricultural crops and their influence on movement patterns compared to natural resources. We examined how individual attributes and resource characteristics altered the selection of resources and movement behavior and found a strong, highly-context dependent response where crop use exponentially increased with crop availability, at low density. There was reduced crop use with increasing crop availability when non-agricultural resources were more available, emphasizing crop damage levels are likely to be highly variable depending on surrounding natural resources and temporal availability of crops. We found significant effects of crop type and sex, with males spending 20% more time and visiting crops 58% more often than females, and both sexes showing different behavioral responses depending on crop type. Our study demonstrates how commonly collected animal movement data can be used to understand context-dependencies in resource use to improve understanding of pest foraging behavior, with implications for prioritizing hotspots of potential economic loss in agro-ecosystems and predicting large-scale damage to crops from local population abundance estimates.

Timing and Extent of Crop Damage by Wild Pigs (*Sus scrofa*) To Corn (*Zea mays*) and Peanuts (*Arachis hypogaea*)

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Over the last 50 years, wild pig populations have undergone an increase in size and distribution across both their native and introduced ranges, considerably increasing the extent and severity of agricultural damage. Our study seeks to maximize the efficiency of management efforts by identifying the stages at which wild pigs damage crops, as well as the local landscape attributes most commonly associated with damage. During the 2017 and 2018 growing seasons, we conducted ground-based surveys throughout the growing season on 29 corn (*Zea mays*) and 41 peanut (*Arachis hypogaea*) fields in South Carolina, USA. Damage to corn occurred most heavily during the seedling, silk, and mature stages, with almost no damage observed during the V4-V6 stage. Damage to peanuts occurred almost entirely in the seedling stage, with negligible levels of damage observed in all other growth stages, including after maturation. Of the landscape attributes we tested, forested and wetland areas adjacent to crop fields were the most important factors positively associated with wild pig damage for both crop types, while adjacent agricultural area and paved roads were negatively associated with wild pig damage. The number of individual wild pigs captured by remote cameras was also an important predictor of the severity of damage to peanut fields. Collectively, these results suggest that management efforts should be targeted shortly prior to planting to maximize the potential yield saved from wild pigs. As damage was positively associated with the presence of wetland and forest habitats, our results also suggest that fields located in proximity to preferred wild pig habitat may be most likely to experience severe damage.

Corn Hybrid Preferences of Feral Swine

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The negative economic impact of feral swine on agronomic crops continues to increase costing farmers millions of dollars each year. We have observational data that suggested that there may be feral swine preference for some corn hybrids compared with others. To determine the effect of genetically engineered corn hybrids on feral swine preference two experiments were conducted across two years. Each year, hybrids were planted, hogs introduced, and aerial images collected at seven-day intervals. Captured images were then analyzed using MultiSpec imaging software to determine percent of damage. Percent damage was then compared across hybrids using the Glimmix procedure of SAS. In Year 1, a Roundup Ready hybrid was compared with a Roundup Ready + Liberty Link + Bt hybrid within 254 sq-m plots, replicated four times. Ten pigs ranging in weight between 23 and 45 kg were released into the plots 41 days after planting. For this experiment, feral pigs preferred the Roundup Ready hybrid compared with the Roundup Ready + Liberty Link + Bt hybrid ($P<0.001$). In Year 2, three replications of five hybrids in 560 sq-m plots were evaluated. Fifteen pigs ranging in weight between 23 and 54 kg were released into the plots 58 days after planting. In this experiment, pigs preferred corn hybrids containing Roundup Ready, Liberty Link and Bt traits compared with conventional non-modified corn ($P=0.0005$). These findings suggest that the genetic modification of the corn plant may affect taste or another nutritional value resulting in preferences of feral swine for one hybrid over the other. These findings should be cautiously interpreted until larger scale studies can be conducted.

Impacts of Wild Pigs on Acorns as a Food Source for Native Wildlife

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Wild pigs (*Sus scrofa*) compete with native wildlife for seasonally available pulse resources such as acorns. Despite much anecdotal observations and diet studies suggesting wild pigs impact acorn availability for other wildlife species, no studies comparatively examined acorn consumption among species in a natural environment (i.e., competition). Therefore, our objective was to estimate the consumption of acorns by wild pigs relative to that of other native wildlife species. We established 40 monitoring stations beneath acorn producing trees at a 3,406-ha study area in eastern Alabama with an approximate density of 7.62 pigs/km^2. At each monitoring station, we placed 5 acorns on a 1m x 1m sand pad and positioned a game camera to record acorn fate (species-specific consumption) during 2-week intervals once a month from November-February 2018-19 and September-February 2019-20. We set cameras to capture images once every minute continuously during the survey period. In summer and fall 2019, we removed wild pigs with trapping and aerial shooting. Therefore, we can compare consumption rates with and without wild pigs on the landscape. Additionally, we constructed acorn traps from 18.9 L plastic buckets to estimate the total acorns potentially available for consumption at each monitoring station. From approximately 3.5 million camera images in 2019-20, we found that 367 acorns were consumed by 13 species of animals while 183, 322, and 328 acorns were lost due to flooding, remained on the sand pad at the time of camera failure, or were not consumed during the sampling period, respectively. Of the acorns consumed in 2018-19, wild pigs consumed 23% whereas white-tailed deer (22%), and squirrels (19%) consumed slightly lesser amounts. Consumption by species

varied among the sampling periods. Wild pigs consume a significant number of acorns and likely reduce this pulse resource for other native wildlife species and may potentially influence oak regeneration.

The Removal of Invasive Wild Pigs Increases Populations of White-Tailed Deer
(No video presentation)
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Invasive species can have a wide range of impacts on ecosystems, including the reduction of population size and/or use of an area by native species. Invasive wild pigs (*Sus scrofa*) are one of the most destructive invasive species globally and threaten many ecosystems in the United States. Due to competition with native species, wild pigs can harm populations of wildlife that are important to humans and ecosystem integrity. In particular, it is believed that wild pigs are possibly competing with white-tailed deer (*Odocoileus virginianus*) and negatively affecting their populations. However, few studies have quantified potential negative impacts between these species. The objective of this study was to evaluate the effect of wild pigs on populations of white-tailed deer. We deployed wildlife cameras across two populations (i.e., south and north) at Buck Island Ranch, Florida from 2015 – 2018. We employed a before-after-control-impact (BACI) study design where wild pigs were removed from the south population, and then the north population, to evaluate the response of white-tailed deer populations to wild pig removal. Results from Royle-Nichols occupancy models indicated that removal of a large portion of the wild pig population can increase white-tailed deer use of an area. However, white-tailed deer did not demonstrate increased use of an area where a lower proportion of the wild pig population was removed. Our results indicate that wild pig removal can effectively increase use of an area by white-tailed deer. However, a sufficient portion of the wild pig population needs to be removed to benefit white-tailed deer. Ultimately, if removal efforts are maintained, it would likely increase access by native wildlife to limited resources, which are especially important during poor resource years. This research can help inform management and conservation plans aimed at increasing populations of wildlife impacted by invasive species.

Impacts of Wild Pigs on Water Quality and Fecal Bacteria in Headwater Riparian Systems
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As wild pigs continue to expand their range in North America, it is important to fully understand their impacts to predict how invaded environments may change. Potential changes to riparian ecosystems are especially concerning as these systems provide essential ecosystem services. We examined water quality in riparian watersheds on a privately-owned property in Alabama that is densely populated by wild pigs (treatment site), and compared it to watersheds at a nearby national forest that did not have a population of wild pigs (control site). Water samples were collected between May 2018 and June 2019 to measure concentrations and loads of sediment (TSS), nitrate and nitrite, base cations, and E. coli and other fecal coliforms. An additional 36 samples were analyzed via qPCR DNA technology for swine fecal bacteria. Linear mixed effects (LME) analysis was used to assess the importance of several variables in explaining water quality and fecal bacteria concentrations at the two study areas. Results indicate

differences in water quality parameters between the treatment and control watersheds. Sulfate, chloride, sodium, calcium, TN, and DOC mean concentrations and mean specific conductivity were all greater at treatment watersheds than at the control watersheds. Mean *E. coli* concentration at the treatment area was 1711.25 cfu/100 mL, compared to 62.50 cfu/100 mL at the control. Concentrations ranged from 0 – 70,767 cfu/100 mL and 0 – 967 cfu/100 mL at treatment and control watersheds, respectively. DNA from swine fecal bacteroidetes was detected in 69.7% of treatment samples and 0% of control samples, and each treatment watershed was positive at least once. Our research fills a gap of knowledge on the influence of wild pig damage in riparian systems and uncovers essential information that can influence management of this invasive species to safeguard water quality in local watersheds.

Wild Pig Disturbance Reduces Tadpole Abundance Within Seasonal Wetlands Across a Subtropical Agroecosystem

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Seasonal wetlands provide important ecosystem services across Florida rangelands, particularly nutrient retention, water storage, and groundwater replenishment. They also provide critical wildlife habitat. These wetlands are often targeted by foraging wild pigs and experience extensive disturbance and alteration to their vegetation, soil, and water quality from rooting. Our study examines the indirect impacts of pig rooting within wetlands upon the larvae of an ecologically important and globally imperiled taxon – frogs. Between June and August 2018, we sampled tadpoles in 36 seasonal wetlands across a 4,250-ha cattle ranch in south-central Florida. We used standardized dipnet sweeps and recorded number of tadpoles, species collected, and developmental stage. For each sampling event we conducted 25 sweeps in non-rooted wetlands, and 50 in rooted wetlands divided equally between disturbed and undisturbed areas. Each wetland was sampled three times with two to three weeks elapsing between sampling events. Fourteen of the wetlands contained rooting disturbance and a total of 1969 tadpoles were captured – comprising nine species and three families. Because tadpole abundance significantly decreased across sampling rounds, we conducted analyses on the total number of tadpoles captured per wetland to account for varying life history strategies among taxa. A comparison between 75 sweeps in non-rooted wetlands and 75 sweeps in undisturbed areas of rooted wetlands revealed no significant difference in overall tadpole abundance – 45.68 ± 13.54 (SE) in non-rooted wetlands and 50.7 ± 13.3 (SE) in rooted. There was, however, a strong significant difference for within rooted wetland abundance – 18.1 ± 6.5 tadpoles in disturbed areas vs. 50.7 ± 13.3 in undisturbed areas. At the species level, this result was consistent across three of the four most abundant taxa. On average, rooted patches declined by over 60% in the abundance of tadpoles with no compensation measured in the non-rooted areas. Within an individual wetland, rooting disturbance was recorded up to 22% of total area with personal observations of other sites within the region nearing 100%. As such, habitat disturbance from wild pig rooting could be considered major stochastic events affecting frog reproductive success, both across Florida and across the wild pig's range.

Management

Immobilizing Wild Pigs in the Field: A Comparison of BAM™ and MMB
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Two years ago, we presented the results of a pen study comparing the efficacy of three novel chemical immobilization combinations to Telazal™-Xylazine for immobilization of wild pigs. In this presentation we will discuss the results of our experiences using the best performing drug combinations (BAM™ [butorphanol, azaperone, meditomidine]; MMB [meditomidine, midazolam, butorphanol] in the field. We have had the opportunity to administer both drug combinations using a variety of techniques (dart, syringe pole, hand injection) to wild pigs in a variety of capture and/or restrain scenarios (corral trap, following transport to a central handling location, restraint in a mechanical squeeze), in different weather and environmental conditions. Both of these drug combinations have merit for use in wild swine; we will discuss the pros and cons of each. In addition, we will discuss how to handle scenarios such as delivery of additional drug dosages to animals that are insufficiently sedated, how to monitor and manage sedated animals in field to ensure best outcomes following immobilization reversal.

Risky Business: Using Risk Assessments to Field Biosafety Plans for Handling Wild Pigs
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In official "fancy talk," the purpose of a field biosafety risk assessment is to a) identify potential events that may negatively impact people, animals, assets, and the environment; b) determine the likelihood that the events might occur; c) discuss the consequences associated with the events, should they occur; d) develop strategies to prevent, address, or resolve the events and consequences. In simpler terms, these risk assessments help us identify sources of potential mishaps, the likelihood they might happen, steps that can be taken to prevent them, and how we will handle them when they do occur. Wild pigs are difficult animals to handle in the field for many reasons, and developing tools and methods to make our jobs easier is important for our safety. Incorporating field biosafety assessments into our project plans on the front end can improve efficiency and decrease the potential for problems when we enter the field to do our job. This presentation will explain what risk assessments are, how they can be incorporated into field biosafety plans, why field biosafety plans are important, and why these items are useful tools for wild pig field work.

Automated Species Identification of Camera Trap Images to Improve Invasive Species Control
(No video presentation)
Ryan S. Miller, Michael Tabak, Mohammed S. Norouzzadeh, David Wolfson, Eric S. Newkirk, Joseph M. Halseth, Raoul K. Boughton, James C. Beasley, Peter E. Schlichting, Kurt C. VerCauteren, and Jeff Clune, Center for Epidemiology and Animal Health, United States Department of Agriculture, 2150 Centre Ave., Fort Collins, CO 80526, USA, Ryan.S.Miller@usda.gov

Remotely triggered cameras (camera traps) are a vital tool for detecting wildlife to address a plethora of needs associated with wildlife and invasive species research and management. When analyzed collectively, species occurrence data from images can inform management by improving understanding of species presence and efficacy of management strategies. A major limitation of using camera traps is the manual visual identification of species in images. Manual identification can require hundreds to thousands of hours of personnel time and can significantly delay project progress. Manual identification also limits the use of cameras for large scale monitoring. To address these limitations, an automated camera trap image classification algorithm - Machine Learning for Wildlife Image Classification (MLWIC2) – has been developed and is available as an R package with options for use as R Shiny apps. MLWIC2 uses deep convolutional neural networks which were trained using 3 million images from 11 sites in North America; it has an accuracy of 96.7% across 59 species, with wild pigs having an accuracy of 98.3%. MLWIC2 can automatically classify 2,000 images per minute on a laptop computer. MLWIC2 can be used to automate identification of wild pigs and species they threaten in camera trap images. Furthermore, MLWIC2 can also distinguishes between empty images and those containing any animal (accuracy of 97%), which can be applied in more diverse settings. Because of the speed this tool can be used to support large scale monitoring to ensure elimination of wild pigs after control or to detect newly established populations. Additionally, MLWIC2 can be used to automatically detect animals in images captured by cellular game cameras. Using cellular game cameras with MLWIC2 can greatly reduce staff time spent managing camera traps and camera trap images. This advancement will enable cameras to be used more efficiently for pre-, during and post-elimination monitoring of control operations.

Environmental DNA (eDNA) Monitoring in a Novel Ecosystem: A Southern Indiana Case Study
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In areas of active feral swine (*Sus scrofa*) management, surveillance tools are needed to confirm elimination of local populations or detect new invasions, with success dependent upon our ability to detect a limited number of individuals on a vast landscape. Previously we demonstrated the efficacy of environmental DNA (eDNA) for the detection of feral swine in controlled experiments. More recently, we implemented eDNA as part of a holistic surveillance approach, using eDNA with complimentary methods including camera trapping and observing field sign such as tracks, wallows, and scat, to monitor feral swine in several western states (e.g., Colorado, New Mexico, and Utah). In these semi-arid states, sampling efforts were focused on the limited water sources available to feral swine. Here, we describe a pilot study to evaluate the efficacy of eDNA monitoring in southern Indiana, where feral swine remain a problematic invasive species, yet water is abundant. During October and November 2019 we collected 10 water samples from each of 8 sites, 4 sites with known feral swine activity and 4 with unknown activity. We extracted DNA in two technical replicates and conducted 6 droplet digital PCR (ddPCR) replicates. We demonstrated successful detection of feral swine using eDNA in this new region; however, as expected, we encountered challenges detecting eDNA, even from sites known to be occupied. Results from our pilot study will help guide eDNA monitoring efforts as we pursue the implementation of this tool in more mesic landscapes. As feral swine continue to expand their range and thus increase ecological and economic damage, eDNA is emerging as a viable monitoring tool for detecting this invasive species in a variety of ecosystems.

Can We Use Fertility Control in Integrated Wild Pig Population Management?
(No video presentation)
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Wild boar and wild pigs are increasing worldwide in parallel with their ecological and environmental impact. Traditionally, culling has been used to mitigate human-wild pig conflicts. However, wild pig populations are growing and the number of hunters is declining. Therefore, alternative or complementary options to culling, such as fertility control, should be investigated. We used the data on two populations of wild boar closed to immigration, each comprising 2000-3000 animal to model the impact of different population management options. We defined a standard stage-specific matrix model and applied an Approximate Bayesian Computation (ABC) approach to derive parameter values. The model simulated the integration of various levels of culling and fertility control to achieve a target population of 400 wild boar, deemed appropriate to reduce the species' impact. The results suggested that fertility control, on its own, will not decrease wild boar population size. However, provided 80% of the females can be made infertile, fertility control will prevent population growth. A minimum of 40% culling is required to reduce the population to target size, albeit slowly (20 years). The results also showed that a combination of 40% culling and 40% sterilisation will reduce the number of wild boar to the target population size in 5 years. We concluded that adding fertility control to realistic culling effort is most effective to reduce wild boar and wild pig numbers. This method could be explored to reduce the size of closed populations of feral pigs, or to eradicate these populations, particularly in contexts where the required level of lethal control is not achievable.

Adaptive Satellite Remote Trapping Techniques to Improve Capture Rates in Areas Without Cellular Coverage
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Feral Swine are responsible for 2.5 billion dollars annually in the United Sates. This value is up from previous years of 1.5 billion dollars annually. Due to their productive biology and destructive nature, it is not farfetched that damage associated with feral swine will continue to rise in the US and other countries throughout the world. Wildlife damage techniques have come a long way since the use of rooter sticks, trip wires, and other manual triggers to capture wild and feral animals in remote locations. The introduction of picture and video automated trap cameras have now made it possible for land managers to know what animals are around their trap, and has allowed them to target entire family groups of animals. This technology increases catch rates, saves time, and saves money in the continued battle to control feral swine damage around the world. A limiting factor for these systems is the reliance on cellular signal and networks. Satellite technology has been adapted to ensure feral animal removal is both effective and cost efficient in areas where cellular networks are nonexistent. These technologies have been applied in remote locations of Australia and New Zealand and have proven to be an effective control technique in areas where cellular networks don't exist. Satellite technology not only is an effective tool for feral swine in these countries, but also controls countless other feral and exotic species. We recommend that trapping technologies continue to adapt and evolve in the ever-changing climate of

nuisance animal management and offer solutions to all stakeholders no matter their limiting circumstances.

Urban Wild Pig Management in Texas

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Wild pigs (*Sus scrofa*) are well established in Texas with population estimates of 3 million individuals. While much of Texas is considered rural, the majority of the citizenry (>50%) lives in the 8 largest metropolitan areas. Wild pigs have adapted to urban and peri-urban areas well and create different conflicts in these landscapes. During FY 2019, employees of the Cooperative Texas Wildlife Services Program responded to 2,159 incidents of wild pigs in urban and peri-urban landscapes in Texas, documenting nearly $775,000 in damages. A total of 933 individual "Work Tasks" (individual daily activities) were recorded and 1,334 pigs were removed. Addressing wild pig damage in urban landscapes involves a different decision process than routine rural wild pig management. The paper will document the difficulties, and some of the solutions, to addressing wild pig damage in this unusual work environment.

Using Management Data to Evaluate the Impacts of Feral Swine Removal Efforts in Missouri

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Efficient methods for control of feral swine are critical to combat the significant threats that feral swine present to agriculture, natural resources, and livestock and human health. However, it is often difficult to assess the efficacy of control methods due to limited resources. Yet, there are two important reasons to focus effort on evaluation: to provide evidence of the impact resources spent on control activities have had on reducing invasive species and to provide feedback for the continual improvement of management efficiency. To evaluate management actions there is often a trade-off in effort aimed at performing management actions and effort aimed at collecting data to evaluate management actions. We developed a method to estimate feral swine abundance from a combination of removal management activities (e.g., aerial gunning, trapping, ground shooting) using only data collected during removal efforts (the method of removal, the date, location, number of animals removed, and the effort). We analyzed removal data from Mingo National Wildlife Refuge in Missouri from December 2015 to September 2019, where the management objective is elimination. Populations of feral swine on Mingo NWR have fluctuated over time but have shown more marked declines in the last 3-6 months. More dramatic declines were observed in the center of the refuge. To counteract population growth (either through births or immigration) the percent of the population of feral swine removed monthly must be greater than the growth rate. On average, we found that removing 10% of the population monthly had only a 50% chance of causing a population decline, whereas removing 15% of the population monthly had a 95% chance of causing a population decline.

Lessons Learned from the Successful Elimination of Wild Pigs in Illinois

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Invasive wild pigs (*Sus scrofa*) can be found throughout much of North America, meaning that their generalist diet, high reproduction rate, and lack of natural predators allows them to readily adapt to a wide variety of environments. Wild pigs were first reported in southern Illinois in 1993 and in more northern counties by the late 1990s. In 2005 reports of wild pigs were confirmed in Fulton County, Illinois and by 2011 federal, state, and local authorities directed a concerted effort to remove wild pigs from the county until the last wild pig (from 376 total) was successfully removed in 2016. We examined surveillance data from camera traps at bait sites and records of wild pig removals during this elimination program to identify environmental and anthropogenic factors that optimized removal of this population. We found that wild pigs spent more time at bait sites during evening and nocturnal periods, periods of lower temperatures, and days with little or no precipitation. We also found that decreasing wild pig abundance did not influence time spent at bait sites. Combining removal effort and wild pig abundance revealed that the cost to remove wild pigs averaged $50 per wild pig for the first 99% of the population and averaged $4,224 per wild pig for the last 1%. Our results suggest that removal efficiency is maximized by identifying periods of high bait site use and confirm that as abundance decreases cost per wild pig removal increases significantly.

Efficacy and Efficiency of a Whole Sounder Removal Program

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Eradication of wild pigs (*Sus scrofa*) from demographically open populations has proven to be a challenge for land managers. Failure to achieve eradication often stems from the lack of a trapping strategy, not knowing the effort and cost required to achieve eradication, or lack of post-removal monitoring to determine whether or not eradication was even achieved. The process of whole sounder removal (WSR), the removal of family groups of wild pigs prior to their ability to augment their size through reproduction, is a viable approach for land managers to achieve eradication in some landscapes. However, the effectiveness of WSR has not been well documented in other landscapes with differing landscape compositions (e.g., forested vs agriculture dominated landscapes). Additionally, fewer studies have quantified the effort required to conduct WSR at a landscape (study area) scale. Our objective was to examine the efficacy and efficiency of whole sounder removal while documenting time, effort, and associated costs. Our study site was a 3,400 ha, privately owned hunting plantation in Macon County, Alabama, comprised primarily of upland pine and bottomland hardwoods. In April 2019, we surveyed the pig population using game cameras spaced on a 1-km2 grid system to determine the location, number, size, and composition of sounders on our study site. We observed 24 sounders totaling 291 pigs. Beginning in May 2019, we began the targeted removal of sounders observed during our survey and the elimination of sounders that immigrated onto the study site. As of January 1st, 2020, we removed 39 sounders, totaling 447 pigs, over 81 trapping events. While removal efforts continue, we believe that the whole sounder removal strategy is a feasible option for achieving eradication.

Investigating the Potential Use of Carpal Gland Secretions for Wild Swine Management
(No video presentation)
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Wild swine (Sus scrofa) are increasingly coming into conflict with humans by causing agricultural and natural resource damage as well as posing a threat of disease transmission to domestic livestock and hunters. New tools would help in the control of burgeoning wild swine populations and to reduce wild swine-human conflicts worldwide. Little research has been directed toward the identification and development of repellents and attractants for wild swine management. Swine have scent glands on their forelegs called carpal glands that may be important for intraspecific communication. Experimental trials involving wild swine and their behavioral reactions to ex vivo carpal gland secretions have not been reported. A captive open field test, utilizing a two-scent post design, was conducted at Kerr Wildlife Management Area, Texas, USA in August, 2012. We used video to capture behavioral responses of solitary wild swine exposed to carpal gland secretions from conspecifics during sixteen trials of 120 minutes duration each. We quantified the investigative and space use behaviors of subjects with open access to control (distilled water) and treatment (carpal gland secretion) swabs within experimental enclosures. Significant nonrandom space use and increased investigative behaviors towards the treatment swabs (scent capsules) were observed in all 16 trials. Carpal gland secretions from feral swine unknown to the subjects served to attract the subjects. If predictable behaviors related to carpal gland scent communication can be exploited, existing control methodologies can be improved, and new wild swine management tools developed.

Development of a Cost-Effective, Versatile Feral Pig Trap
(No video presentation)
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Feral pigs (*Sus scrofa*) have become a serious threat to ecological systems and pose risks to agricultural activities and livestock health throughout the world. The successful control of any invasive species requires a removal method that places a very high percentage of the target population at risk. The continued proliferation of feral pig populations within the United States shows that current control efforts and methods have failed in this regard. Current feral pig trapping strategies focus heavily on "smart" corral traps constructed from materials such as welded fence panels and steel tubing. While these traps are effective, they have significant limitations that prohibit their ability to provide landscape-scale control. These limitations include; 1) high up-front purchase prices, 2) substantial labor costs for setup, trap management, and relocation, 3) challenging transportation logistics (i.e., trucks and trailers), and 4) impractical siting needs (i.e., must be situated on relatively even terrain, and require access to a cellular network). Therefore, it is unlikely that this trap configuration will be widely distributed and gain enough market penetration to endanger a high enough percentage of pigs across their range to effect meaningful control. A new trapping strategy is needed that fits the following criteria; 1) simplified, 2) adaptable, 3) efficient, and 4) cost-effective. Our objectives were to 1) increase feral pig trapping capacity of landowners by increasing the number of pig traps on the landscape and in areas where current smart traps are technologically limited, 2) decrease the labor and equipment required to tend

traps, and 3) reduced trap costs. We have developed a feral pig trapping system that fits all of the above criteria.

Disease

Feral Swine Disease Surveillance and Projects

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The National Feral Swine Program (NFSP) works with USDA APHIS Veterinary Services and USDA APHIS Wildlife Services National Wildlife Disease Program to conduct national disease surveillance in feral swine, specifically focused on classical swine fever, swine brucellosis, and pseudorabies. In addition to the diseases of national concern, the NFSP supports a number of pilot projects to address disease issues that arise at a local level. In close collaboration with Wildlife Services field personnel and others on the ground, the NFSP is able to quickly and robustly identify and sample for additional pathogens of zoonotic, livestock, or companion animal concern. These projects are often multi-agency collaborative efforts and comprise a variety of diseases, including chronic wasting disease, bovine tuberculosis, hepatitis E, and leptospirosis.

Feral Swine Surveillance and the Threat of Transboundary Diseases

(No video presentation)

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Wildlife Services began opportunistic disease surveillance of feral swine in 2006. Surveillance for Classical Swine fever, which is a transboundary disease, was initiated at the request of Veterinary Services and the surveillance of two important endemic diseases of swine, brucellosis and pseudorabies, were immediately included. In addition to these three diseases for which we have maintained continued surveillance, we have conducted surveillance for shorter periods for swine influenza, leptospirosis, trichinosis, toxoplasmosis, PRRS, Seneca, PEDV and other important diseases of swine. Our surveillance demonstrates that feral swine remain a reservoir of numerous diseases eradicated from the US commercial swine herd. The Disease Program maintains an archive of these samples and makes them available to collaborators upon request. The National Feral Swine Program and the National Wildlife Disease Program have worked jointly to respond to the recent global threat of African Swine Fever by conducting Foreign Animal Disease Awareness courses for field personnel as well as establishing a feral swine African Swine Fever Morbidity and Mortality Investigation Program.

Disease Surveillance and Control in Wild Pigs: Insights for Managing Risks from Influenza A and African Swine Fever

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Wild pigs are reservoirs for important endemic and foreign animal diseases (FADs) such as influenza A (IA) and African swine fever (ASF). Below we summarize insights from two separate studies on disease risk assessment in wild pigs. IA. To better understand potential transmission risk from endemic diseases, serological samples are collected opportunistically during management. However, it is difficult to infer disease risk from serology data because antibodies can remain long after pathogens are cleared. Thus, we developed a method for inferring infection times from antibody samples to better understand seasonality of IA virus in wild pigs and identify risk factors. Applying the model to IA virus serosurveillance data from 15 U.S. states, we found that infection risk in wild pigs was highest from Jan.–Mar., moderate from May–Jul., and low year-round; and was positively correlated with humidity and infection trends in domestic swine and humans. Spatial spread of infection among states was not diffusive. Results suggested that infection risk is influenced by local factors and potentially long-distance translocation of infection. ASF. To better understand risk from FADs, it is useful to understand dynamics of disease in areas where the disease is endemic. In Europe, ASF is endemic in wild boar. Dead carcasses and higher boar densities are thought to drive transmission and persistence but the roles of these factors remain unknown. To address this gap, we fit a spatially-explicit model of ASF virus in wild boar using surveillance and ecological data from Eastern Poland. We inferred that between 50 to 68% of transmission events were carcass-based. Carcass-based transmission increased with decreasing host density. Densities below 1 boar / km^2 did not support autonomous persistence. Results suggested that management policies should emphasize carcass removal and consider how reductions in host densities may drive carcass-based transmission.

Analysis of Risk and Economic Costs Associated with African Swine Fever (ASF), Classical Swine Fever (CSF), and Foot-and-Mouth Disease (FMD) Introduction into the United States Based on a Review of Literature

(No video presentation)

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Foot-and-mouth disease (FMD), African swine fever (ASF), and classical swine fever (CSF) are considered to be three of the most important animal diseases and are currently foreign to the U.S. Emerging and re-emerging pathogens can have tremendous impacts in terms of livestock morbidity and mortality events, production losses, forced trade restrictions, and costs associated with treatment and control. With the most important fed-cattle industry in the world, the United States is the world's top producer of beef for domestic and export use. It is also the world's third-largest producer and consumer of pork and pork products and has been in recent years either the world’s largest or second largest exporter of pork and pork products. Therefore, understanding the potential routes of introduction into the U.S. and the potential economic impact of each pathogen are crucial in order to 1) allocate resources to

prevent routes of introduction that are believed to be more probable, 2) evaluate cost and efficacy of control methods, and 3) ensure that protections are put in place to minimize impact to the most vulnerable industries. With two scoping reviews, this study assesses the risk posed by ASF, CSF, and FMD in the event of a viral introduction into the United States, and illustrates the economic costs associated with introductions of each pathogen by examining currently available literature.

Transmission of Antimicrobial Resistant Bacteria at the Wildlife-Livestock Interface
(No video presentation)
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Transmission of antimicrobial resistant microorganisms (ARMs) occurs through complex pathways. ARMs have been identified in humans, livestock, natural environments, and even in wildlife species where antibiotics are not used intentionally. However, transmission pathways of ARMs at the wildlife-livestock interface are poorly understood. This study investigated gut microbiota community and antibiotic resistance profiles of feral swine (*Sus scrofa*), coyotes (*Canis latrans*), and cattle (*Bos taurus*), as well as environmental microbiota to understand ARMs transmission pathways between grazing livestock and wildlife. Our results indicated that ARMs against medically important antibiotics prevailed at the wildlife-livestock interfaces, regardless of antibiotic use, and cohabitation enhanced transmission of microorganisms between animals. Gut microbiota of cattle were more similar ($P < 0.05$) to that of feral swine caught within the cattle grazing area (FWCGA) than feral swine caught outside the cattle grazing area (FOCGA). The animal home range of cattle were completely overlapped with FWCGA, but not FOCGA, measured by using global positioning system data. FWCGA had a greater number of phylum Firmicutes ($\geq 80\%$) overlapping with cattle than FOCGA. Notably, FOCGA showed a higher prevalence of cefotaxime resistant bacteria and antibiotic resistant genes than FWCGA ($P < 0.05$). This study highlights that even when antibiotics have not been administered to livestock, cattle might acquire ARMs from wildlife. Therefore, control at the interface of livestock and wildlife is necessary to prevent introduction of ARMs to livestock populations even in areas where antibiotics are not used.

Influenza D Virus Transmission in Feral Swine
(No video presentation)
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Influenza D virus (IDV) has been identified in domestic cattle, swine, camelid, and small ruminant populations across many nations. Nineteen percent of 256 feral swine samples collected 2012-2013 were seropositive for IDV. Of 96 archived influenza A positive samples collected 2010-2013, 42.7% were also seropositive for IDV. To test the transmissibility of IDV in feral swine, we randomly separated 26 captive feral swine into 3 groups: inoculated (IDV, n = 12), contact (n = 8), and control (saline, n = 6). Pens contained 1 or 2 inoculated animals and 1 contact animal. Control feral swine were housed separately and remained negative for IDV. At 2 days post inoculation (dpi), a contact animal was introduced into pens with inoculated feral swine. We collected nasal washes and blood on days 0, 3, 5, 7, 9, 11and 21 dpi. Pigs were euthanized and necropsied 3, 5, 7, 9, 11 and 21 dpi to collect tissue

samples from the respiratory tract. Viral titration of nasal washes showed that, at 3 dpi, 7 of 12 (58.3%) D/46N-inoculated swine shed virus. At 5 dpi, 6 of the 8 (75%) remaining virus-inoculated swine shed virus. The remaining 5 virus-inoculated swine did not shed virus by 7 dpi. Hemagglutination inhibition assay results indicated that 7 of 11 (63.6%) of the inoculated animals seroconverted at 5 dpi, and the remaining virus-inoculated animals seroconverted at 7 dpi. Titrations in tissues indicated virus in the nasal turbinate, soft palate, trachea and lung. The transmissibility of IDV through direct contact is similar to that in domestic swine; but less efficient than that in cattle. Given the limited transmissibility of IDV in feral swine, we speculate that feral swine could have additional opportunities for exposure to IDV from other species such as cattle.

Effects of Social Structure and Management on Risk of Disease Establishment in Wild Pigs

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Wild pigs (*Sus scrofa*) are globally distributed across their native range in Eurasia and northern Africa as well as the introduced ranges in the Americas, Australia, sub-Saharan Africa, and many islands. In North America, wild pigs are an invasive, socially-structured species that are a serious health concern for domestic swine given their ability to transmit numerous devasting diseases such as African swine fever (ASF). Contact heterogeneity among hosts can significantly affect the invasion and spread of infectious disease, but little is known about the factors shaping contact networks in wild pigs. Thus, characterizing the structure of wild pig contact networks is essential for effective disease control strategies. Using proximity loggers and GPS data from 49 wild pigs in Florida and South Carolina, USA, we employed a probabilistic framework to estimate weighted contact networks. We determined the effects of demography and spatial distributions on contact structure. We then estimated the impacts of management-induced perturbations on contact structure and predicted their effects on the establishment of ASF. We found group membership was the primary factor structuring contacts. Between-group contacts depended primarily on spatial distributions, with fewer contacts among groups separated by >2 km and no contacts among groups >4 km apart. Modeling ASF dynamics on the contact network demonstrated that indirect contacts resulting from baiting (a typical method of attracting wild pigs or other wildlife to a site to enhance recreational hunting) increased the risk of ASF establishment by ~47%. Low-intensity population reduction (<10% of the population) had no detectable impact on contact structure but significantly reduced the predicted ASF establishment risk relative to before population reduction. Given the increasing global concern regarding ASF invasion, our findings highlight the importance of understanding contact structure for assessing disease establishment risk, thus providing insight for preventing and responding to disease transmission in wild pigs.

Biology and Ecology

Introduction to Genome-Wide Association Studies: Disease in Feral Swine
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Invasive feral swine (*Sus scrofa*) are known to carry zoonotic pathogens of concern to humans and domestic animals including Suid herpesvirus 1 (SuHV-1) - the causative agent of Aujeszky's disease (pseudorabies virus [PRV]) – a disease that disrupts the central nervous system, causes respiratory illness, and results in reproductive losses in domestic swine. Contact with infected feral swine poses a spillover risks to wildlife, companion animals, domestic livestock and humans. Genetic mechanisms underlying host susceptibility/resistance to pseudorabies virus are relatively unknown. We sought to identify quantitative trait loci associated with PRV infection among naturally infected feral swine using a case/control genome-wide association study design. Serology and genotype data (68,516 bi-allelic single nucleotide polymorphisms) were collected for 5,826 feral swine distributed across the invaded range within the United States, of which 1,024 were PRV positive (cases) and 4,802 were negative (controls). Bayesian multiple-SNP regression was conducted for PRV status using GenSel, employing Markov chain Monte Carlo (MCMC) sampling and BayesB methodology (π=0.995). Genetic variance explained by consecutive, non-overlapping 1 MB genomic windows was estimated and those explaining >1% of the genetic variance were considered significant. Genomic windows associated with PRV were identified on chromosome 8, 10, and 13, accounting for 1.46%, 1.86%, and 1.03% of the genetic variance, respectively. Subsequent bioinformatic analyses revealed two putative candidate genes on chromosome 13 that have been previously associated with immunosuppression. Further, our results align with previous work that identified candidate genes associated with clinical disease following experimental challenge with PRV in domestic pigs. Using genetic tools to quantify variation in disease susceptibility among feral swine populations enables improved identification of drivers of disease and the concomitant spillover risk to domestic herds.

Effects of Landscape on Wild Pig Behavior
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Understanding how animals move throughout the landscape and interact with resources in various habitat types is an important tool for management. The observed landscape patterns that comprise an animal's home range are determined by single movement steps, which provide information on the interactions between the individual's external environment and their behavioral state. Therefore, when looking at these individual movement steps collectively, assuming they are not random, they can be interpreted as an animal's behavioral response to the environment. Invasive wild pigs (*Sus scrofa*) are behavioral generalists that have the potential to alter ecosystems across broad spatial scales. Thus, elucidating the correlation between wild pig behavior and landscape attributes can reveal how unexpected populations emerge in new places and aid in the advancement of management strategies for

controlling populations. Using GPS data from collared wild pigs in the southeastern U.S., our goal is to use movement characteristics of wild pigs to distinguish and define behavioral states and explore the connection between these states and resource selection. We analyzed data with 30-minute resolution using hidden markov models to infer different behavioral states and estimate their relationship to landscape characteristics and associated habitat quality. We used turn angles and step length to differentiate between behaviors and determine habitats associated with these behaviors. We then ran a resource selection function on each behavioral state to determine selection of certain habitat types and/or environmental conditions when exhibiting these movement characteristics and associated behavioral states. The purpose of this research is to increase our understanding of the influence of landscape attributes on wild pig resource selection and how movements of wild pigs vary with landscape characteristics. Such information will aid wildlife managers in their ability to control wild pig populations more effectively and efficiently, ultimately reducing the negative environmental and economic impacts of this invasive species.

Parental Investment Strategies in a Highly Polytocous Species: Maternal Attributes and Resource Availability Modulate Litter Size and Sex Ratio

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Female condition significantly influences timing of reproduction, age at first breeding and offspring survival, and is proposed as a driver of offspring sex ratio. The Triver's-Willard hypothesis (TWH) predicts high-quality mothers should invest more into sons because males have higher variance in individual fitness for species in which reproductive success is more variable in one sex. Thus, females should adjust offspring sex ratio in response to factors that could modify both their own lifetime reproductive success and that of their progeny. Though well studied in vertebrates, it is poorly understood if or how the TWH applies to polytocous species, those that produce several offspring per litter, because the trade-offs between size and number of offspring must also be taken into consideration. Williams' hypothesis (WH) accounts for these possible trade-offs on sex ratio variation. The extrinsic modification hypothesis (EMH) predicts modulation of offspring sex ratio in response to environmental conditions. Using wild pigs as a model, we tested whether (1) maternal attributes (age, mass) modulated litter sex ratio (TWH), (2) maternal mass influenced production cost, based on litter size and sex-ratio (WM), and (3) environmental conditions influenced litter size (EMH), in a polytocous species. Older females, generally larger and with more parental experience, had male-biased litters, providing support for the TWH, however maternal mass does not influence sex ratio. Increased maternal size and condition (an index of resources) both positively influenced litter production cost, supporting the WH and EMH. Increased maternal size and condition also positively influenced litter size but not sex ratio. Our results suggest that for species with large litters, the benefits from adjusting litter size outweigh those from modulating offspring sex ratio.

What is a Sounder: Genomic Relatedness of Wild Pig Social Groups

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Wild pigs display complex social structures with three main social units: sounders (multigenerational groups of presumably closely related, breeding-aged females with offspring), groups of dispersing breeding-aged males, and solitary breeding-aged males. However, recent studies have described varying group sizes and familial associations within social units. To elucidate the genetic composition of wild pig social units, we genotyped 778 wild pigs at 62,331 loci, sampled from 133 trap groups (124 sounders, 9 male social units) collected from 2014 to 2019 on the Savannah River Site, South Carolina, USA (SRS) and in Oklahoma, USA (OK). We estimated pairwise relatedness (R) and familial relationships for (1) all individuals within social units (sounders and male groups) and (2) just breeding-aged individuals, to remove bias associated with the presence or absence of dependent offspring within sounders. We then calculated mean R for social units and the local population within each study site. We found social unit size varied between SRS (range: 2-14 pigs; $\overline{x}$ = 4 pigs) and OK (2-44 pigs; $\overline{x}$ = 11 pigs), as well as the number of breeding-aged individuals within social units (SRS: 1-4 pigs, $\overline{x}$ = 2 pigs; OK: 1-19 pigs, $\overline{x}$ = 3 pigs). Most of the social units were composed exclusively of close relatives (1st- and 2nd-degree), and sounders were predominately composed of 1st-degree (parent/offspring, full sibling) females. However, approximately one-third of the sounders included a distantly related or unrelated female. Almost all male social units were composed only of close relatives. Our results provide the most comprehensive analysis to date on the genetic composition of wild pig sounders and male social units in North America. Although social units were largely composed of closely related individuals, sounders routinely contained unrelated females, suggesting there may be additional factors influencing sounder composition beyond traditional familial relationships.

Wild Boar and the Rewilding of Fukushima's Human Evacuation Zone

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There is substantial interest in understanding the ecological impacts of the nuclear accidents at the Chernobyl and Fukushima Daiichi nuclear power plants. However, population-level data for large mammals have been limited, and there remains much speculation regarding the status of wildlife species in these areas. Using a network of remote cameras placed along a gradient of radiological contamination and human presence, we collected data on the population-level (i.e. abundance and occupancy patterns) impacts of the 2011 Fukushima Daiichi nuclear accident on wildlife. Despite the presence of radiological contamination, we found no evidence of population-level impacts in mid- to large-sized mammals or gallinaceous birds, and show several species were most abundant in human-evacuated areas, despite the presence of radiological contamination. In particular, wild boar, which often are in conflict with humans in agricultural landscapes, were nearly four times more abundant in the evacuated zone compared to populated areas, suggesting wild boar have responded favorably to the absence of humans, despite extensive control programs that have been implemented in evacuated areas to reduce damages caused by the growing boar population. Further, our data provide evidence wild boar have modulated their behavior within evacuated areas, increasing their diurnal activity in the absence of human habitation. These data provide unique evidence of the natural rewilding of the Fukushima

landscape following human abandonment, and suggest that if any effects of radiological exposure in wild boar or other mid- to large-sized mammals in the Fukushima Exclusion Zone exist, they occur at individual or molecular scales, and do not appear to manifest in population-level responses.

Florida's Spectacular Steepheads, Feral Pig Chronic Damage

(No video presentation)

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Since the mid-1960s, we have been monitoring the salamander fauna of special Florida ravines termed steepheads. Steepheads occur in deep deposits of sand in which deep creek valleys are formed by the sapping of groundwater from surficial aquifers. Water gushing from the toe of the steep headwater slopes carries the sand away, undercutting the slope which slumps down, is carried away again, and continues the process. The steephead of the first-order valley thus migrates headward from bottom up, as opposed to the classic gully-eroded landscapes that are sculpted from top-down rainwater erosion. Steephead ravine valleys are unique to north Florida and provide thermally buffered, high quality seepage habitats for plants and animals, including several threatened and endangered species, and isolated populations of Pleistocene and even Tertiary relicts. We report our extensive observations over three periods (1968-1974, 1998-1999, 2017-2020) of severe feral pig damage that has been increasing in steepheads in the past half century. We adduce ecological evidence that feral pig rooting is responsible for the complete disappearance of the Southern Dusky Salamander (*Desmognathus auriculatus*) from Eglin Air Force Base steepheads, and the severe decline in three other species as well.

Mixed Ancestry from Wild and Domestic Lineages Contributes to the Rapid Expansion of Invasive Feral Swine

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Invasive alien species are a significant threat to both economic and ecological systems. Identifying processes that give rise to invasive populations is essential for implementing effective control strategies. We conducted an ancestry analysis of invasive feral swine (*Sus scrofa*, Linnaeus, 1758), a highly destructive ungulate that is widely distributed throughout the contiguous United States, to describe introduction pathways, sources of newly-emergent populations, and processes contributing to an ongoing invasion. Comparisons of high-density single nucleotide polymorphism genotypes for 6,566 invasive feral swine to a comprehensive reference set of *S. scrofa* revealed that the vast majority of feral swine were of mixed ancestry, with dominant genetic associations to Western heritage breeds of domestic pig and European populations of wild boar. Further, the rapid expansion of invasive feral swine over the past 30 years was attributable to secondary introductions from established populations of admixed ancestry as opposed to direct introductions of domestic breeds or wild boar. Spatially-widespread genetic associations of invasive feral swine to European wild boar deviated strongly from historical *S. scrofa* introduction pressure, which was largely restricted to domestic pigs with infrequent, localized wild boar releases. The deviation between historical introduction pressure and contemporary genetic ancestry suggests wild boar-hybridization may contribute to differential fitness in the

environment and heightened invasive potential for individuals of admixed domestic pig-wild boar ancestry.

Human Dimensions

Community Engagement Strategies for Improving Feral Pig Management: Integrating Biophysical and Human Dimensions Research

(No video presentation)

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Significant advances have been made using the biophysical sciences to improve our knowledge of feral pig (*Sus scrofa*) ecology in Australia. Similarly, new management tools, such as HOGGONE®, are being developed to help manage feral pig populations and their damaging impacts. Despite these developments, landscape-scale management of feral pigs and their impacts is hampered by limited participation by land managers and others in applying coordinated control strategies. In partnership with land managers from four communities, as well as organisational stakeholders such as Northern Tablelands and North West Local Land Services, NSW National Parks and Wildlife, Arrow Energy, Santos GLNG and Southern Queensland Landscapes, this study integrates feral pig ecological research with human dimensions research applied in an experimental framework. We are testing whether a 'thick' engagement strategy, grounded in community-based research, will improve collective action and motivate communities to address the feral pig problem. This study is being conducted at six sites in eastern Australia. Across four of these sites we have fitted 97 feral pigs with iridium-enabled telemetry collars to collect movement and spatial ecology. Simultaneously, the human communities associated with each site were assigned a unique community engagement treatment. The relative benefits of these treatments for catalysing relationships and strengthening feral pig management have been assessed using a most significant change evaluation strategy. Here we present our human dimension findings from this innovative study and highlight key lessons regarding community engagement for feral pig management purposes.

Partners Against Invasive Species: Raising Awareness and Assisting Landowners in West Alabama

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Project PAIS, Partners Against Invasive Species, is a collaborative effort between The University of West Alabama (UWA), a regional Non-Land Grant College of Agriculture (NLGCA), and the Sumter County Soil and Water Conservation District (SCSWCD), a unit of the Alabama Soil and Water Conservation Committee. PAIS is targeted at providing education on invasive species and outreach activities to farmers, ranchers, and foresters in the west Alabama region. Project PAIS also has the additional benefit of growing the student enrollment in agricultural sciences at UWA. A primary function of PAIS is education and control efforts related to feral swine in the West Alabama Black Belt region. For feral swine management, PAIS monitors game cameras on baited sites where stakeholders

have reported feral swine activity. When significant activity is verified, the PAIS team deploys one of a variety of remotely operated traps. The traps are operated by stakeholders, who are responsible for the removal of captured feral swine. Since beginning operations in spring of 2018, Project PAIS has assisted almost fifty landowners and removed over 700 feral swine.

Educating the Public About Managing Wild Pigs: The Texas Experience, 30 Years Later
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In 1990, Texas A&M AgriLife Extension began dedicated educational activities on managing wild pigs in Texas. 30 years later, we teach many of the same approaches and techniques of management as in 1990. We conducted a large-scale, web-based survey to assess the Human Dimensions of Wild Pigs in Texas. Within this, we asked a variety of questions regarding positive and negative interactions with wild pigs, knowledge about wild pigs, and specifically, we asked about experience with educational events and management activities therein. We consider the effects of demographics, geography, landowner status, and participation in various agricultural producer or wildlife enthusiast groups. Our findings suggest that knowledge about wild pigs is still severely limited across the public. Nevertheless, respondents did not identify lack of knowledge as a barrier to use of management methods. Education may have not succeeded in reaching its goal, but the causal factors require more inquiry. We investigated the relationship between educational experience, knowledge, and persistence of management efforts. Although lack of knowledge or education is often cited as a key barrier to management practice adoption among Extension professionals, those seeking to engender better wild pig management ethics may need to consider other social factors that limit success. We consider whether or not education can alter these factors, and how managers should approach such problems. We end with suggestions on ways to adapt educational efforts to improve wild pig management in the future.

The Human Dimensions of Wild Pig Management: A Typology of Wild Pig Hunters in Texas
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Exotic, invasive wild pigs (*Sus scrofa*) affect the natural environment in many ways, including degrading water quality, damaging forested and grassland areas, and predating upon native wildlife. Invasive wild pigs pose threats to livestock and human health by harboring and transmitting disease and parasites, and to crop production and storage through foraging and consumption. However, wild pigs impact many different stakeholder groups both positively and negatively. Stakeholders may identify benefits associated with wild pigs such as increased game availability and market sale or lease hunting income. The duality of the issue necessitates a deep understanding of varying stakeholder drivers towards wild pig use and management. Stakeholder diversity and state-wide wild pig presence in Texas provides an ideal opportunity to investigate the complexity of the issue of wild pig management. Although a critical need for effective management, existing research on wild pig management in Texas does not include comprehensive knowledge of wild pig hunter attitudes and motivations. In this study, we identify factors associated with wild pig hunters to generate a greater understanding of the human

dimensions of wild pig management in Texas. We collect responses to a mixed-mode survey concerning knowledge, attitudes, demographics, and habit-based factors associated with wild pigs from licensed Texas hunters. We then create a model for participation in wild pig hunting which increases our understanding of this important stakeholder group. We end with implications for those seeking to manage wild pig abundance in the context of recreational harvest.

SFWMD Feral Hog Removal Program – Policy, Procedures, and Techniques
(No video presentation)
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The SFWMD (District) Hog Removal Program was expanded and fully adopted beginning in 2008 to address impacts feral hogs were having on lands being managed for conservation purposes. The District coordinates with the Florida Fish and Wildlife Conservation Commission (FWC) on District properties established as Wildlife Management, Wildlife and Environmental and Public Use Areas, and is issued a hog control and gun and light permit for wildlife management area cooperating landowner. The rooting behavior of feral hogs has the capability to impact the health and diversity of native plant communities, promote the establishment and expansion of exotic vegetation, degrade hiking and equestrian trails, impede the spread of fire during prescribed burns, and cause erosion on levees and canal banks. The omnivorous diet of feral hogs is detrimental to native flora and fauna and at elevated densities can compete with native wildlife for resources. The District uses a multi-faceted approach to control hog populations through public hunting programs administered by the FWC when possible and liberalized hunting rules on District lands. Some properties, however, are not suited for public hunting due to ongoing construction activities, proximity to urban areas, potential conflicts with project purposes, or other land resource reasons. Also, on some District properties that support high density hog populations, hunting by itself may not be an effective means to adequately control hog numbers. Therefore, a hog removal agent may be used to control hog populations on both hunted and non-hunted properties if deemed necessary for resource protection purposes or to control rooting damage and erosion on levees and canal banks maintained by the District. Hog removal agents are only used when public hunting programs cannot successfully control hog populations or on areas that are not capable of supporting public hunting. Potential methods and techniques of take include trapping, the use of dogs, and shooting. Hog removal agents provide these services at no-cost to the District beyond program management and procurement labor costs. This presentation will provide informational data describing the reduction in hog removal numbers that have been recorded over the years. The reduction in removal numbers and observational data from land managers on the extent of environmental impacts on conservation and project lands suggests the positive impacts of this program.

Summarizing Florida's Feral Hog Regulations: An Inter-Agency Exercise

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Before affecting feral hog (*Sus scrofa*) management or beginning related projects, policy makers, managers and researchers need clarity on the lawful boundaries that apply in their state. Specifically, they require information on general regulatory status of the feral hog and related topics such as feral hog take (i.e., trapping, hunting, shooting), holding, transporting and sale. To our knowledge, no such summary has been compiled in Florida – until now. The Florida Feral Hog Working Group (FHWG) – an inter-agency group of professionals serving wild hog issues – was established in 2018 following growing interest to better coordinate wild hog policy, research, outreach, control, hunting, and other stakeholder services between agency and non-government organization (NGOs) partners to best serve Florida stakeholders and natural resource management. With this goal in mind, the FHWG's first objective was to draft a document entitled "Feral Hog Regulations in Florida" that contains feral hog-related rules, regulations and policy promulgated by the Florida Legislature, the Florida Department of Agriculture and Consumer Services (FDACS) and the Florida Fish and Wildlife Conservation Commission (FWC). The Florida Legislature promulgates Florida Statutes (F.S.). The FWC has constitutional authority to promulgate rules that regulate wildlife – including wild hogs – in Florida Administrative Code (F.A.C.). The FDACS regulates the holding, transport and sale of feral swine and provides related permits to customers. Law enforcement personnel from both the FDACS and FWC enforce regulations described in F.A.C. and F.S. This document has clarified the boundaries of policy and management, has helped to identify research needs, and enabled accurate outreach to stakeholders affected by wild hog issues. The effort to produce this document was substantial, but we believe well-worth the informational foundation it provides.

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