THE WILDLIFE SOCIETY VIRTUAL CONFERENCE

DRONE SYMPOSIUM (OCTOBER 1, 2020)

DRONES AND WILDLIFE MANAGEMENT: ARE WE TAPPING INTO THEIR FULL POTENTIAL IN AN ETHICAL WAY?

Sponsored by:
TWS Drone Working Group and TWS Military Lands Working Group

Organizers: Dr. Morgan B. Pfeiffer, Research Biologist USDA APHIS Wildlife Services, National Wildlife Research Center, Sandusky, OH; morgan.b.pfeiffer@usda.gov.

Rick Spaulding, ManTech International Corp., Sr. Biologist/Project Manager; Chair, TWS Drone Working Group, Bainbridge Island, WA; rick.spaulding@ManTech.com.

Abstract: Small unmanned aerial systems (sUAS) or unmanned aerial vehicles (UAVs), hereafter referred to as 'drones', are increasingly being tested and used in wildlife management. Applications include incidental monitoring, systematic surveys, wildlife health assessments, habitat and landscape mapping, tool/bait delivery, and dispersal of wildlife. Although many of the current uses are preliminary or "proof-of-concept", drone technology has the ability to significantly reduce sampling and management costs/efforts, produce high quality data, and provide a unique vantage point to study complex systems. However, uncertainly over drone regulations, platform use restrictions/purchases, and nascent of post-processing data techniques present challenges to their wide-spread use and integration into wildlife management programs. Furthermore, a growing number of studies indicate potential ethical concerns over the exposure of wildlife to drones, yet few studies or management programs explicitly address this issue. To that end, we organized this symposium as a gathering of stakeholders to discuss potential ethical and logistic barriers to drone use in wildlife management. The symposium is broken up into six sections:

1) Federal Aviation Administration (FAA) and U.S. Fish and Wildlife Service (USFWS) current regulations on drone operation.
2) Potential impacts of drone operations on wildlife.
3) Unique applications.
4) Standardization for systematic drone surveys and reporting of drone operations.
5) Considerations and techniques for data post-processing.
6) Future directions.

List of Presentations

PART 1

Regulations and Permits for Drone Use in Wildlife Management and Research – S. Earsom

The FAA Drone Integration Pilot Program (IPP): Implications for Wildlife Management and Research – J. Grimsley, S. Webb, M. Proctor, and D. Payne

An Overview of the Use of Drone Technology for the Study and Management of Birds – D. Chabot and D. Bird

Animal Responses to Vehicle Approach: Applications to Use of sUAS in Wildlife Research – B. Blackwell

How Do Birds Perceive Drones? Implications for Using sUAS for Wildlife Surveillance Systems or Wildlife Deterrents – E. Fernandez-Juricic

Response of Turkey Vultures in a Landfill Context to Approach by Drones – M. Pfeiffer, B. Blackwell, T. Seamans, B. Buckingham, J. Hoblet. E. Fernández-Juricic, S. Lima, and T. DeVault

Bison and Wild Horses: Large Mammal Responses to Drones – C. Felege, R. Newman, B. McCann, and S. Ellis-Felege

PART 2

USDA Wildlife Services' Integration of UAVs for Wildlife Damage Management – S. Smith

Using Drones in the Management of Agriculture-Wildlife Conflict: Can Large Blackbird Flocks be Deterred from Commercial Sunflower fields? – P. Klug

Drones Extend the Reach of Wildlife Damage Management Tools – T. Shields

Overview of sUAS Imagery for Wildlife Monitoring – C. McCraine

Identifying Wildlife from Aerial Imagery Using CNNs – S. Samiappan and M. Zhou

Standardized Protocol for Reporting Methods when Using Drones for Wildlife Research – S. Ellis-Felege, A. Barnas, D. Chabot, A. Hodgson, D. Johnston, and D. Bird

The Data Deluge: Integrating AI to Streamline Image Analysis for Wildlife Surveys – S. Yannuzzi, T. Desell, A. ElSaid, J. Riedy, B. Sather, J. Westrem; and S. Ellis-Felege

USDA Wildlife Services' Integration of UAVs for Wildlife Damage Management

Steven Smith (steven.h.smith@usda.gov)

Wildlife Services (WS) first applied unmanned aerial vehicles (UAVs) outside of research in 2015 when the first two Certificate of Authorizations (COAs) were granted by the Federal Aviation Administration (FAA) to personnel in Georgia and Idaho. In the 5 years since, WS' use of UAVs has expanded to include nearly 100 certified pilots and an internal Working Group for providing oversight, training, and support. WS pilots have logged over 500 hours of flight time on multiple platforms for applications including damage assessment and surveys, location scouting, remote trap checks, harassment of injurious species, and locating target animals. In 2019 WS was issued an agency Certificate of Waiver (COW) to conduct night operations. As of May 2020, 10 WS pilots have been trained and certified to carry out night operations under this COW for locating and surveying white-tailed deer, feral swine, and other nocturnal species.


USDA
United States Department of Agriculture
N451LM
Roland
Steve Smith, State Director, North Carolina
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[redacted]

FAA FORM 7711-1 UAS COA Attachment
Blanket Area Public Agency COA
2015-ESA-146-COA

Page 1 of 14

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

CERTIFICATE OF WAIVER OR AUTHORIZATION

ISSUED TO

US Dept. of Agriculture, Wildlife Services

This certificate is issued for the operations specifically described hereinafter. No person shall conduct any operation pursuant to the authority of this certificate except in accordance with the standard and special provisions contained in this certificate, and such other requirements of the Federal Aviation Regulations not specifically waived by this certificate.

OPERATIONS AUTHORIZED

Operation of small Unmanned Aircraft System(s) weighting less than 55 lbs., in Class G airspace at or below 400 feet Above Ground Level (AGL) under the provisions of this authorization. See Special Provisions.

LIST OF WAIVED REGULATIONS BY SECTION AND TITLE

N/A

STANDARD PROVISIONS

1. A copy of the application made for this certificate shall be attached and become a part hereof.
2. This certificate shall be presented for inspection upon the request of any authorized representative of the Federal Aviation Administration, or of any State or municipal official charged with the duty of enforcing local laws or regulations.
3. The holder of this certificate shall be responsible for the strict observance of the terms and provisions contained herein.

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April 2016 – First COAs issued to two WS UAS pilots
August 2016 – WS UAS Sub-Committee meets for the first time (Part 107 takes effect)
June 2017 – Sub-Committee decides to move away from Public Agency COA and operate under Part 107
March 2018 – First WS basic UAS training held in Ft. Collins, CO
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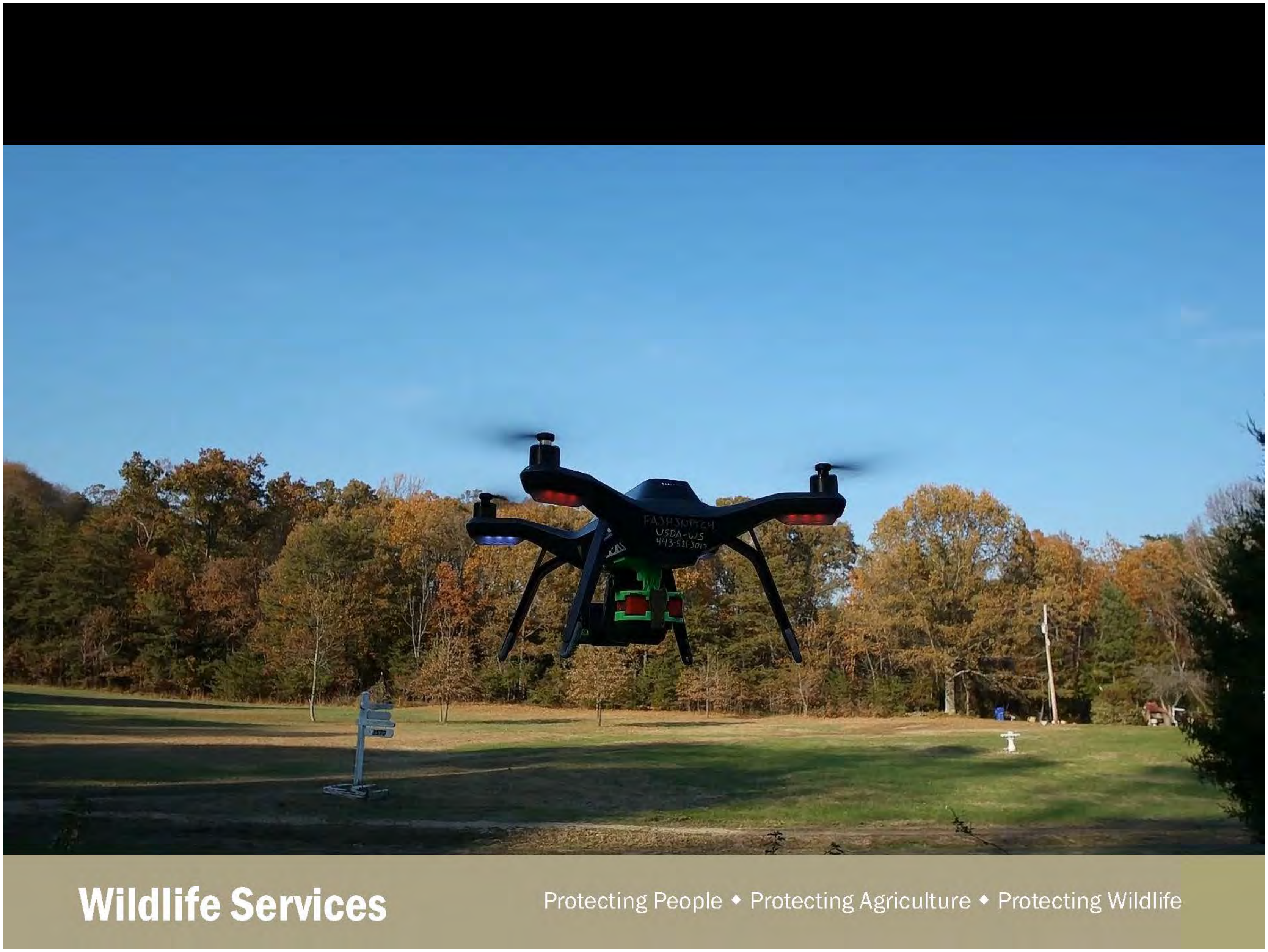
USDA-WS
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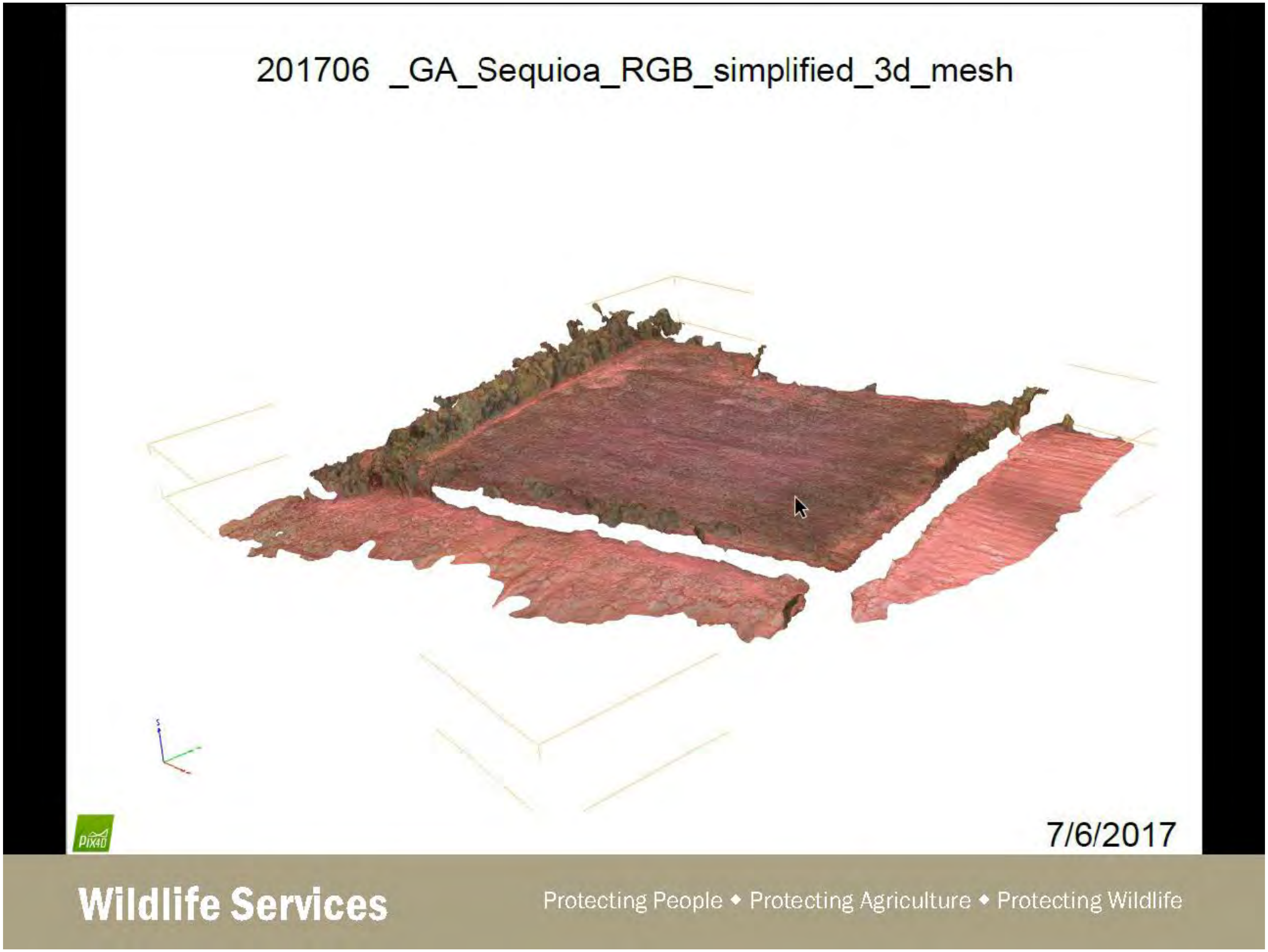
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7/6/2017
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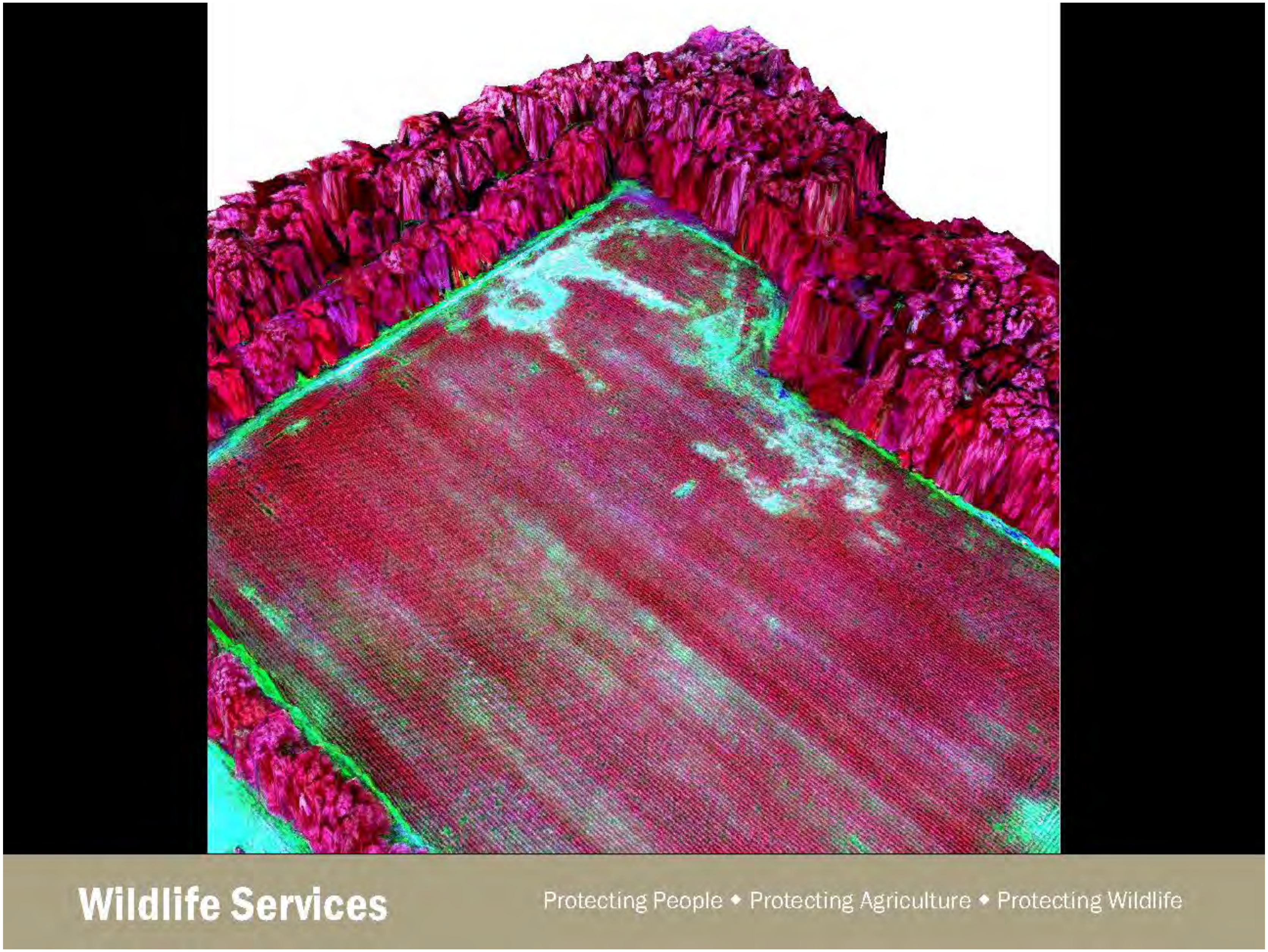
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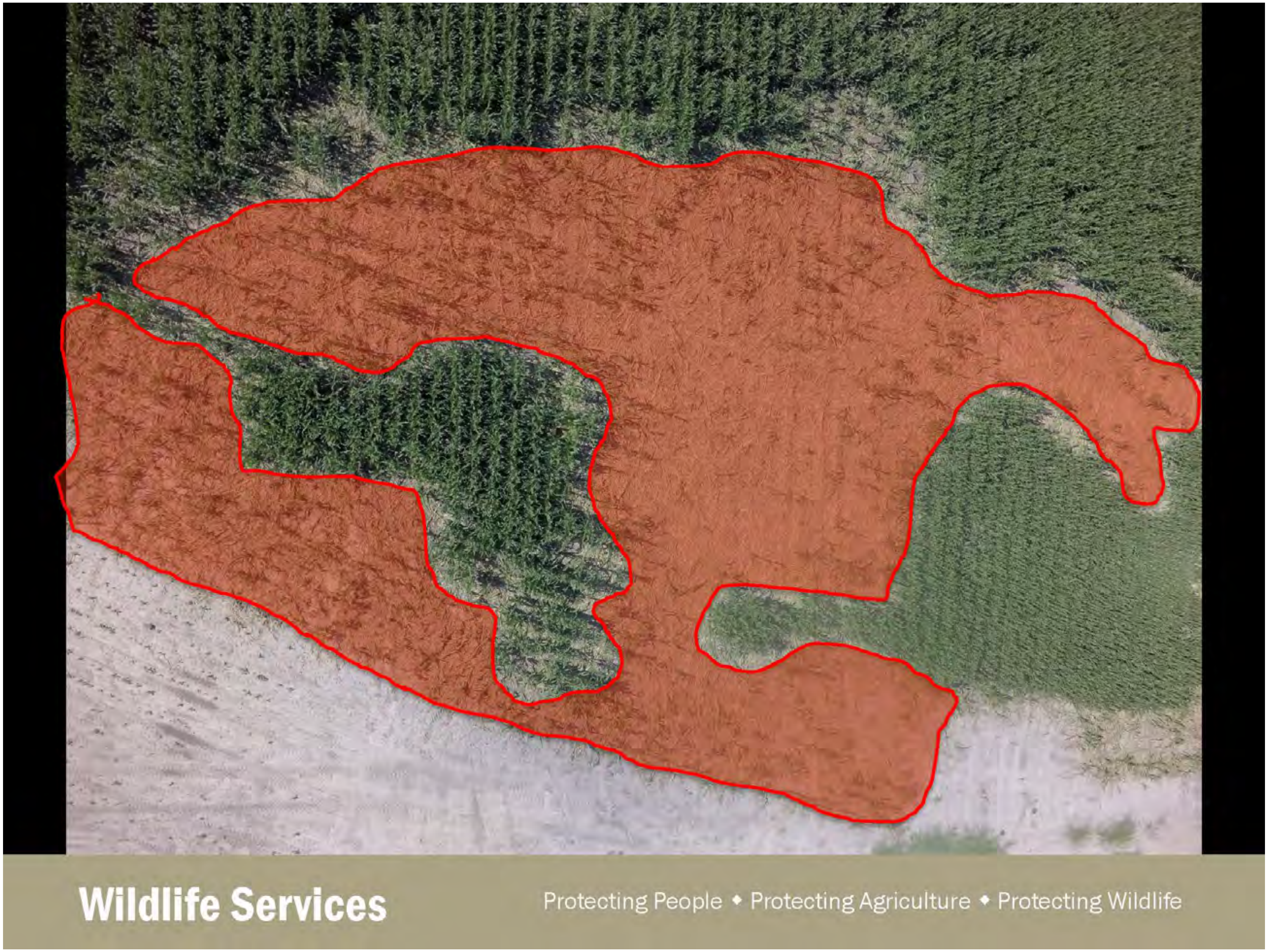
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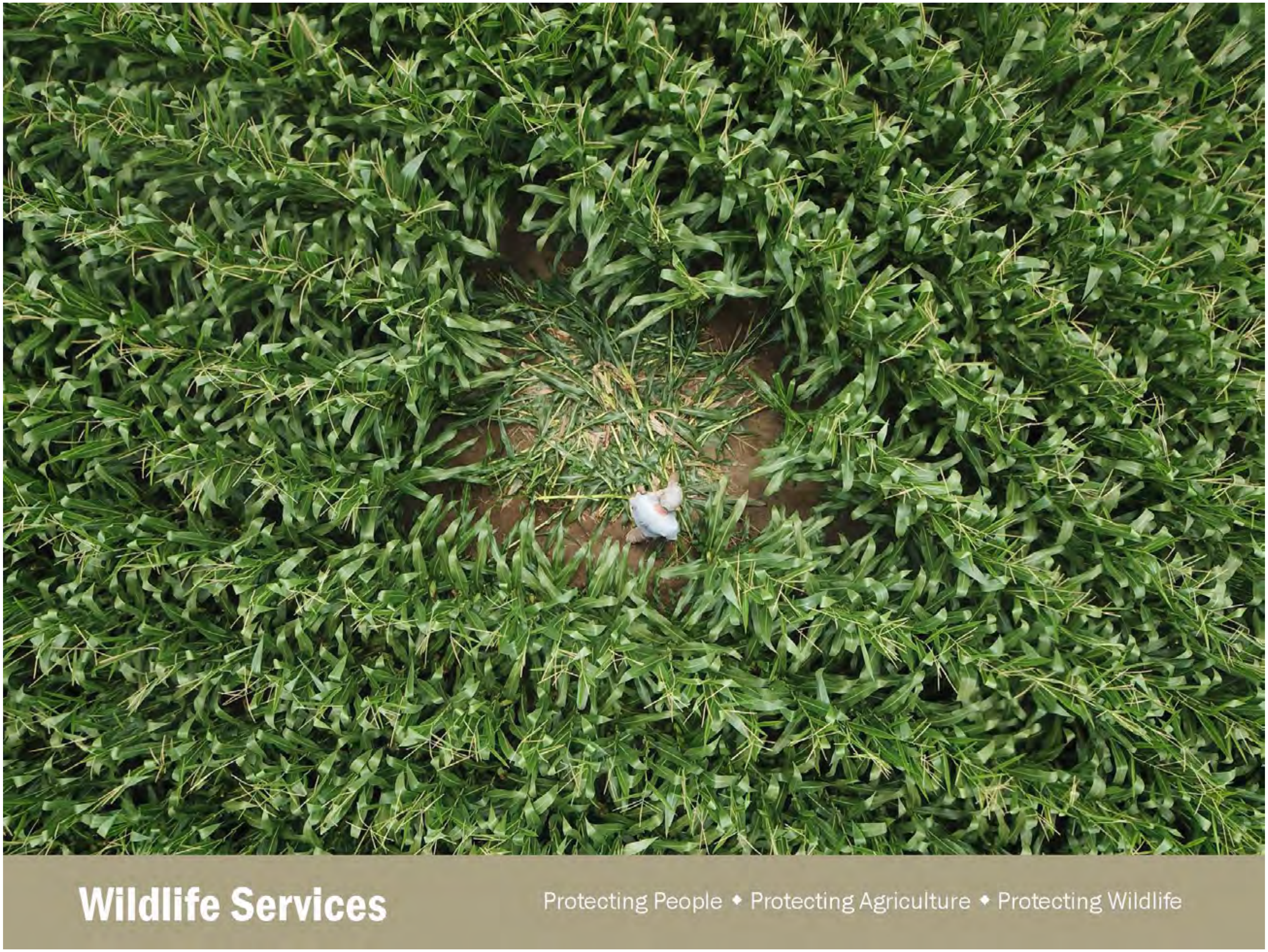
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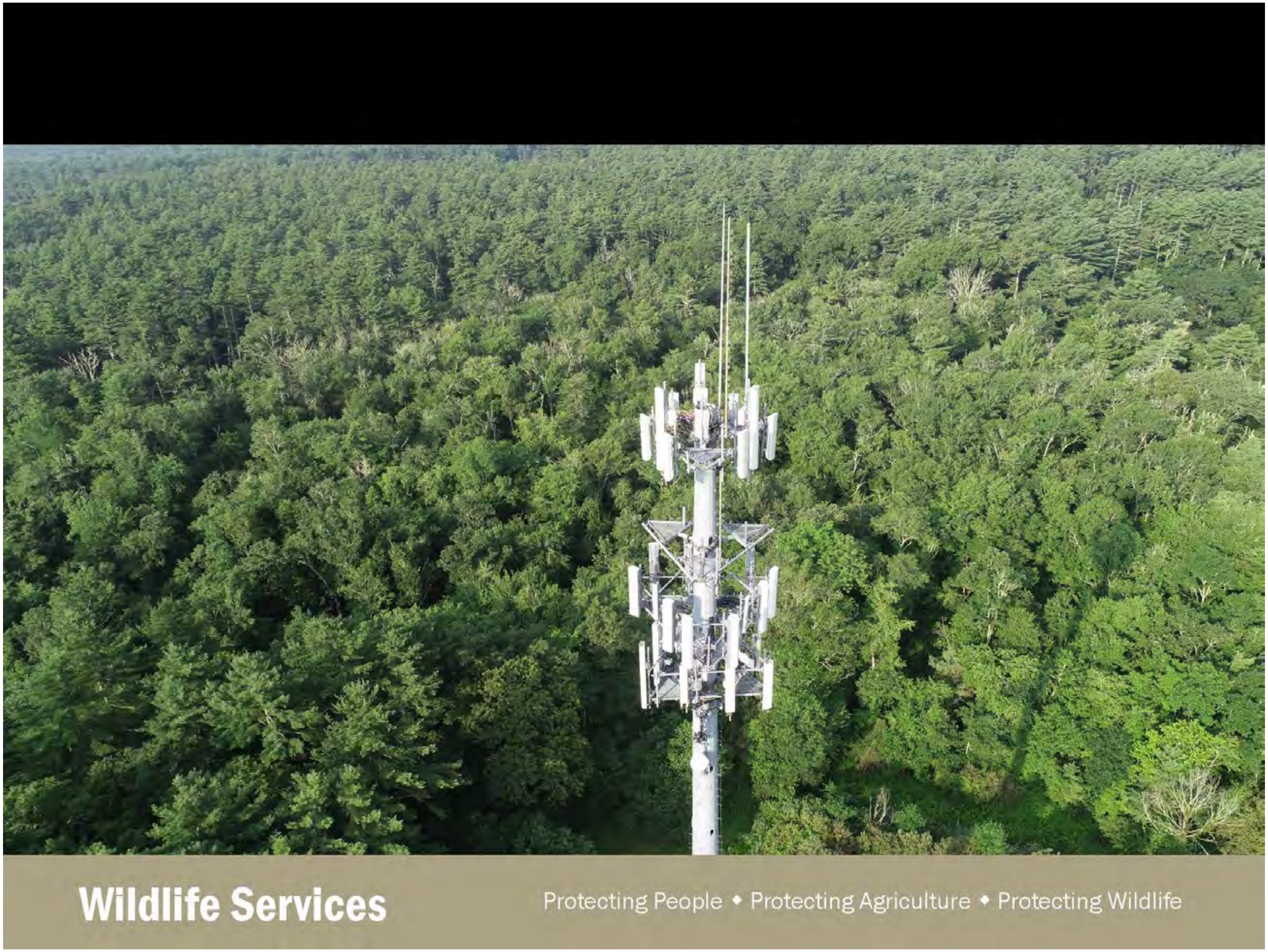
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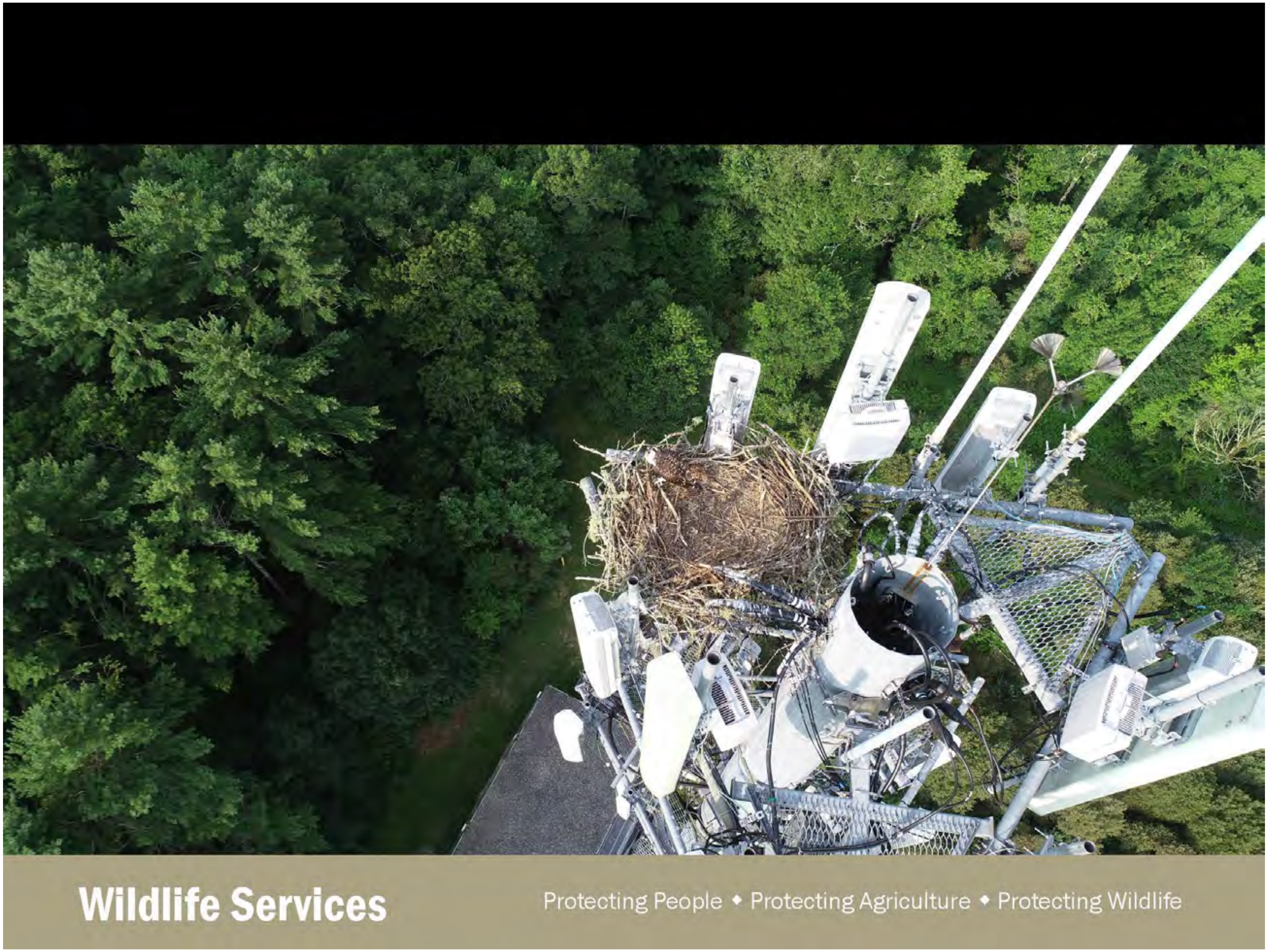
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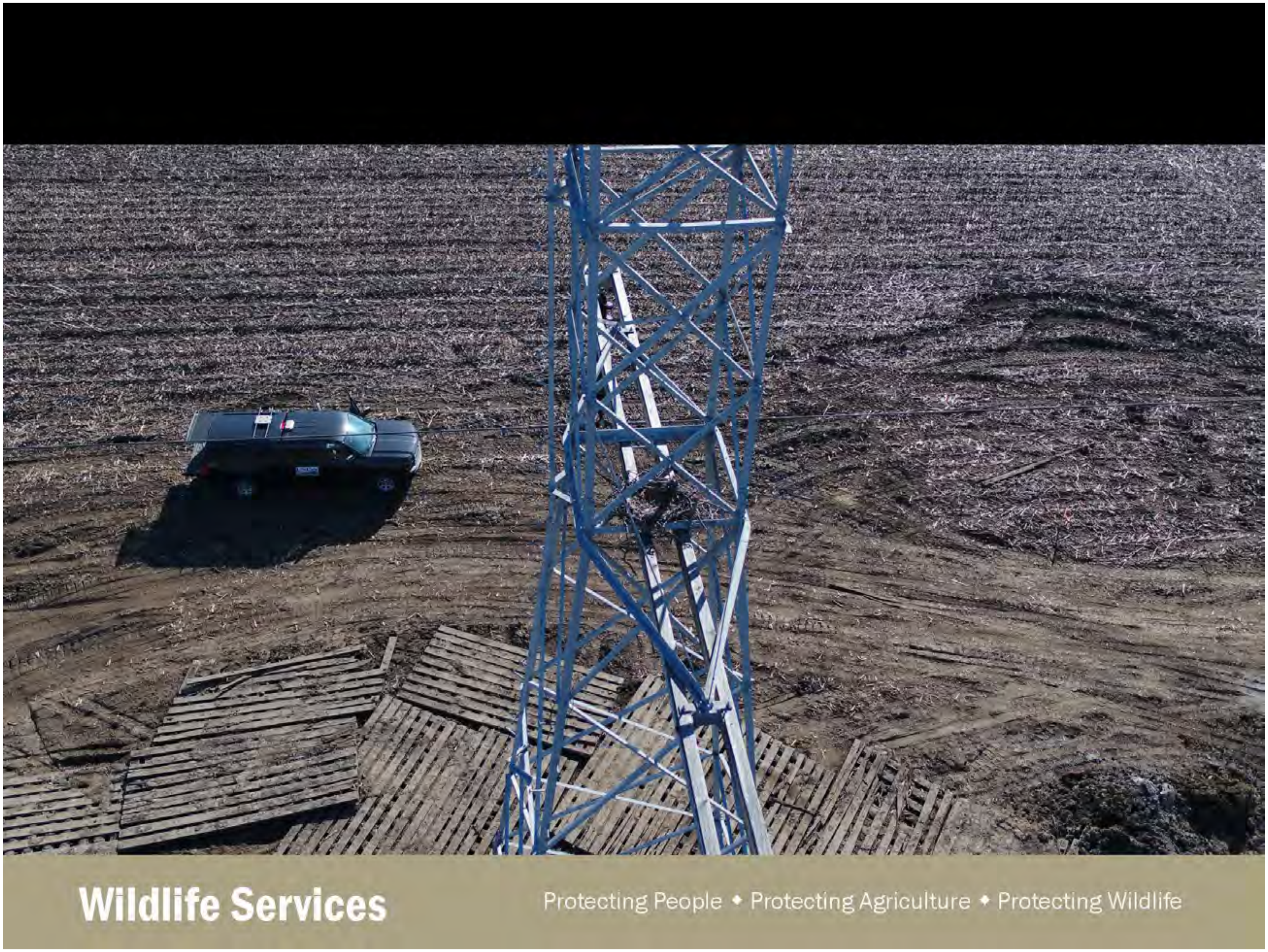
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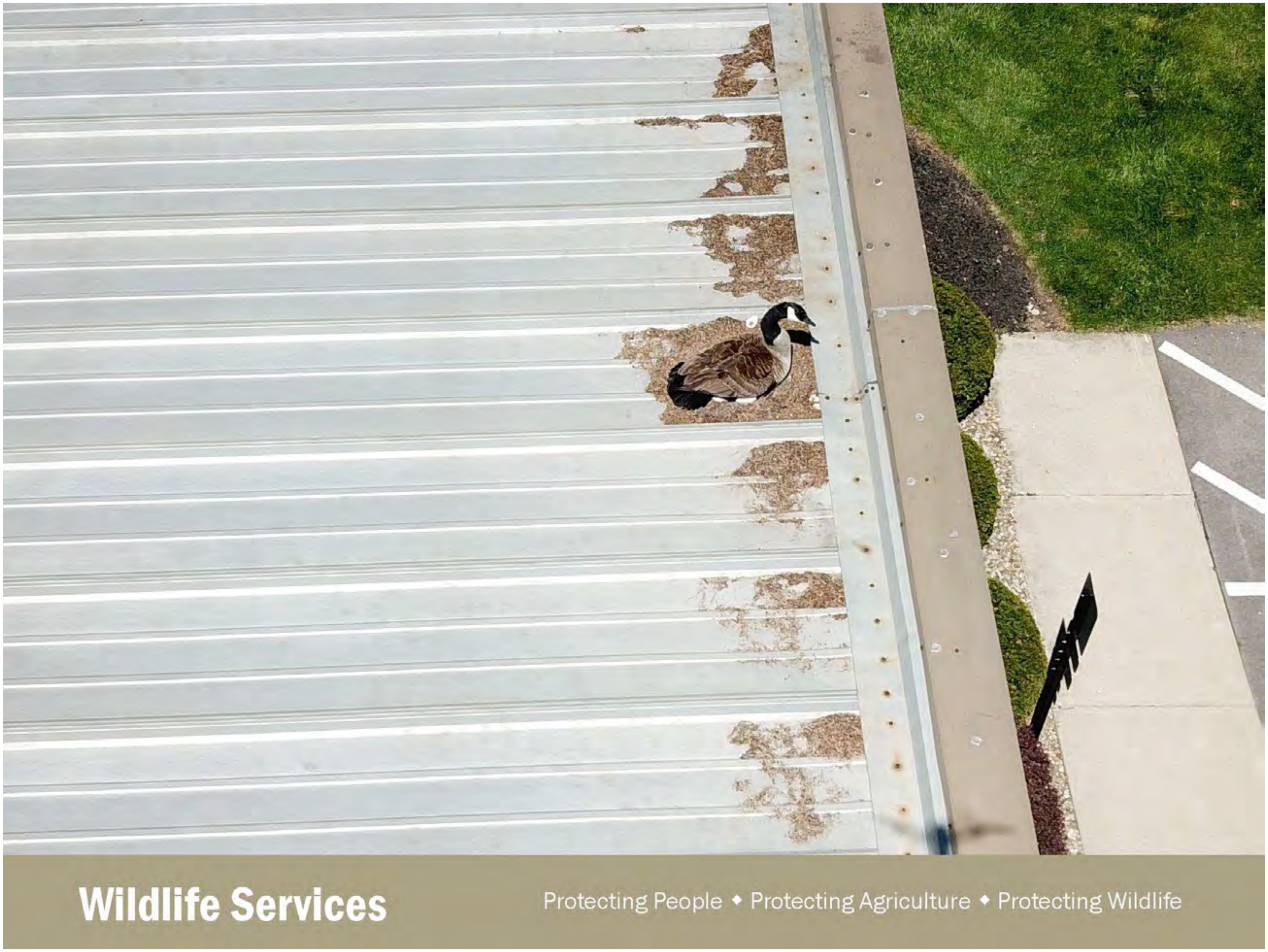
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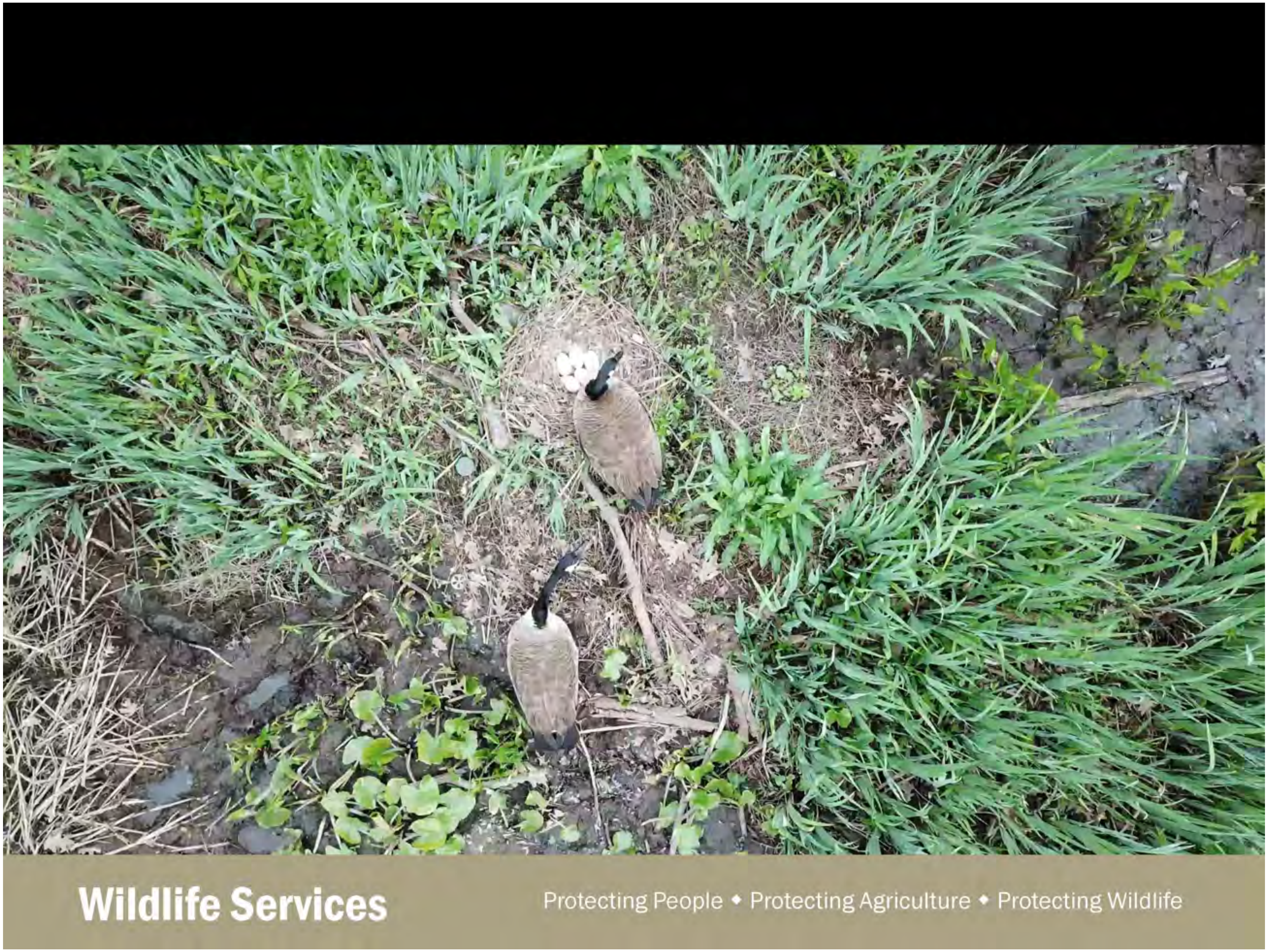
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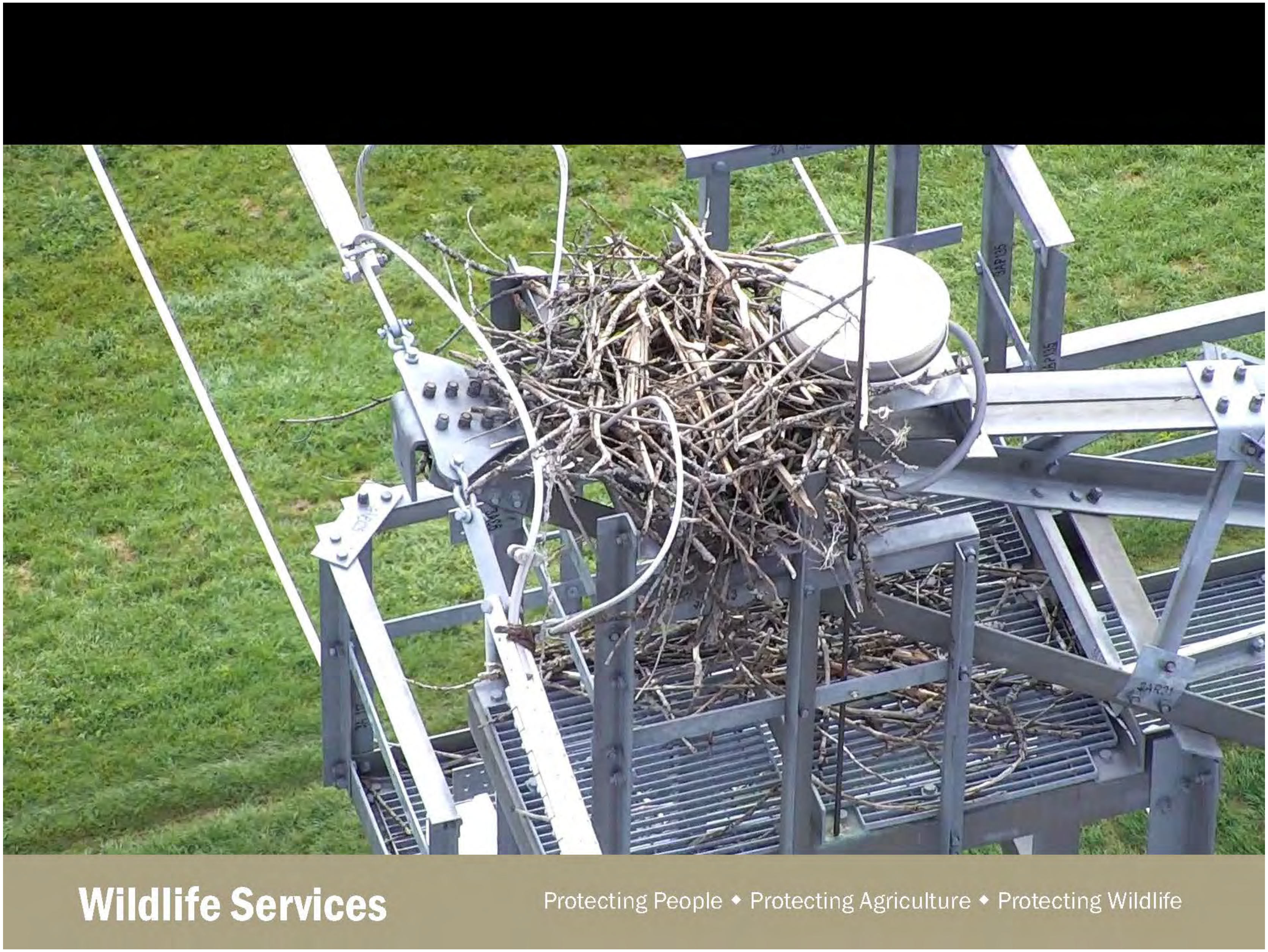
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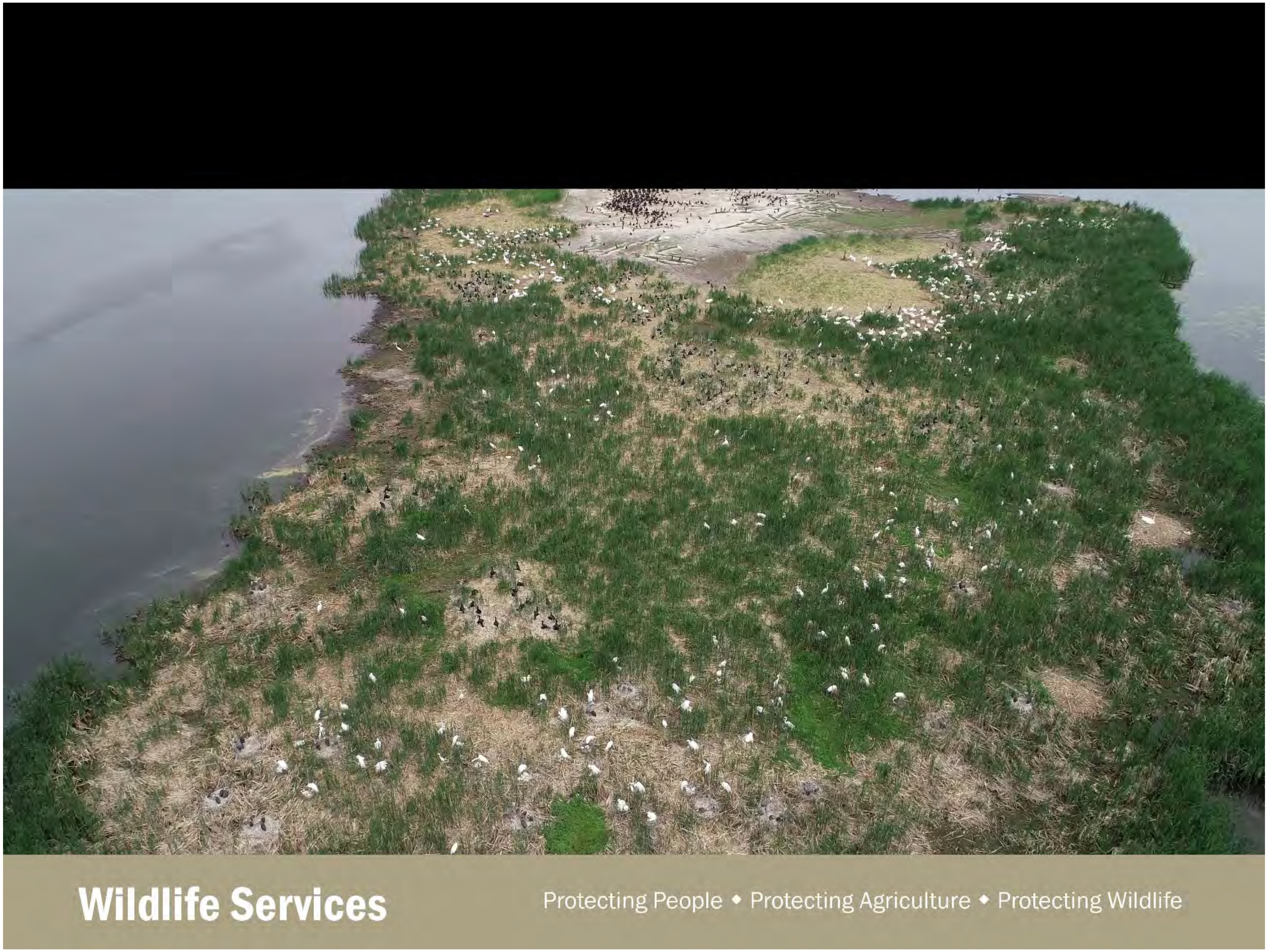
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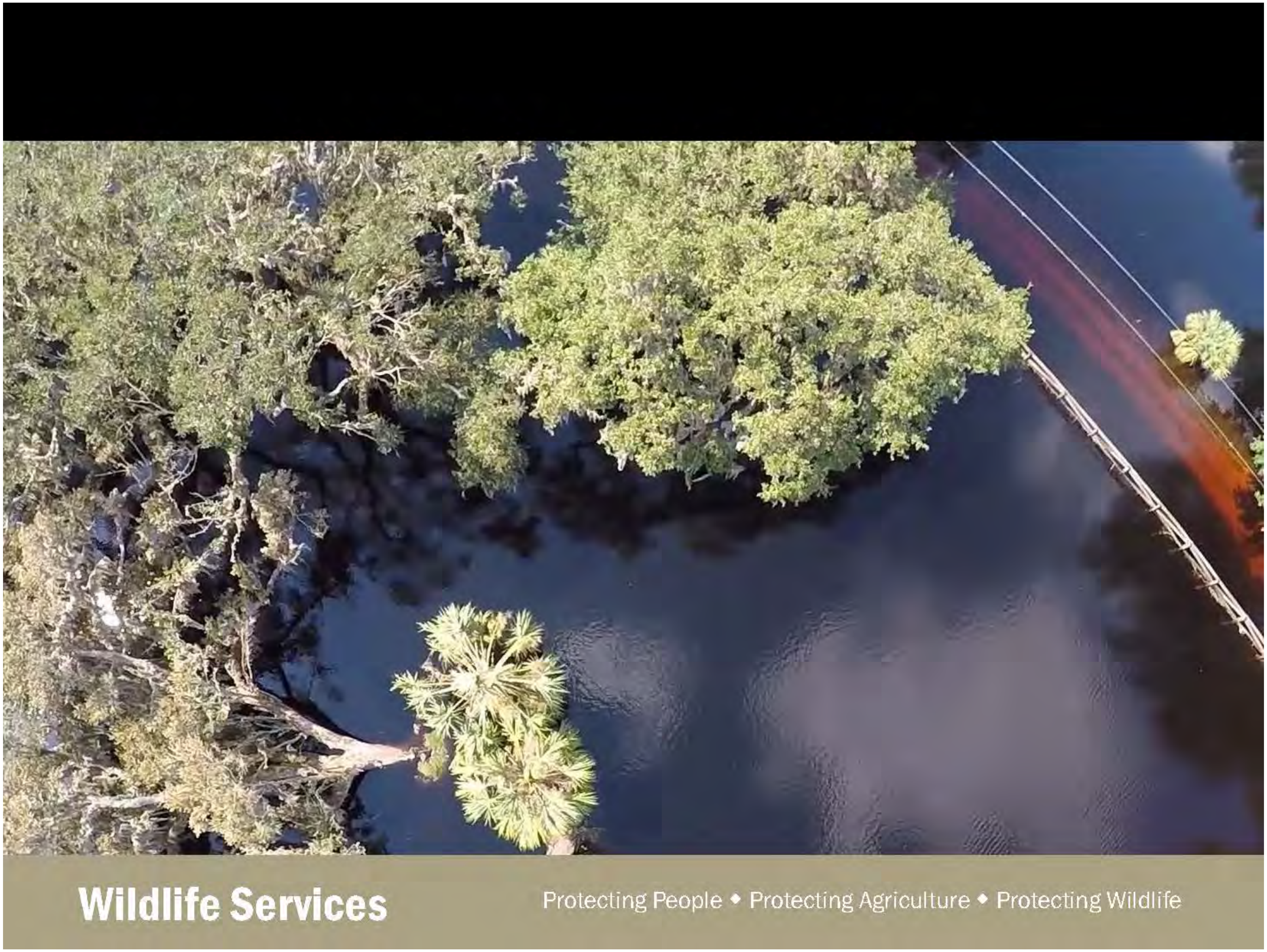
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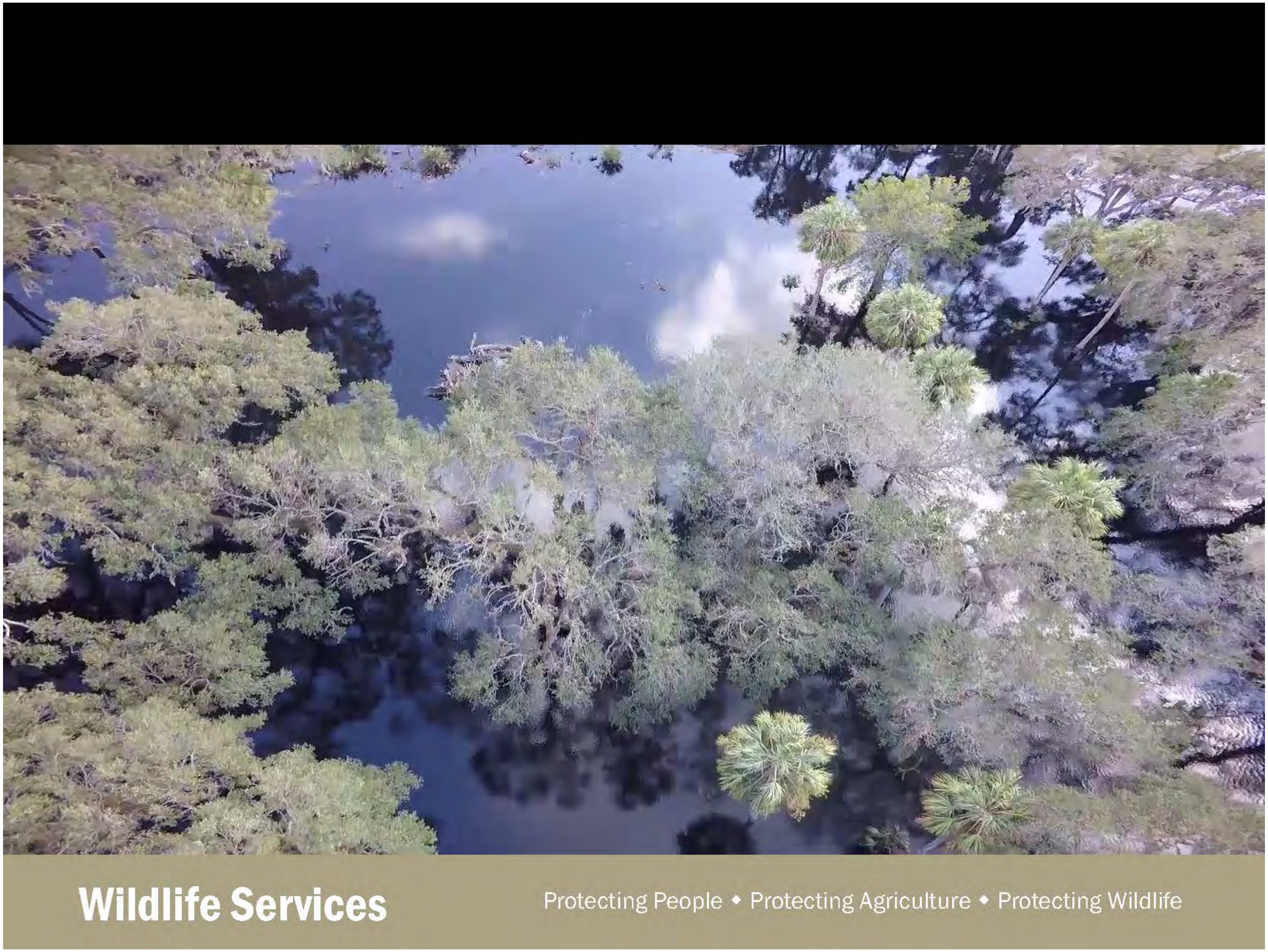
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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

CERTIFICATE OF WAIVER

ISSUED TO

Steven Smith
Responsible Person: Steven Smith
Waiver Number: 107W-2018-11783

ADDRESS –

[redacted]
Bogart, GA 30622

This certificate is issued for the operations specifically described hereinafter. No person shall conduct any operation pursuant to the authority of this certificate except in accordance with the standard and special provisions contained in this certificate, and such other requirements of the Federal Aviation Regulations not specifically waived by this certificate.

OPERATIONS AUTHORIZED

Night small unmanned aircraft system (sUAS) operations.

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[redacted]

U.S. DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

CERTIFICATE OF WAIVER

Issued To: USDA-APHIS-Wildlife Services
Responsible Person: Mark Lutman
Waiver Number: 107W-2020-01228

Address:
4101 Laporte Ave
Fort Collins, CO 80521

This certificate is issued for the operations specifically described hereinafter. No person shall conduct any operation pursuant to the authority of this certificate except in accordance with the standard and special provisions contained in this certificate, and such other requirements of the Federal Aviation Regulations not specifically waived by this certificate.

OPERATIONS AUTHORIZED

Night small unmanned aircraft system (sUAS) operations.

LIST OF WAIVED REGULATIONS BY SECTION AND TITLE

14 CFR § 107.29—Daylight operation

STANDARD PROVISIONS

1. A copy of the application made for this certificate shall be attached to and become a part hereof.

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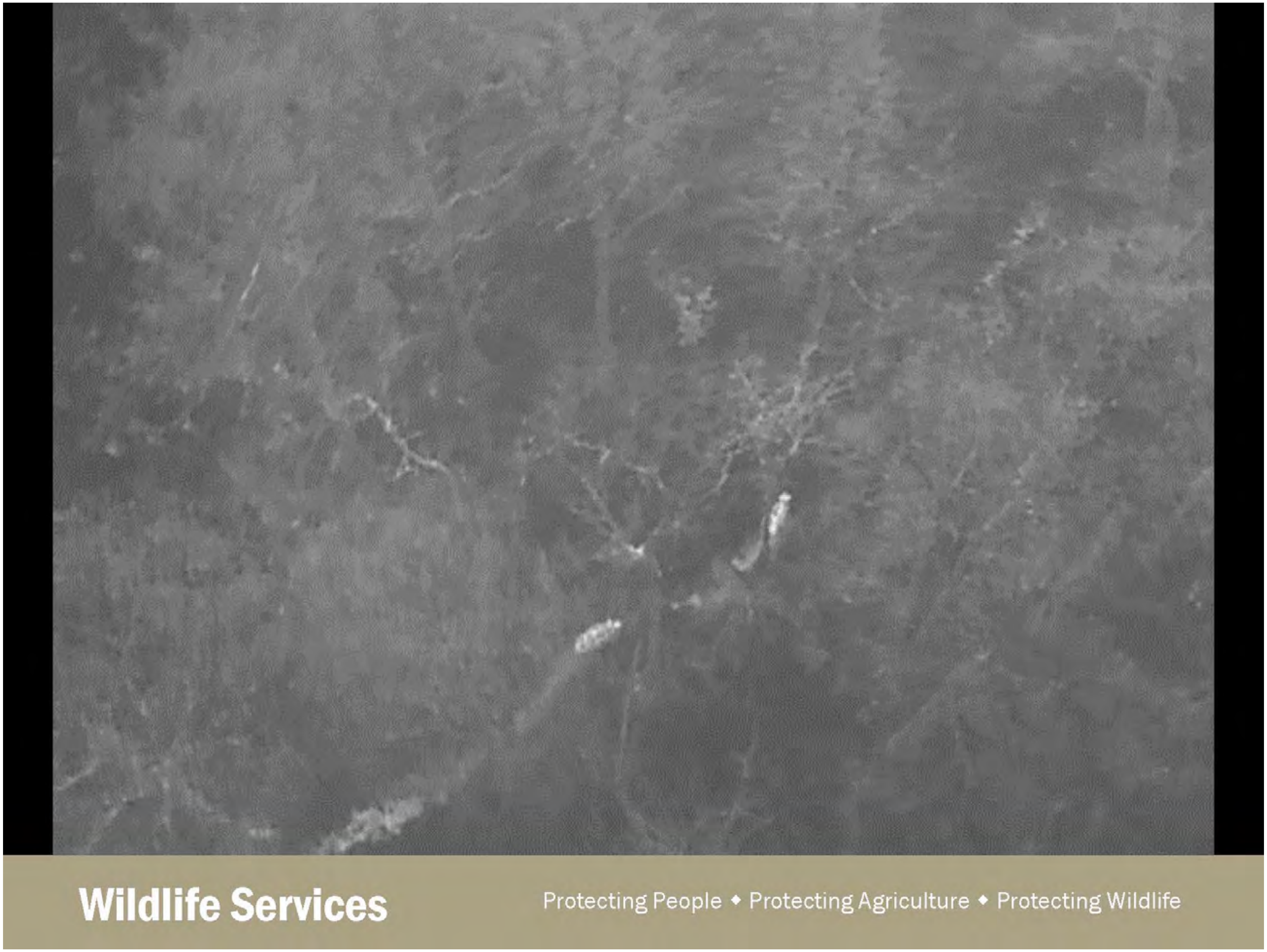
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Special Thanks

Wildlife Services' UAS Pilots

- Amanda Hasler - New Jersey
- Jeff Grabarkewitz, Pete Sahr, Alan Schumacher, and Tim White - Minnesota
- Joe Martin - Ohio
- Clay Stroud - Alabama
- Morgan Pfeiffer - NWRC
- Luke Miller - Missouri
- Chad Alberg - Wisconsin
- Daniel Dawson – Virginia
- Ryan Bevilacqua – Massachusetts
- Jay Cumbee – South Carolina
- Ryan Lancour – North Carolina

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Using Drones in the Management of Agriculture-Wildlife Conflict: Can Large Blackbird Flocks Be Deterred from Commercial Sunflower Fields?

Page Klug (page.e.klug@usda.gov)

A promising tool in wildlife damage management is the small unmanned aircraft system (sUAS). sUAS are an ideal frightening device given they are a multi-functional tool for agriculture, are easy to fly, and can be modified to enhance the antipredator response of nuisance species. Thus, we have begun evaluating sUAS as a hazing tool to minimize blackbird damage to sunflower. My first objective is to discuss the antipredator response of captive red-winged blackbirds (*Agelaius phoeniceus*) to three UAS platforms (i.e., multirotor, fixed-wing, and predator model) approaching at direct and overhead trajectories. My second objective is to discuss field evaluations of sUAS efficacy as a hazing tool including the influence of altitude and horizontal distance on the escape response of large mixed-flocks of blackbirds (Icteridae). We did not observe an effect of trajectory on alert response in captive birds, however, blackbirds alerted to the predator model 8 seconds earlier than the fixed-wing and 13 seconds earlier than the multirotor. Additionally, blackbirds returned to foraging earlier and alarm-called and took flight less frequently in response to multirotor approaches compared to the predator model. Overhead approaches failed to elicit flight, suggesting sUAS hazing may be most effective at low altitude, direct approaches. In direct approaches, only the multirotor failed to elicit an escape response. In the field blackbird flocks responded to all three platforms by taking flight. In a separate study, blackbird flocks did not respond to a fixed-wing flown at 52 m above ground level (AGL) but exhibited responses to a multirotor when flown within 30 m AGL. Flocks responded to a large spraying UAS (5 m AGL; 4 m/s) at an average of 38 ± 9.6 m. Future research will explore increasing the negative stimulus (e.g., multiple drones in coordination and deploying nonlethal chemical repellents) to enhance deterrence on large flocks.


Using Drones in the Management of Agriculture-Wildlife Conflict: Can Large Blackbird Flocks Be Deterred from Commercial Sunflower Fields?
Page E. Klug
USDA APHIS Wildlife Services National Wildlife Research Center
North Dakota Field Station, Fargo, ND
United States Department of Agriculture
Animal and Plant Health Inspection Service
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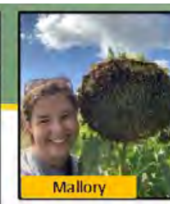
Thank You!



USDA-APHIS-WS NWRC
Drs. Brad Blackwell, Morgan Pfeiffer, George Linz

Purdue University
Dr. Esteban Fernandez-Juricic, Patrice Baumhardt

NDSU Biological Sciences
Drs. **Mark Clark**, Tim Greives, Ned Dochtermann, Wendy Reed;
Conor Egan, Mallory White, Lucas Wandrie
Jennifer Preuss, Kaitlyn Boteler, William Kennerley, Allison Schumacher, Jessica Duttenhefner, Isaac Carbajal

National Sunflower Association
John Sandbakken, board of directors, & sunflower producers

USDA-APHIS-WS North Dakota
John Paulson and field staff

Red River Zoo Sally Jacobson and staff

Use of tradenames does not imply endorsement by the U.S. government

United States Department of Agriculture
Animal and Plant Health Inspection Service
Wildlife Services – National Wildlife Research Center


OUTLINE
• Human-Wildlife Conflict
• Wildlife-Drone Interactions
• Individual Birds in Seminatural Setting
• Large Flocks in Commercial Sunflower Fields
• Conclusions
• Future Directions
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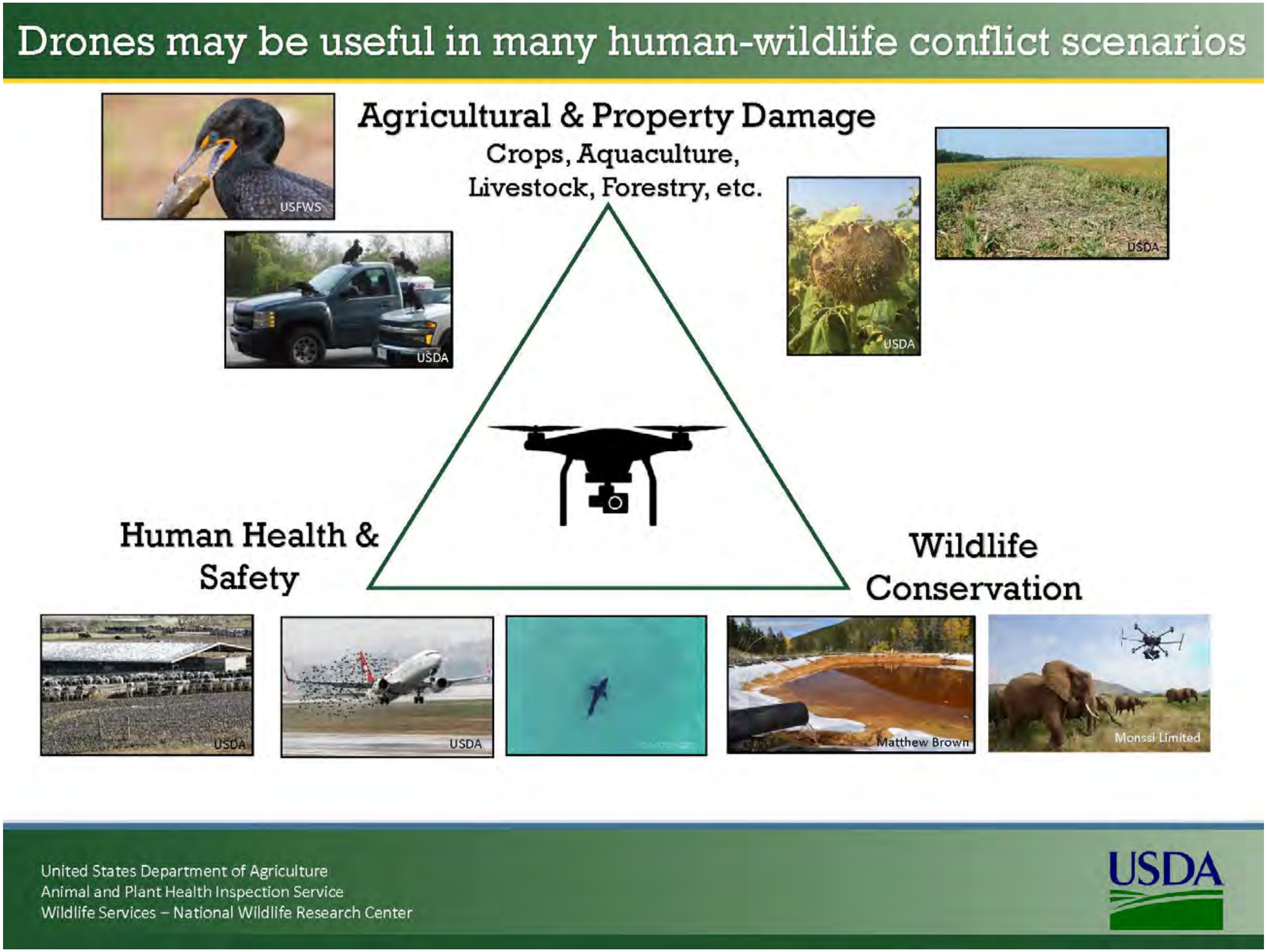
Animal and Plant Health Inspection Service
Wildlife Services – National Wildlife Research Center
USDA


Drones may be useful in many human-wildlife conflict scenarios
Agricultural & Property Damage
Crops, Aquaculture,
Livestock, Forestry, etc.
Human Health &
Safety
Wildlife
Conservation
USFWS
USDA
Matthew Brown
Monssi Limited
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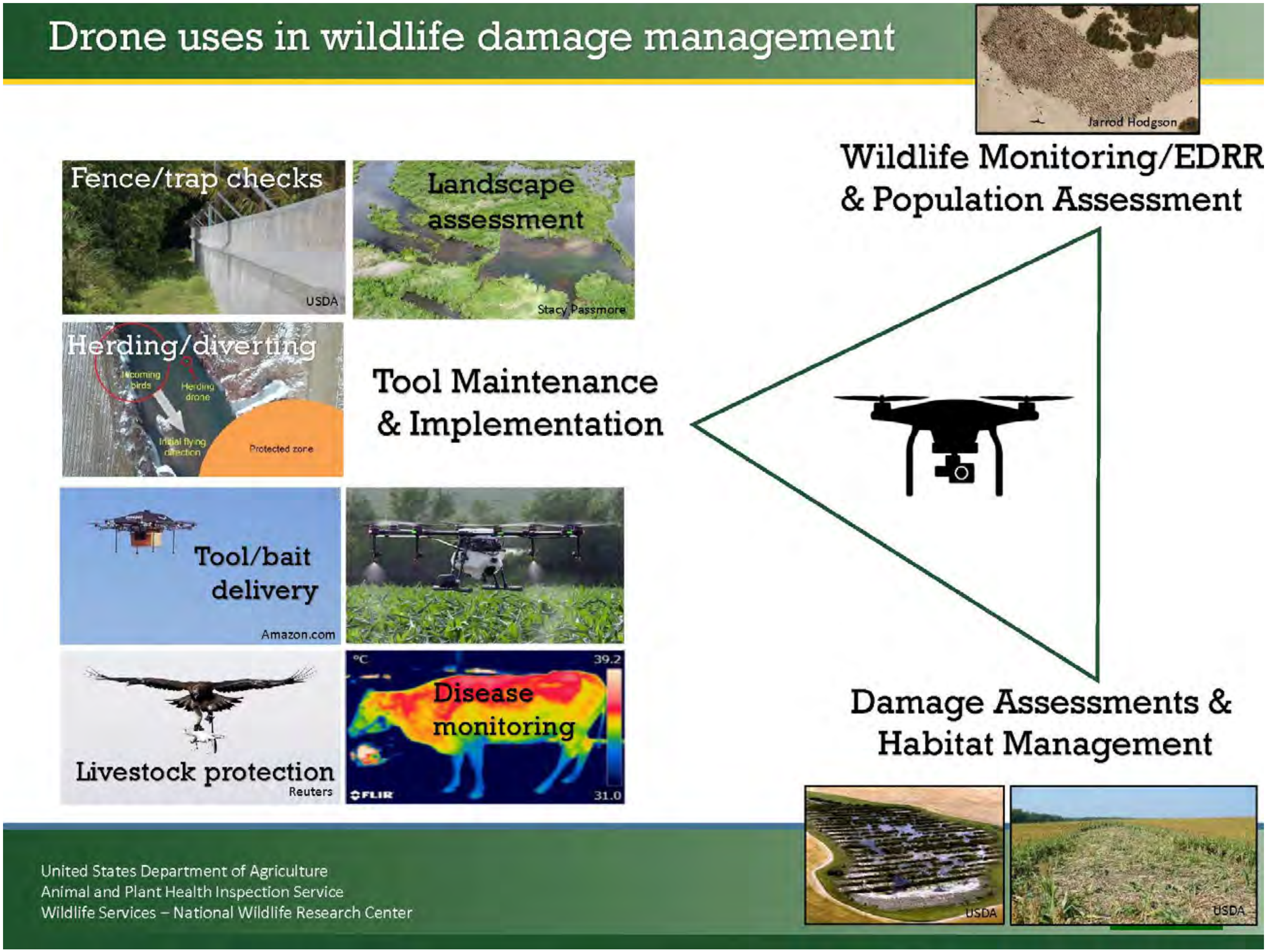
Drone uses in wildlife damage management
Jarrod Hodgson
Wildlife Monitoring/EDRR & Population Assessment
Fence/trap checks
USDA
Landscape assessment
Stacy Passmore
Herding/diverting
Incoming birds
Herding drone
Initial flying direction
Protected zone
Tool Maintenance & Implementation
Tool/bait delivery
Amazon.com
°C
39.2
Disease monitoring
FLIR
31.0
Livestock protection
Reuters
Damage Assessments & Habitat Management
USDA
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United States Department of Agriculture
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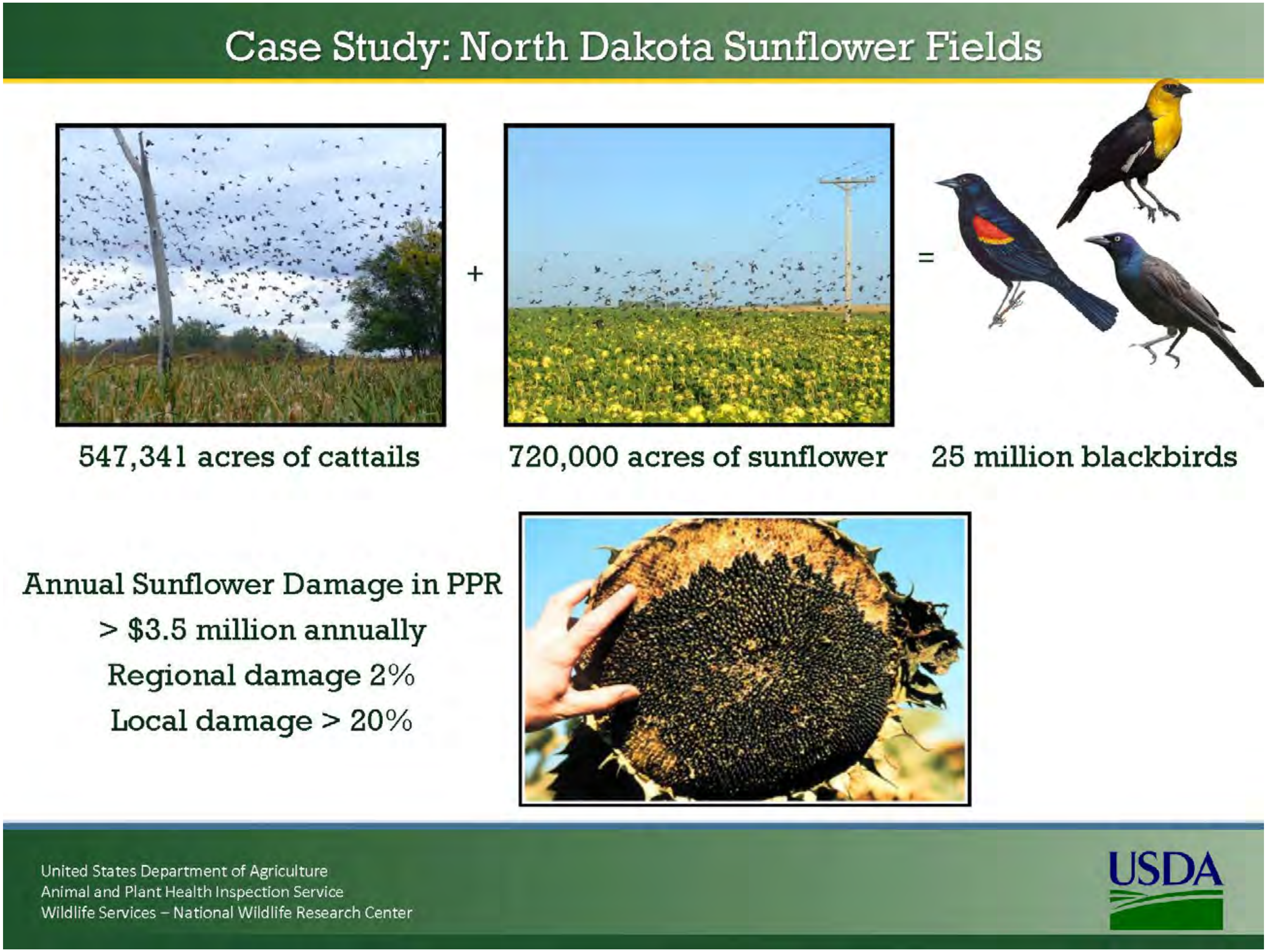
Case Study: North Dakota Sunflower Fields
547,341 acres of cattails
+
720,000 acres of sunflower
=
25 million blackbirds
Annual Sunflower Damage in PPR
> $3.5 million annually
Regional damage 2%
Local damage > 20%
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Large flocks in an agricultural landscape with no alternative food

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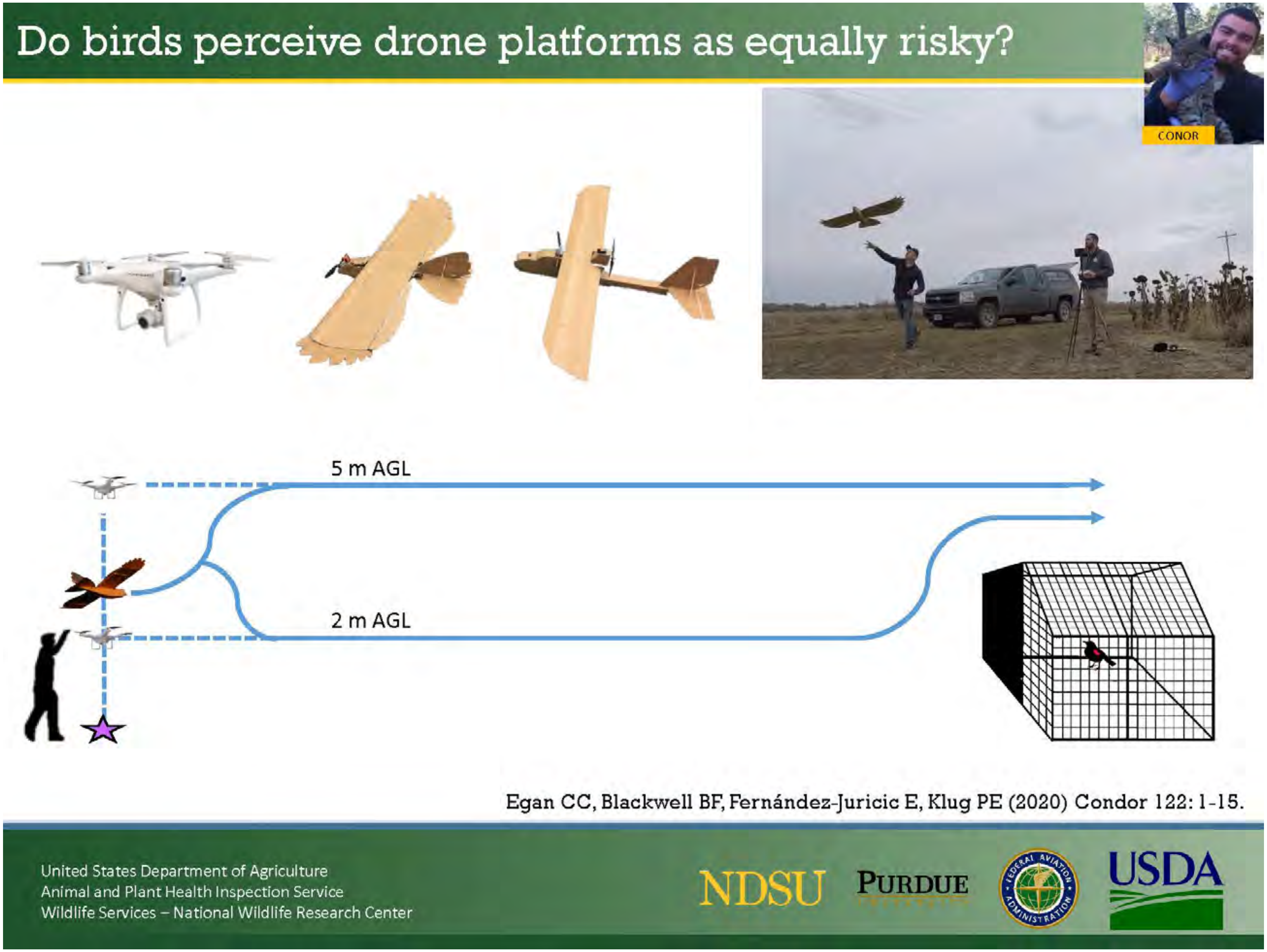
Do birds perceive drone platforms as equally risky?
CONOR
5 m AGL
2 m AGL
Egan CC, Blackwell BF, Fernández-Juricic E, Klug PE (2020) Condor 122: 1-15.
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Animal and Plant Health Inspection Service
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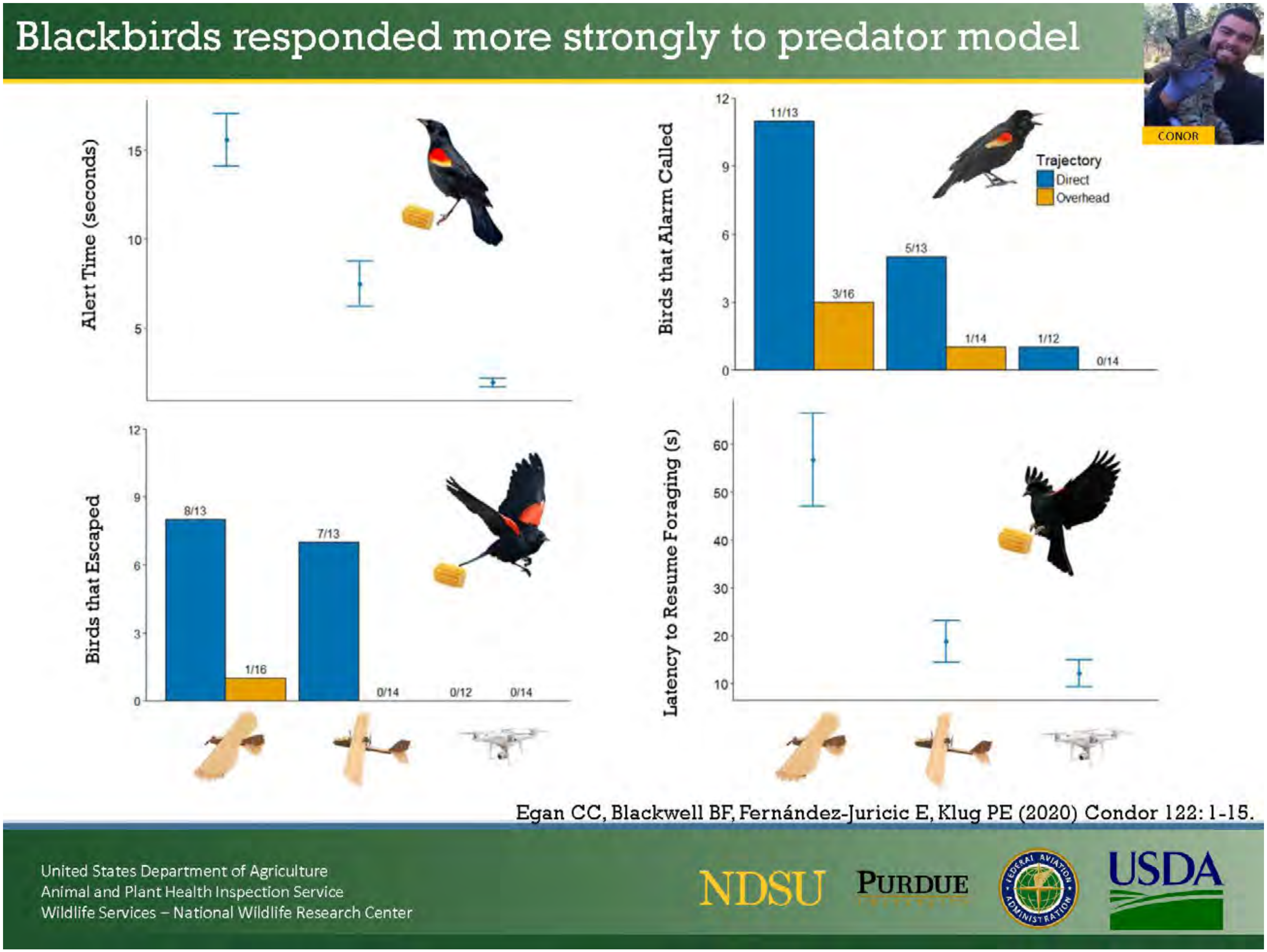
NDSU
PURDUE
USDA


Blackbirds responded more strongly to predator model
CONOR
Alert Time (seconds)
Birds that Alarm Called
11/13
3/16
5/13
1/14
1/12
0/14
Trajectory
Direct
Overhead
Birds that Escaped
8/13
1/16
7/13
0/14
0/12
0/14
Latency to Resume Foraging (s)
Egan CC, Blackwell BF, Fernández-Juricic E, Klug PE (2020) Condor 122: 1-15.
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Will we see the same avian responses in the field trials?

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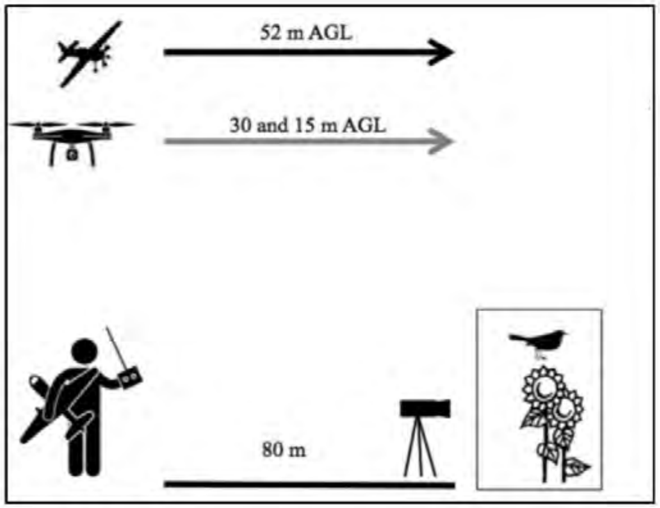
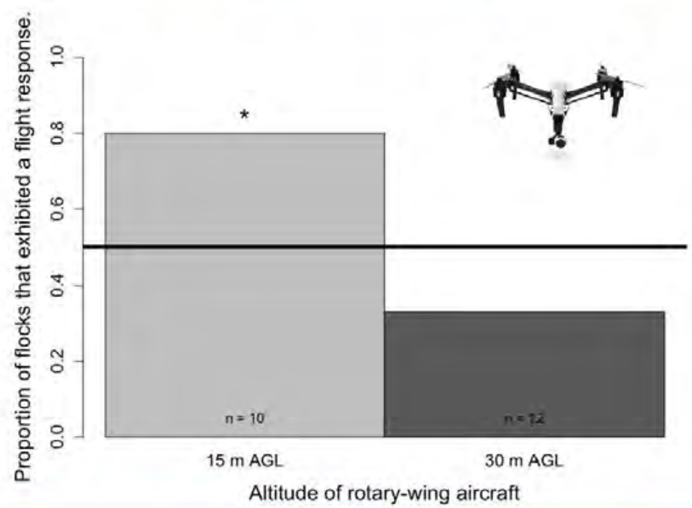
Blackbird flocks find drones less disturbing at higher altitudes



Treatment (AGL)	Behavioral Response		
	No Response	Vigilant	Escape
Control	21	0	0
Fixed-wing (67 m)	3	0	0
Fixed-wing (52 m)	3	0	0
Multirotor (30 m)	2	6	4
Multirotor (15 m)	1	1	8



Wandrie LJ, Klug PE, Clark ME (2019) Crop Protection 117:15-19.

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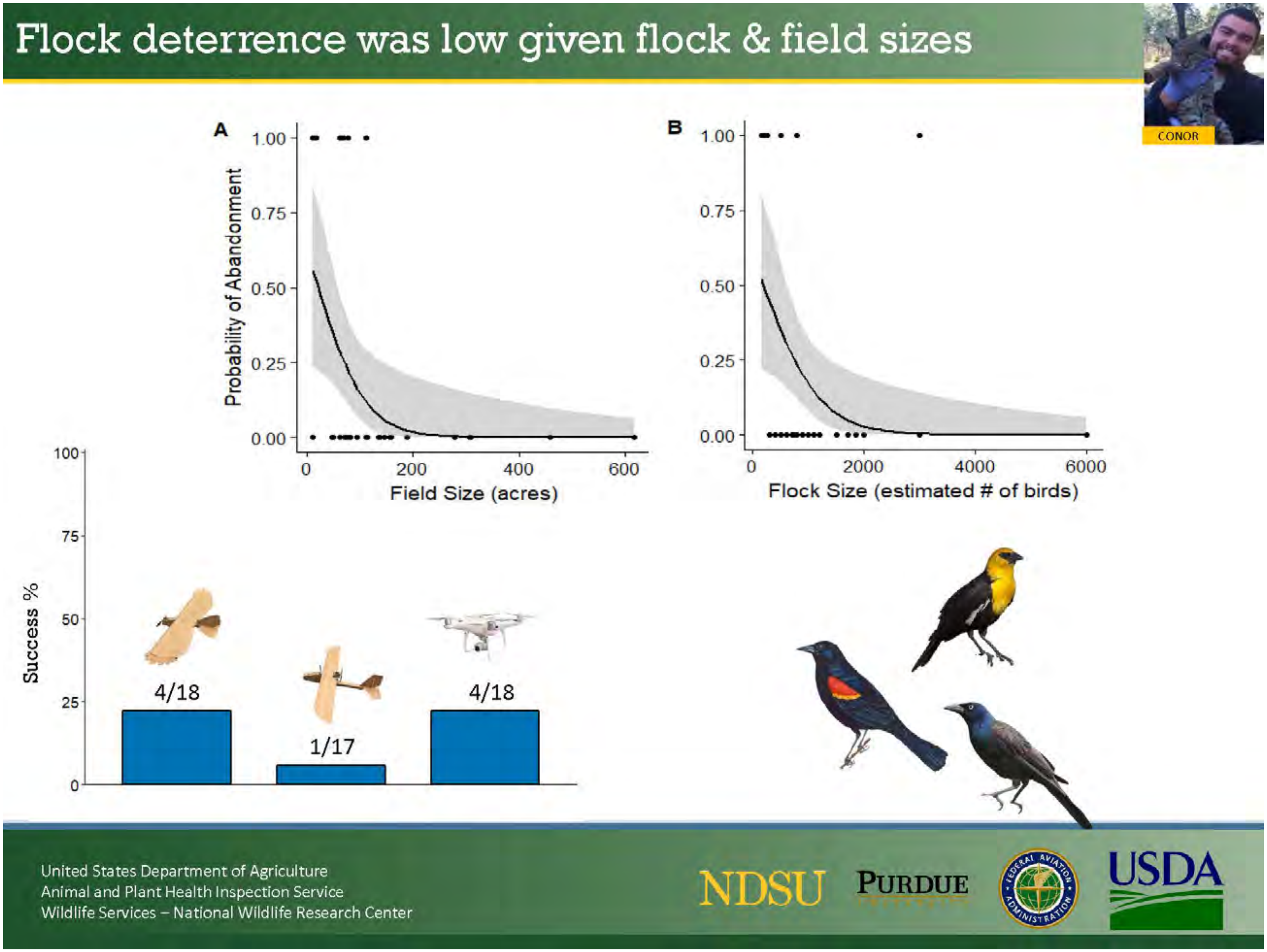
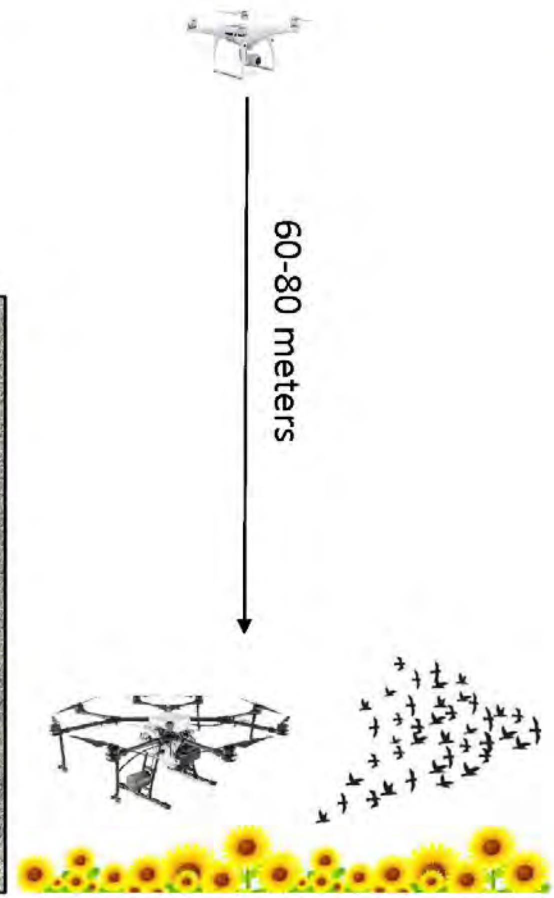
NDSU USDA


Flock deterrence was low given flock & field sizes
CONOR
A
1.00
0.75
0.50
0.25
0.00
Probability of Abandonment
0
200
400
600
Field Size (acres)
B
1.00
0.75
0.50
0.25
0.00
0
2000
4000
6000
Flock Size (estimated # of birds)
100
75
50
25
0
Success %
4/18
1/17
4/18
United States Department of Agriculture
Animal and Plant Health Inspection Service
Wildlife Services – National Wildlife Research Center
NDSU
PURDUE
USDA

Can spraying drones increase negative stimulus on large flocks?

Petition for Exemption under Special Authority for Certain Unmanned Aircraft Systems (49 U.S.C. §44807) to apply for the FAA 14 CFR Part 137 (Agricultural Aircraft Operations) certification.



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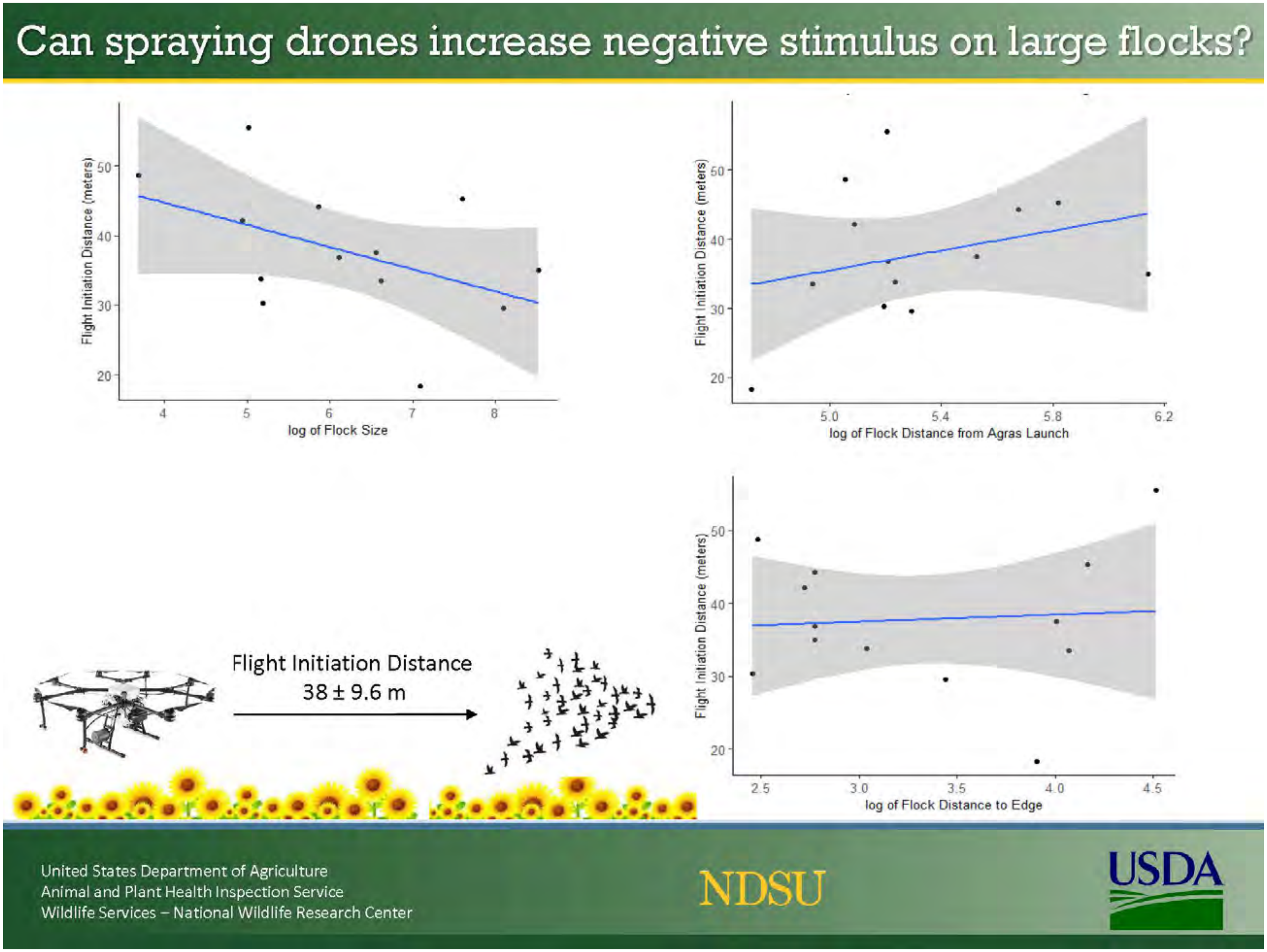
National Sunflower Association NDSU USDA


Can spraying drones increase negative stimulus on large flocks?
Flight Initiation Distance (meters)
log of Flock Size
log of Flock Distance from Agras Launch
log of Flock Distance to Edge
Flight Initiation Distance
38 ± 9.6 m
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Animal and Plant Health Inspection Service
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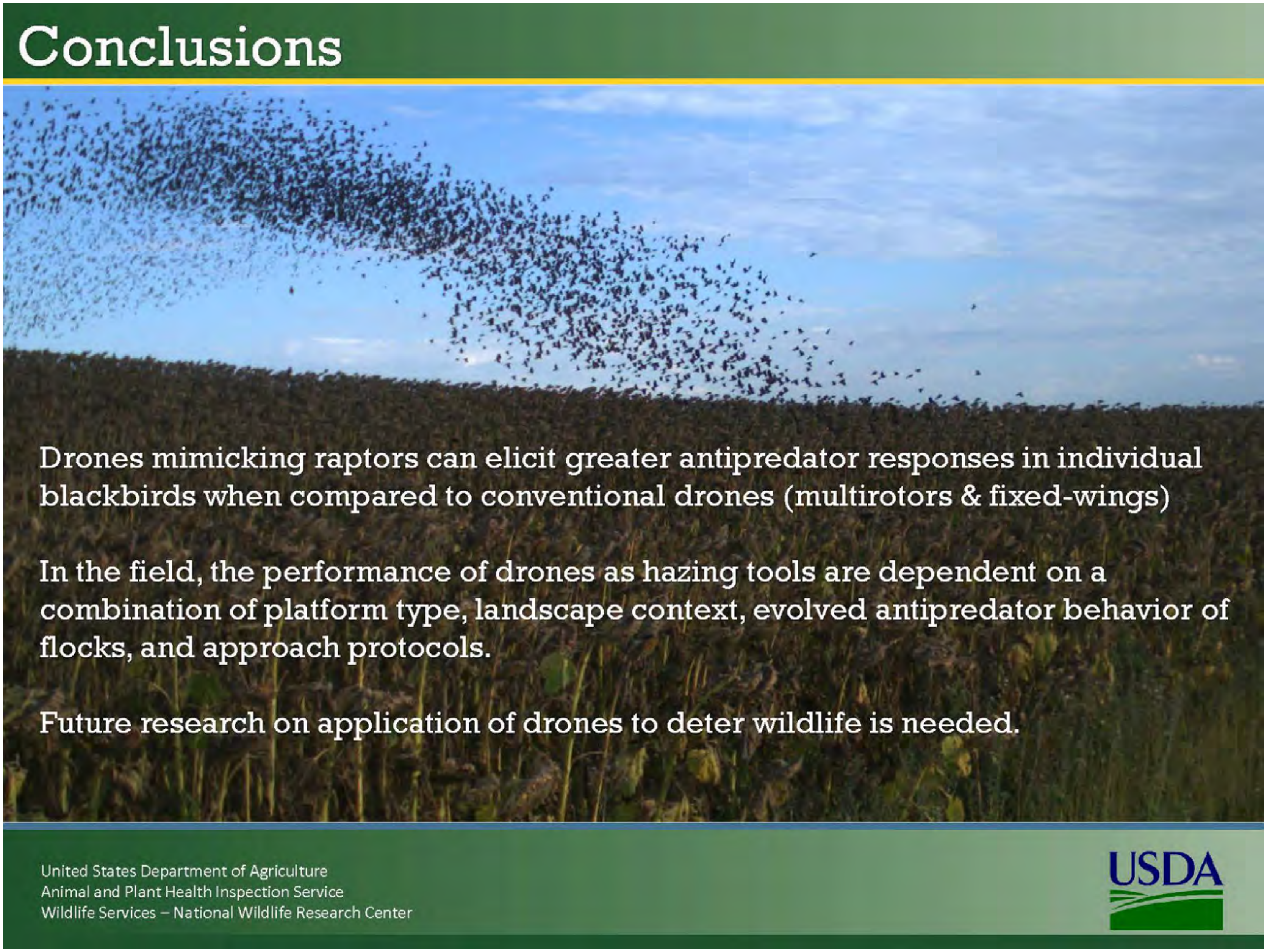
NDSU
USDA


Conclusions
Drones mimicking raptors can elicit greater antipredator responses in individual blackbirds when compared to conventional drones (multirotors & fixed-wings)
In the field, the performance of drones as hazing tools are dependent on a combination of platform type, landscape context, evolved antipredator behavior of flocks, and approach protocols.
Future research on application of drones to deter wildlife is needed.
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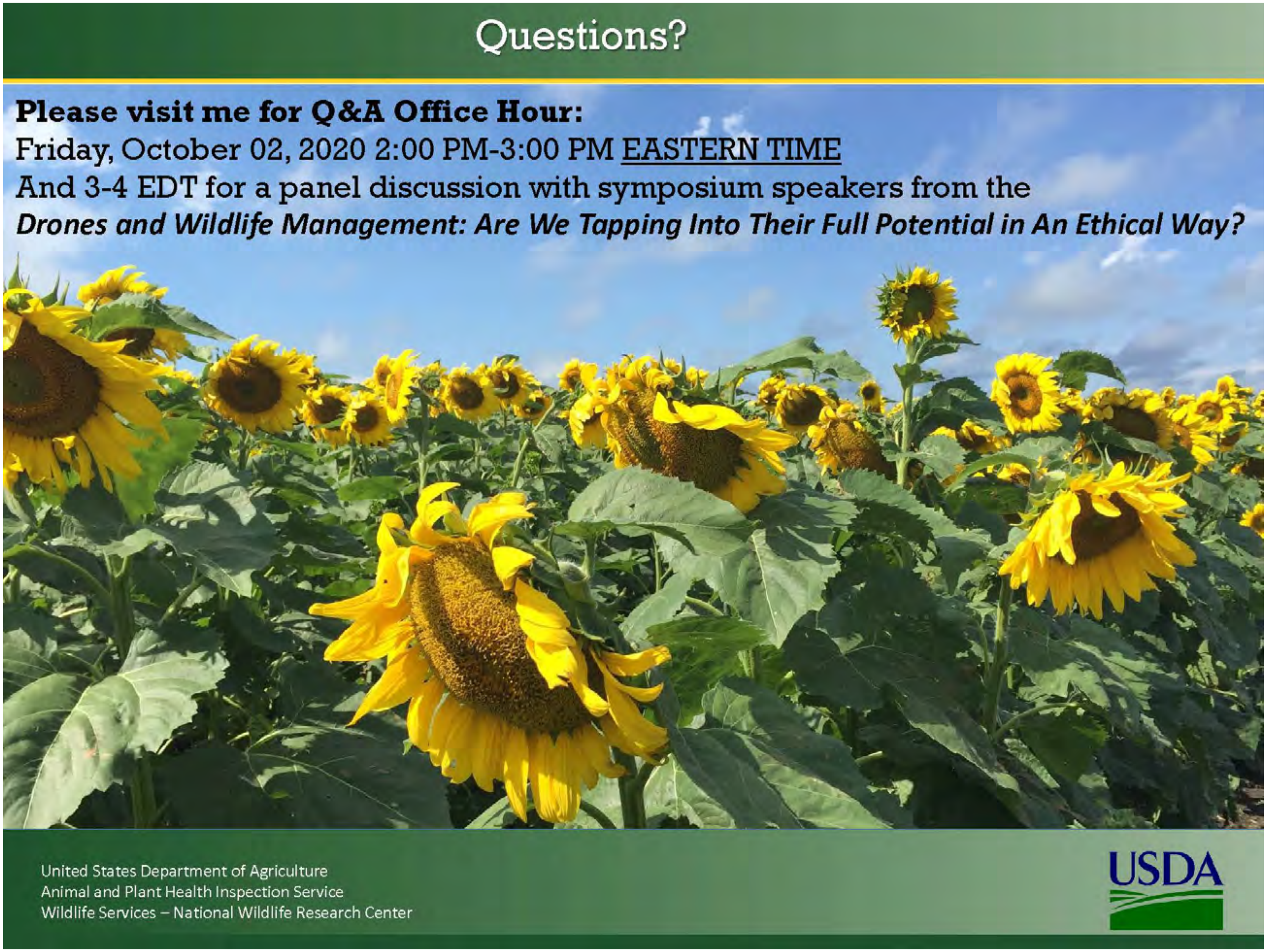
Questions?
Please visit me for Q&A Office Hour:
Friday, October 02, 2020 2:00 PM-3:00 PM EASTERN TIME
And 3-4 EDT for a panel discussion with symposium speakers from the
Drones and Wildlife Management: Are We Tapping Into Their Full Potential in An Ethical Way?
United States Department of Agriculture
Animal and Plant Health Inspection Service
Wildlife Services – National Wildlife Research Center
USDA

Drones Extend the Reach of Wildlife Management Tools

Tim Shields (t.shields@hardshelllabs.com)

Aerial drones offer wildlife biologists and managers tools to extend the reach of established techniques as well as opportunities for novel approaches to previously insoluble problems. Population management of nuisance birds includes lethal removal of individuals and preventing clutches from hatching by coating eggs with oil, a substance which prevents oxygen flow to the bird embryo. Lethal removal of adult birds has drawbacks: poisoning is controversial, and shooting is expensive and logistically challenging. Egg oiling can be limited by the physical location of nests; however, we highlight a drone-based solution. Through the use of a remote fluid application system (RFAS) mounted on commercially available unmanned aerial vehicles (UAVs) we have been able to treat large numbers of common raven (*Corvus corax*) nests in the interest of desert tortoise (*Gopherus agassizii*) and greater sage grouse (*Centrocercus urophasianus*) conservation, where both species suffer from heightened predation from this subsidized predator. Our work has included treating raven nests on electrical utility transmission towers, an important artificial nesting substrate, as well as a variety of natural substrate nests. Having refined the technology and methodology of drone-based remote egg oiling, the potential to address avian threats to other threatened and endangered species is clear.

Drones Extend the Reach of Wildlife Management Tools: A Case in Point

Tim Shields, Hardshell Labs

Mercy Vaughn, Sundance Biology

The Wildlife Society, 2020 Conference, for the session:

Drones and Wildlife Management: Are We Tapping Into Their Full Potential in An Ethical Way?


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NATIONAL FISH AND WILDLIFE FOUNDATION
NFWF
LA
DWP
Los Angeles
Department of
Water & Power
Renewable
Energy Action
Team

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- Larry LaPre, PhD
- Kathy Holmes
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- Dan Reinke, PhD
- Matt Huffine
- Jennifer Brown
- Steve Fettig, PhD
- Tara Callaway
- Chris Smith
- Paul Anderson
- Travis Geske
- Larkin Donley
- Frank Guercio
- many others


Biblical
Proportions

Active population management of nuisance birds

The options:

Lethal Removal of individuals-
- DRC 1339 avian renal poison
- Firearms

Egg Oiling: Apply a thin coat of oil to eggs with oil to prevent oxygen flow to the bird embryo. Clutches are physically undamaged but non-viable. Adult birds continue care of eggs after oiling

Lethal removal of adult birds has drawbacks: All forms are inherently **controversial**

DRC-1339
- Effective for large scale culls
- Highly regulated and requiring expertise for use
- Difficult to accurately assess effects since poisoned birds die away from bait sites and are dispersed

Shooting by Wildlife Services
- Highly specific
- Labor intensive and thus expensive
- Difficult when dealing with birds as intelligent as ravens

USFWS Depredation Permits
- Limited geographic scope, usually a single site
- Take amounts strictly limited

Prior limitation of egg oiling:
Necessity of human physical access to nest

- Useful for ground nesters or nests within easy reach of ground
  - Canada geese
  - Double-crested cormorants
  - Some gull species

Our solution is the Remote Fluid Application System (RFAS)

- Versions carried on telescoping poles and aerial drones
- Nests viewed remotely and oil applied accurately to eggs and nest

RFAS units are mounted on commercially available UAVs

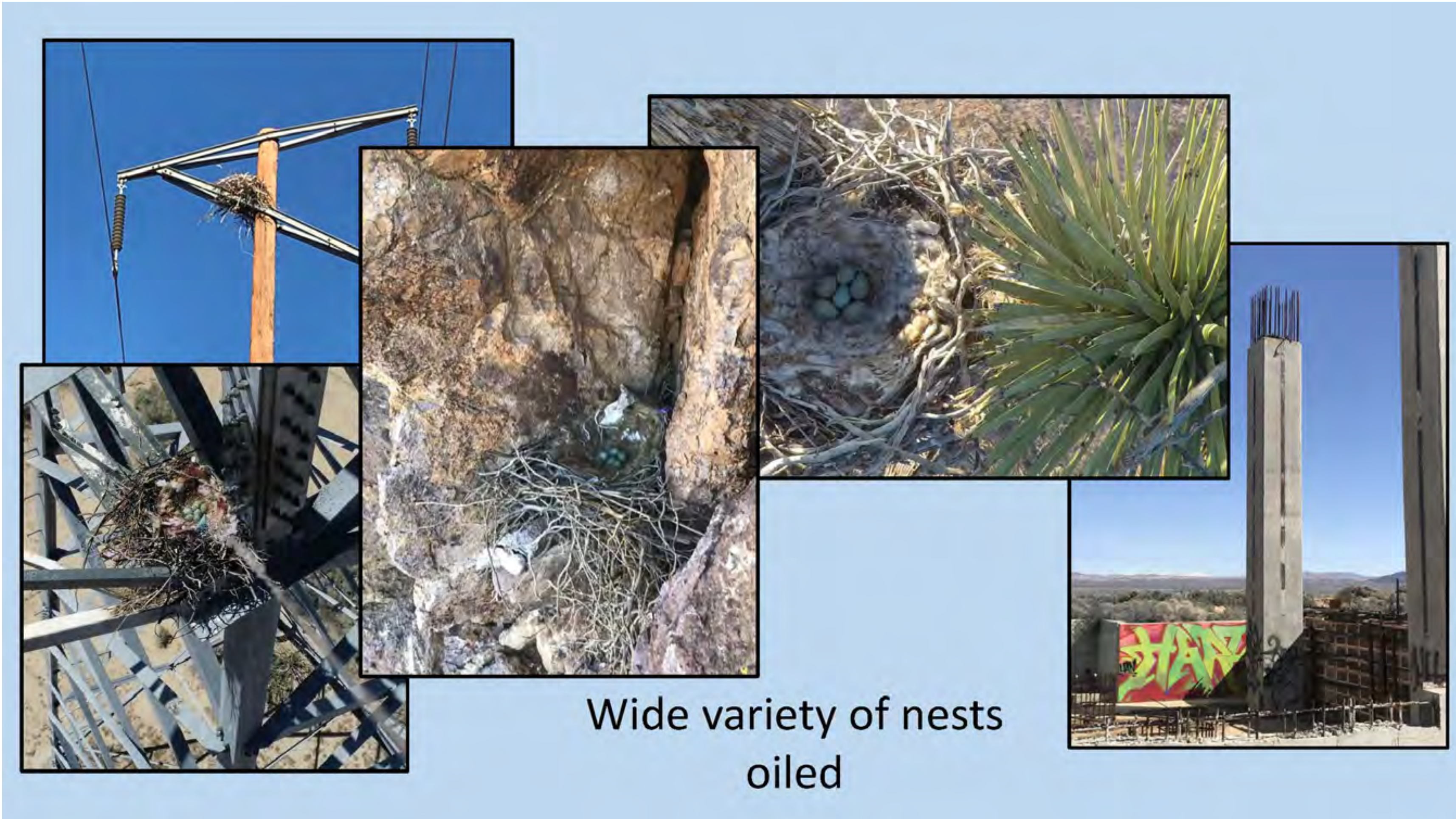
Components of system Include:

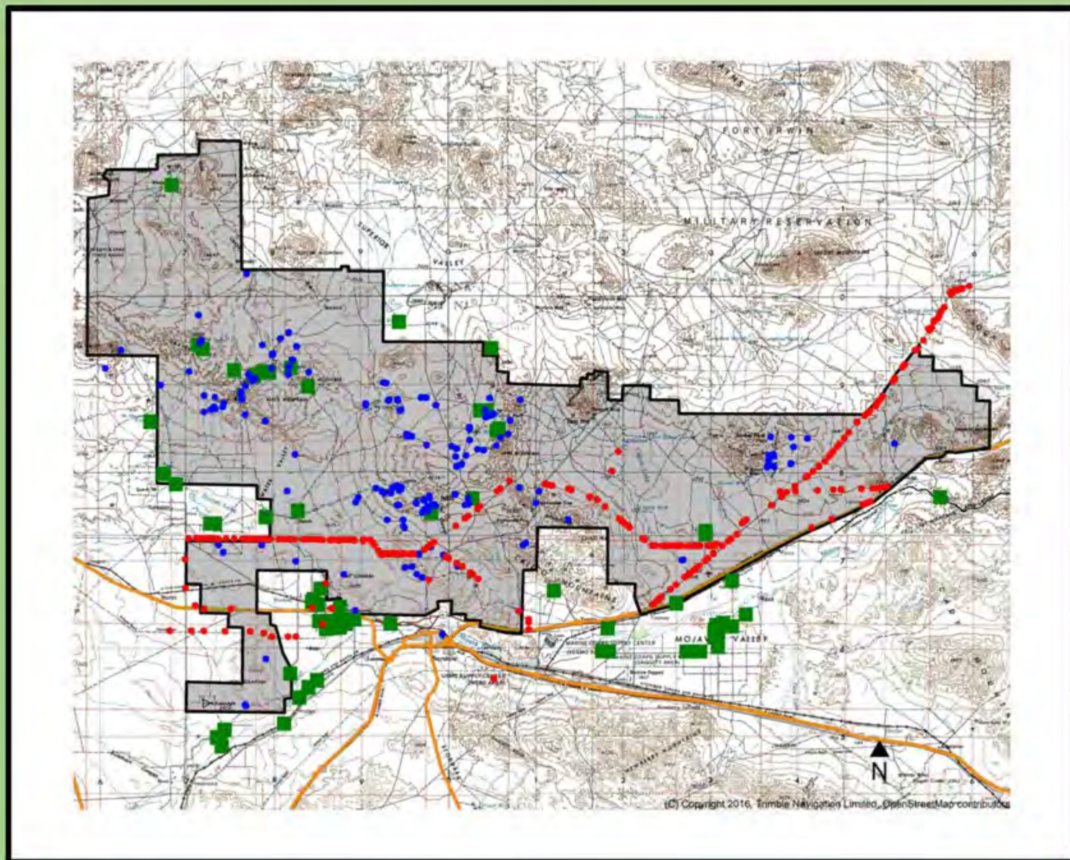
- Oil reservoir
- Pressure vessel
- Gimbal mounted camera with appended nozzle
  - Can be separate camera or stock drone camera
- Radio controlled valve to trigger oil flow

Cliff face nest in Mojave Desert

Since 2016, using pole and drone based RFAS, we have been able to treat over 700 Common Raven (*Corvus corax*) nests in the interest of desert tortoise (*Gopherus agassizii*) and greater sage grouse (*Centrocercus urophasianus*) conservation, both of which species suffer from heightened predation from this subsidized predator.

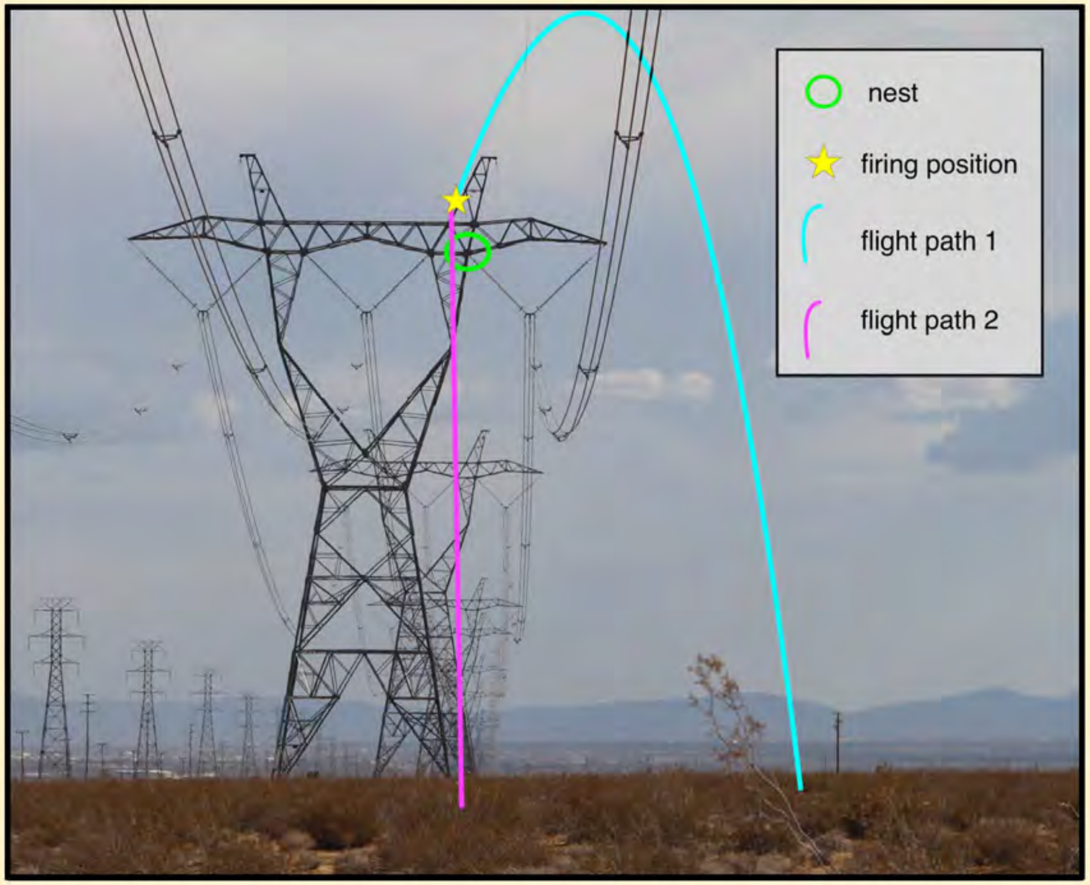
Windmill nest in Long Valley, CA


Wide variety of nests
oiled



Raven nests in Superior-Cronese Desert Tortoise Critical Habitat Unit:

the effect of utility towers as nest sites

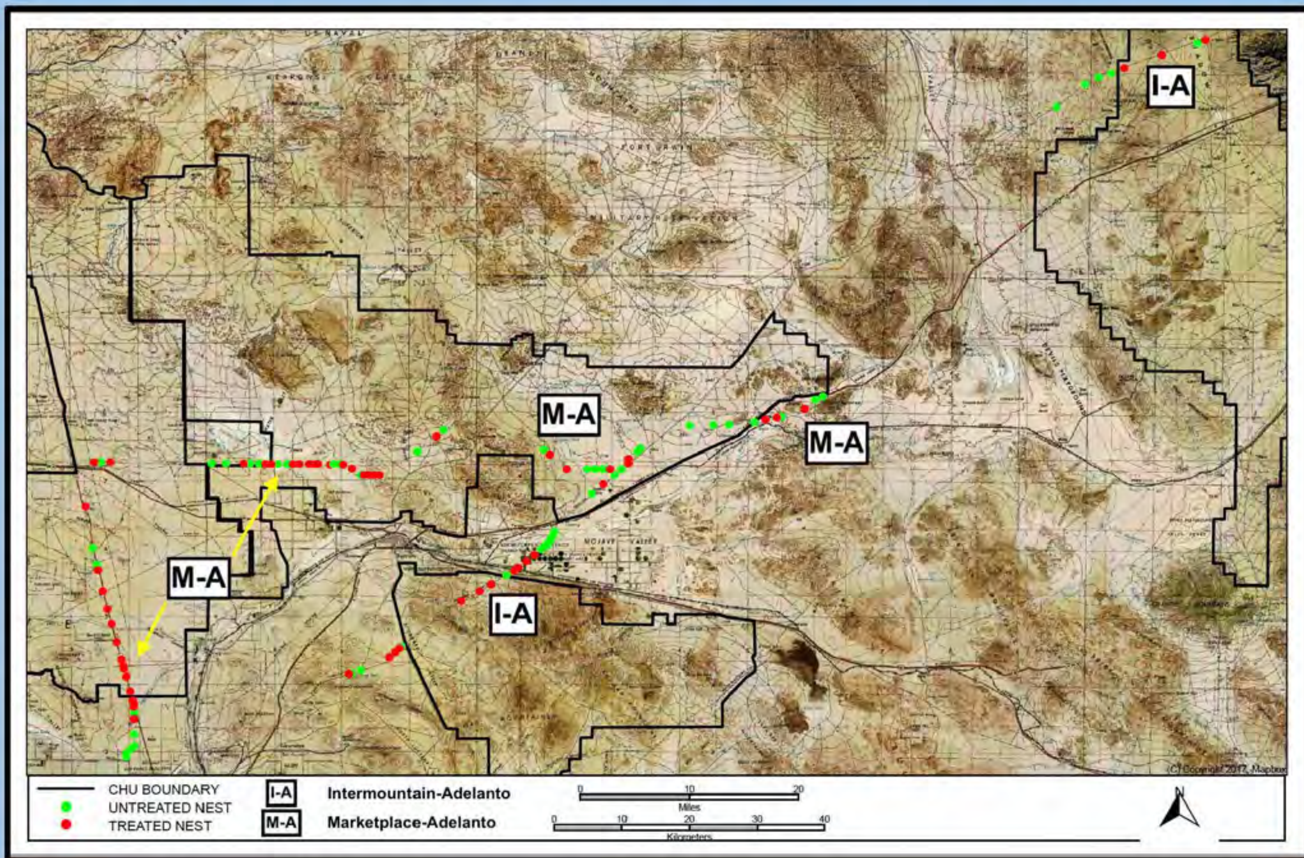


Flight paths to LADWP 500 kV tower

DJI Mavic 2 Zoom photo drone


Looking into utility tower raven nests

DJI Matrice M-200
with RFAS



2020 Utility Tower Raven Nest Results

Total visited: 118

Total Oiled: 58

The Human Element

Partnerships

Sundance Biology and Hardshell Labs- complementary skills
T3B- engineering and extensive testing of RFAS

Relationships with Agencies

USFWS Migratory Bird Permit Office-egg oiling permit
CDFW- egg oiling permit
USFWS Desert Tortoise Recovery Office- collaboration on planning, logistics, reporting
USGS- collaboration with Dr. Peter Coates, sage grouse conservation researcher
NDOW-egg oiling permit
BLM, US Park Service, Department of Defense- land management agencies on whose land we oil raven nests
Numerous other state conservation agencies

Relationships with Private Companies and Utilities

Hyundai-Kia Motor Group- host of our REO development work
Los Angeles Department of Water and Power- collaboration on utility tower oiling
Southern California Edison- collaboration on utility tower oiling
Avian Power Line Interaction Committee- funding and contact with many utilities

Drone Pilots and Biologists

Professional filmmaker drone pilots work on tower oiling
Engineers, pilots and biologists interact and exchange information

Next Steps:

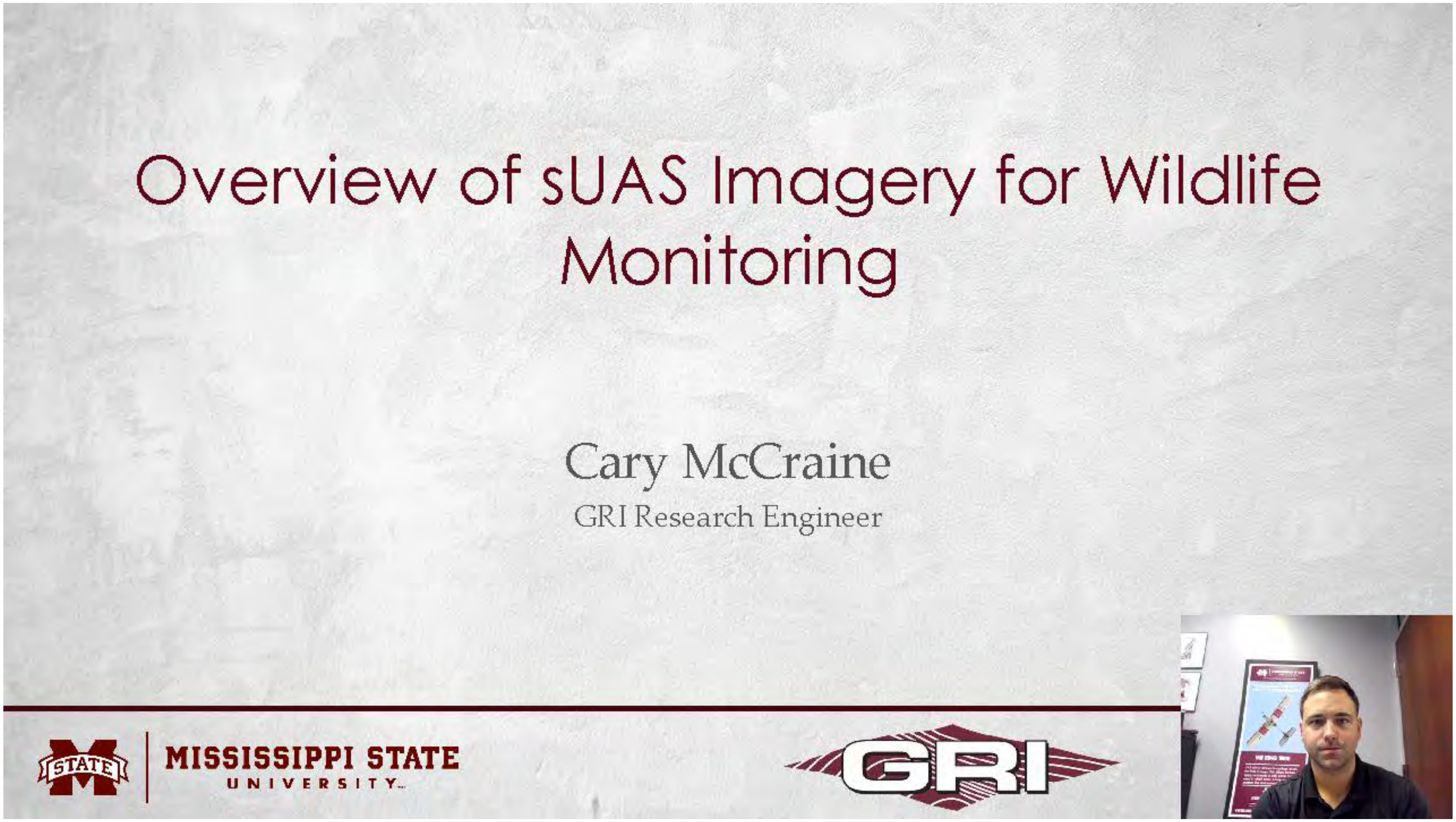
- Further refinements to RFAS systems to equip a wider range of drones with egg oiling hardware
- Integration of artificial intelligence capacity for autonomous recognition of eggs, nestlings and adults, and obstacles
- Longer term observation of raven nest choices in response to repeated nest oiling
  - Abandonment of areas or particular nest substrates (emphasis on utility towers)?
- Expansion of egg oiling to other problematic bird species or for the benefit of other T&E species
- Adaptation of RFAS for delivery of other fluids
  - Control of invasive weeds
  - Very precise application of pesticides
  - Delivery of methyl anthranilate or other bird irritants to influence bird distribution

Kramer Hills Permanent Study Plot, 1988

Overview of sUAS Imagery for Wildlife Monitoring

Cary McCraine (cdm366@msstate.edu)

Small unmanned aerial systems (sUAS) have proven their usefulness in a multitude of fields including precision agriculture, surveying, and wireless networks. The ability to carry an array of different sensors makes them an extremely versatile tool for anyone trying to collect small scale remotely sensed data. There are numerous cases of sUAS being used in wildlife settings such as to deter nuisance animals and monitor wildlife activity. This talk will primarily concentrate on photogrammetry of wildlife using sUAS. It will emphasize the basics of sensor selection and how to optimally collect data based on the end goal. Additionally, it will cover a couple sample workflows and lessons learned from past wildlife/sUAS projects.


Overview of sUAS Imagery for Wildlife Monitoring
Cary McCraine
GRI Research Engineer
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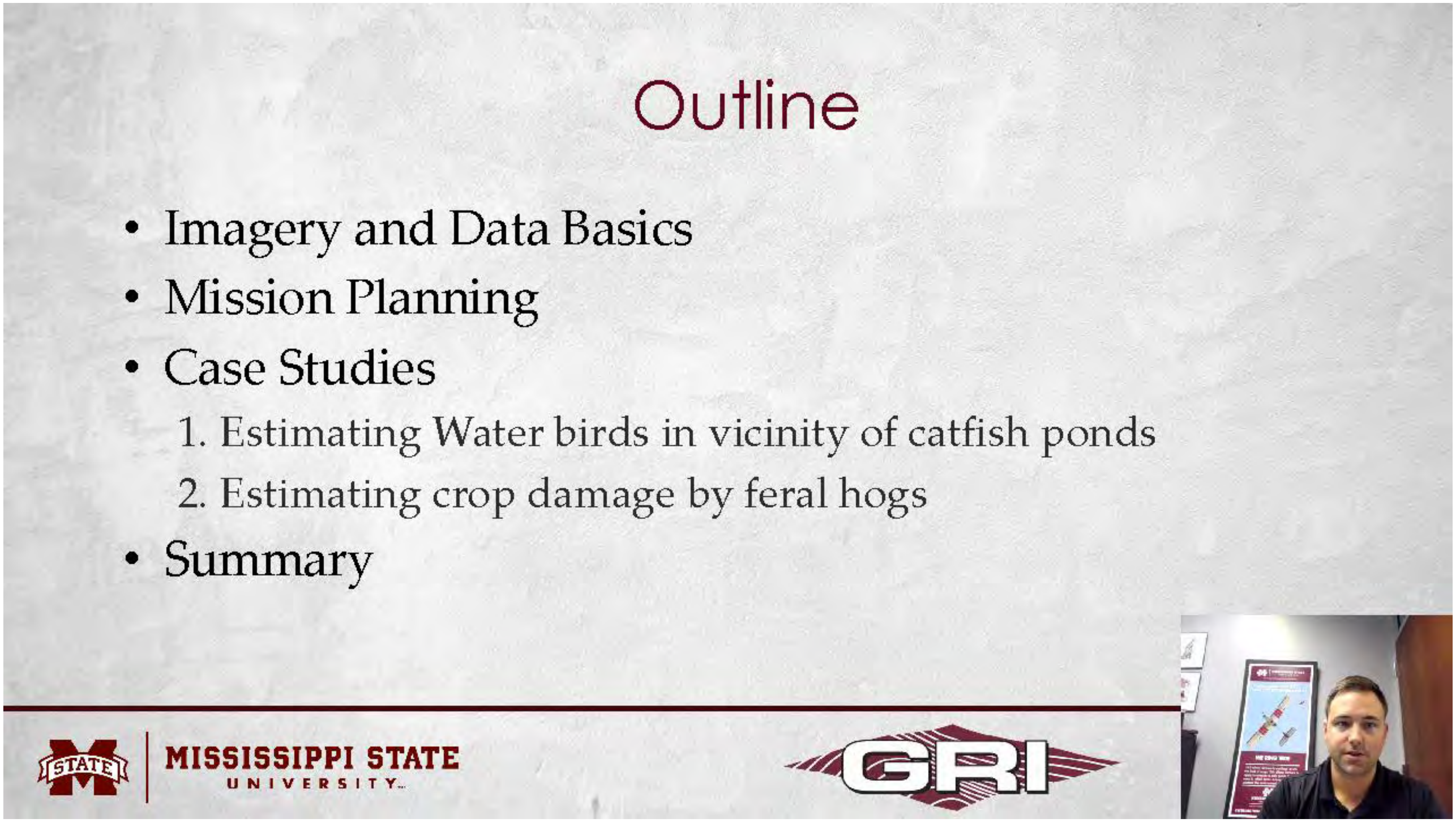
Outline
• Imagery and Data Basics
• Mission Planning
• Case Studies
1. Estimating Water birds in vicinity of catfish ponds
2. Estimating crop damage by feral hogs
• Summary
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Imagery and Data Basics

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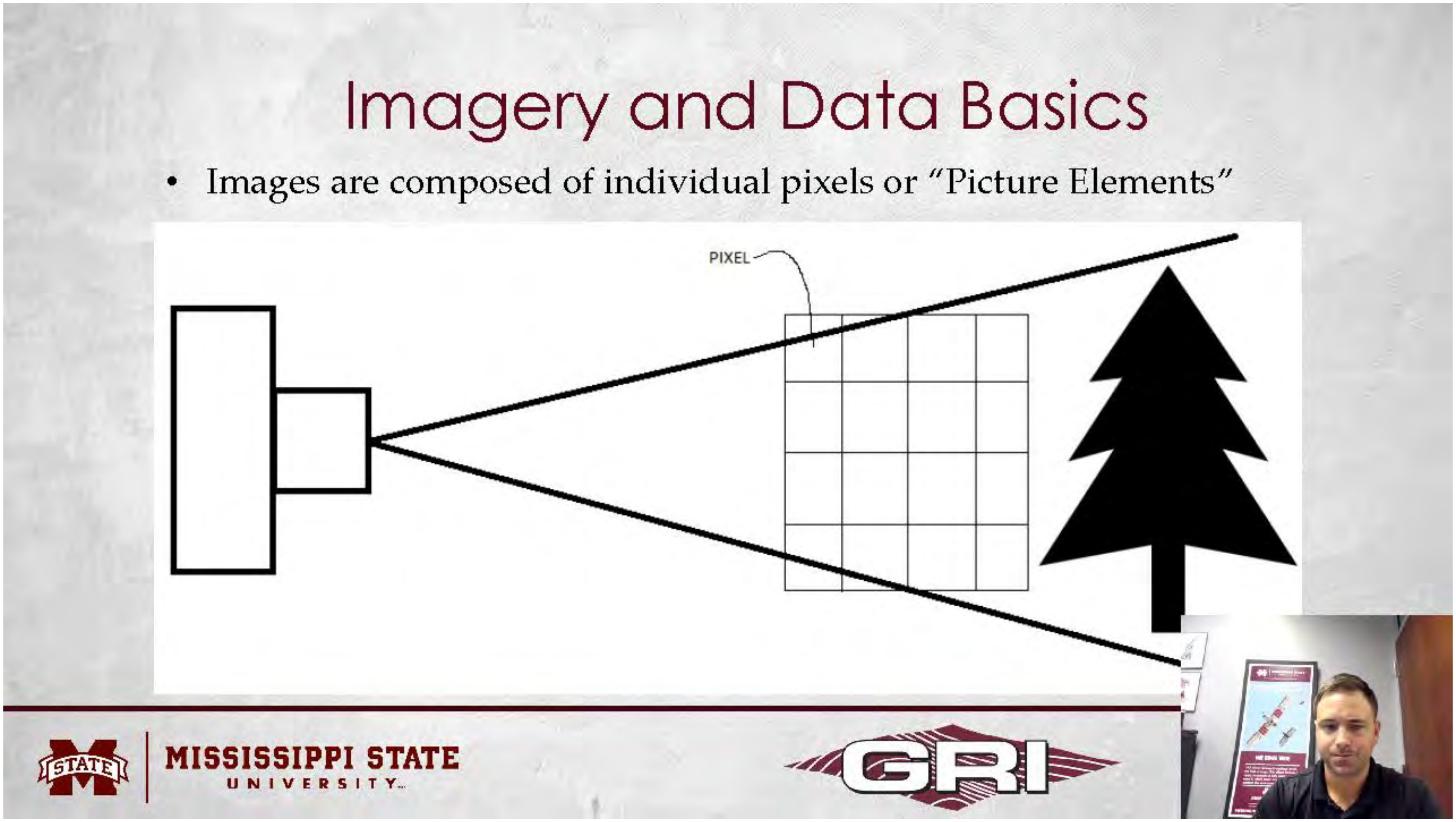
Imagery and Data Basics
• Images are composed of individual pixels or "Picture Elements"
PIXEL
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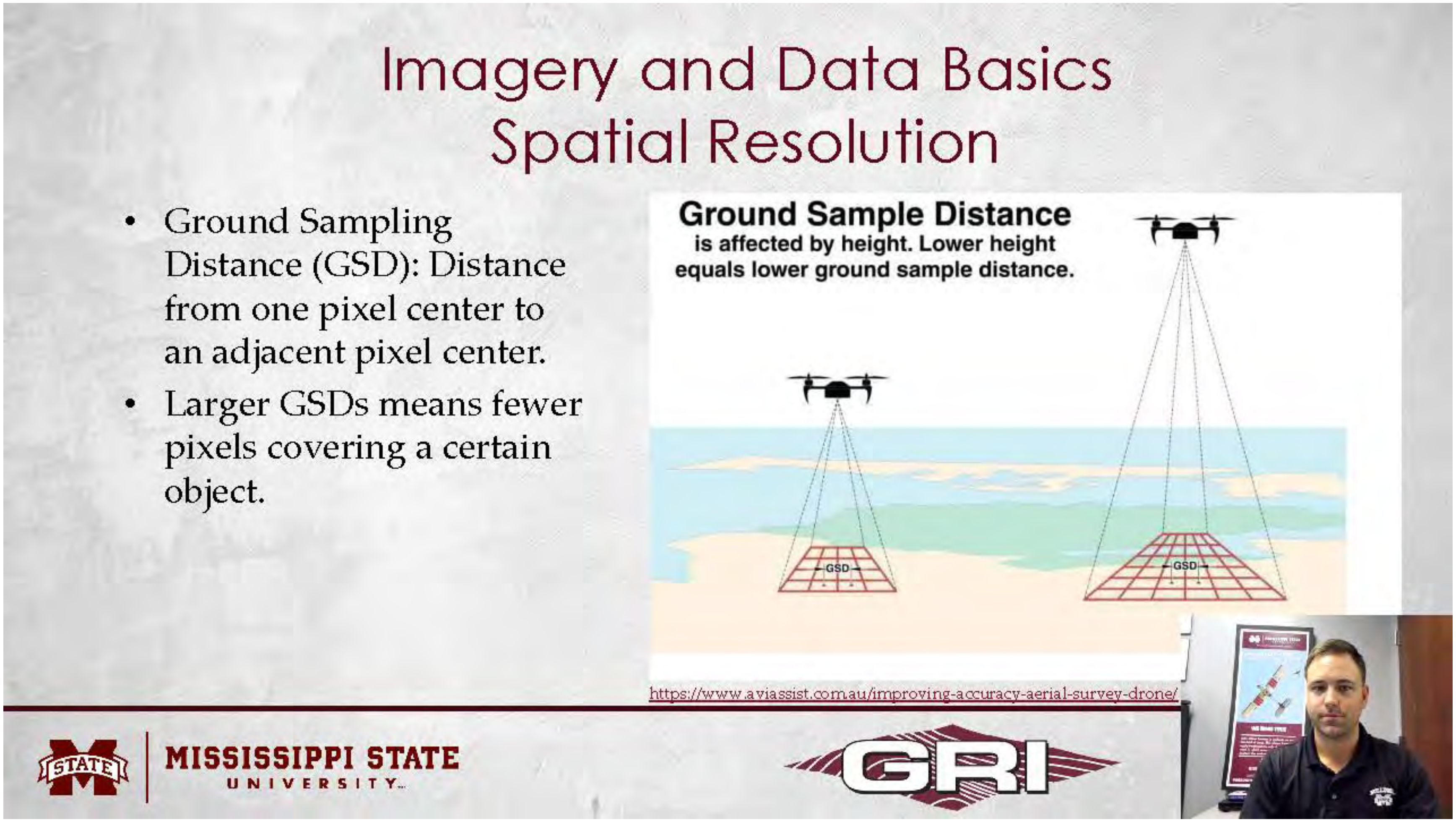
Imagery and Data Basics
Spatial Resolution
• Ground Sampling Distance (GSD): Distance from one pixel center to an adjacent pixel center.
• Larger GSDs means fewer pixels covering a certain object.
Ground Sample Distance
is affected by height. Lower height
equals lower ground sample distance.
GSD
GSD
https://www.aviassist.com.au/improving-accuracy-aerial-survey-drone/
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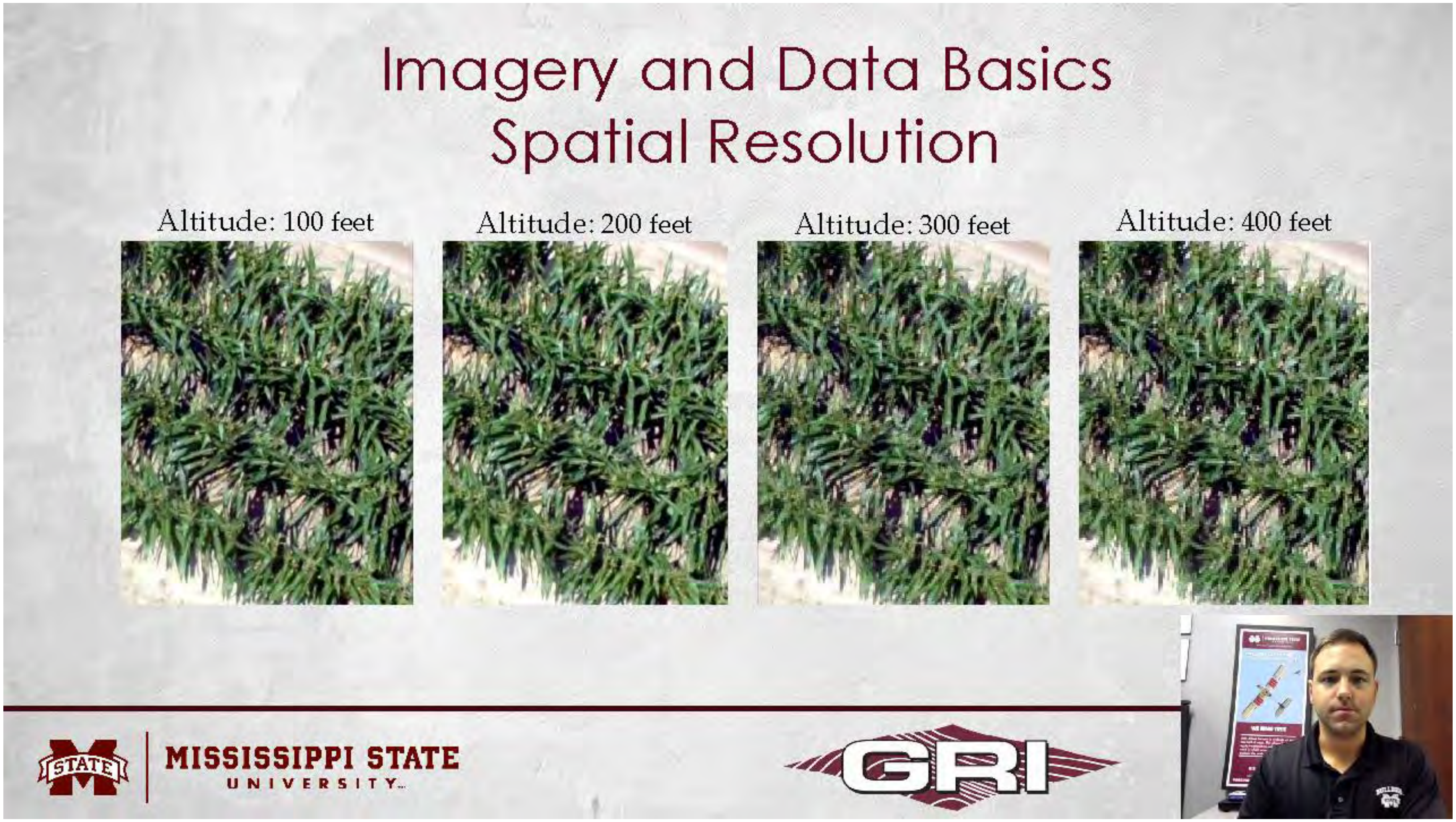
Imagery and Data Basics
Spatial Resolution
Altitude: 100 feet
Altitude: 200 feet
Altitude: 300 feet
Altitude: 400 feet
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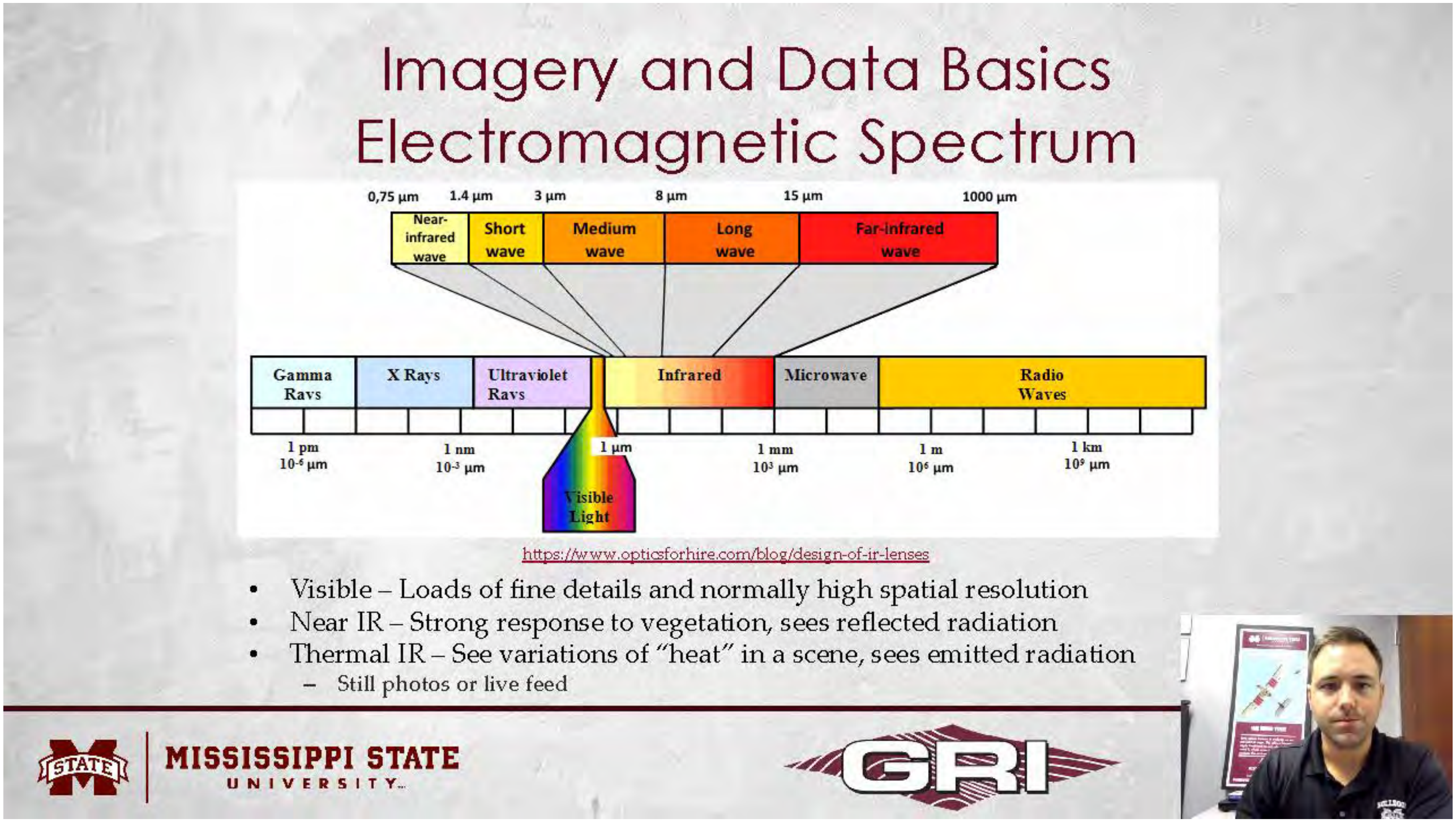
Imagery and Data Basics
Electromagnetic Spectrum
0,75 µm
1.4 µm
3 µm
8 µm
15 µm
1000 µm
Near-infrared wave
Short wave
Medium wave
Long wave
Far-infrared wave
Gamma Rays
X Rays
Ultraviolet Rays
Infrared
Microwave
Radio Waves
1 pm 10-6 µm
1 nm 10-3 µm
1 µm
1 mm 10³ µm
1 m 10⁶ µm
1 km 10⁹ µm
Visible Light
https://www.opticsforhire.com/blog/design-of-ir-lenses
• Visible – Loads of fine details and normally high spatial resolution
• Near IR – Strong response to vegetation, sees reflected radiation
• Thermal IR – See variations of "heat" in a scene, sees emitted radiation
– Still photos or live feed
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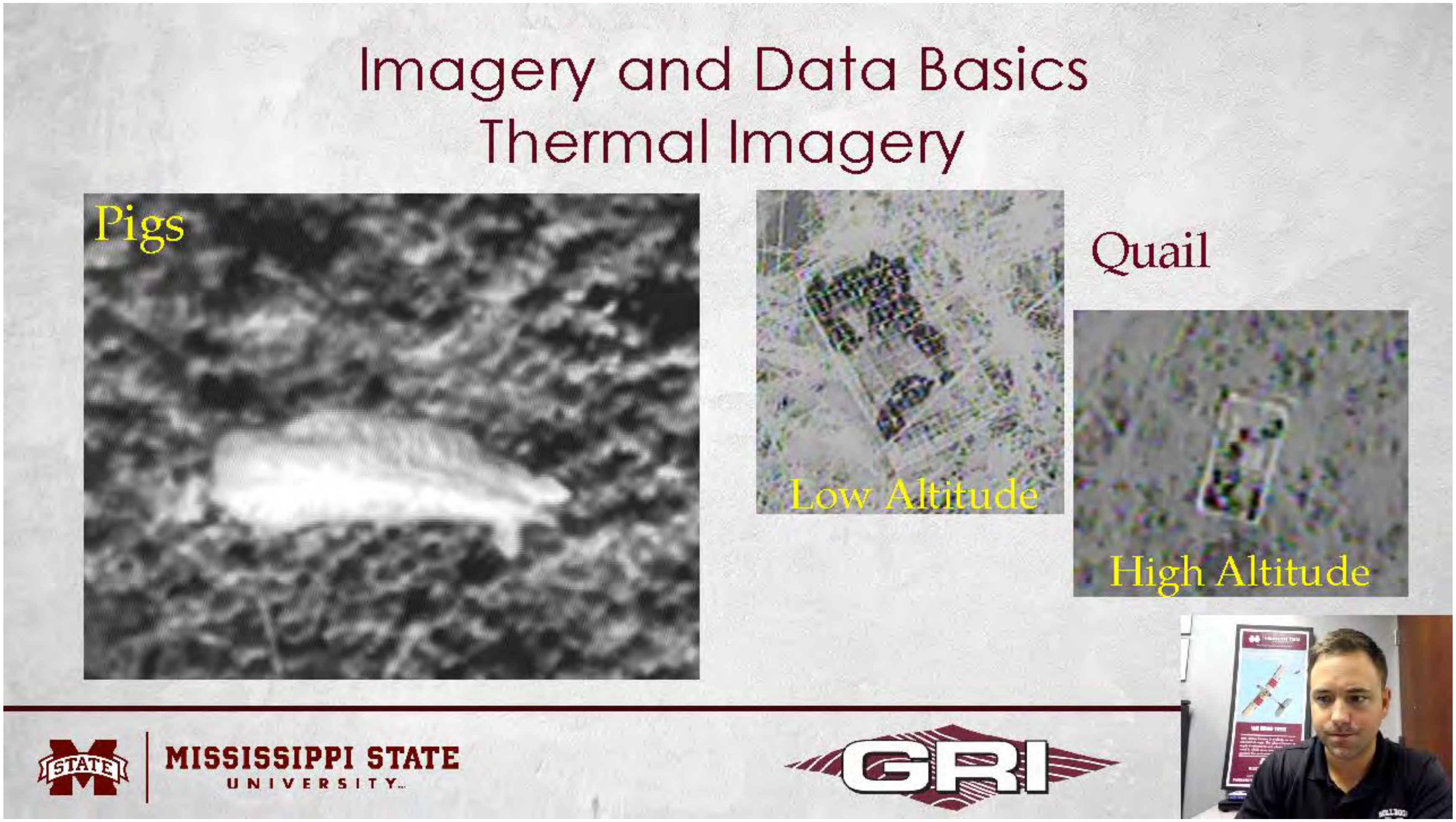
Imagery and Data Basics
Thermal Imagery
Pigs
Quail
Low Altitude
High Altitude
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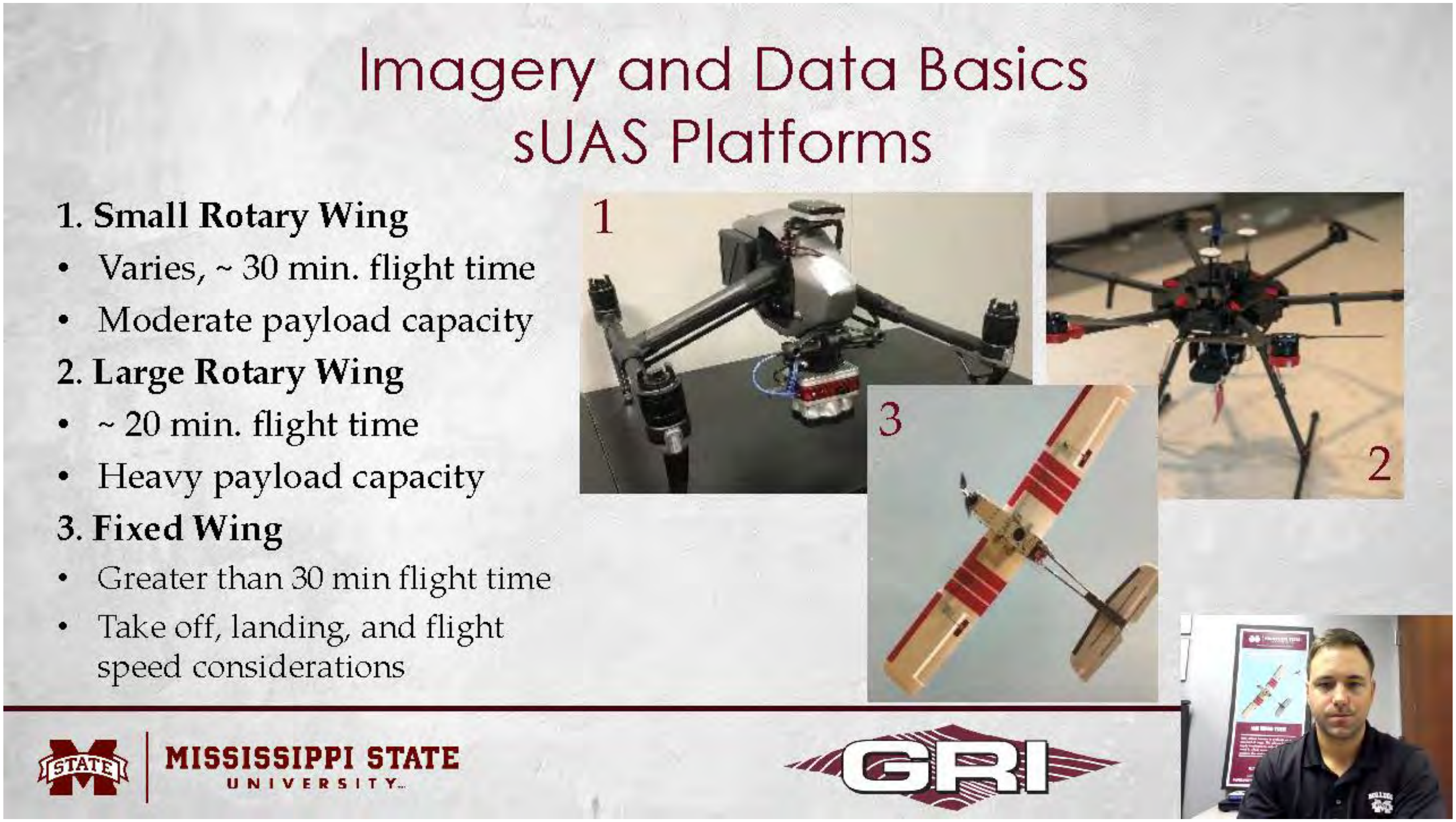
Imagery and Data Basics
sUAS Platforms
1. Small Rotary Wing
• Varies, ~ 30 min. flight time
• Moderate payload capacity
2. Large Rotary Wing
• ~ 20 min. flight time
• Heavy payload capacity
3. Fixed Wing
• Greater than 30 min flight time
• Take off, landing, and flight speed considerations
1
2
3
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Mission Planning
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Mission Planning

- The GOAL drives the mission!
  - What is your target?
  - How big is the target?
  - Is there a region in the EM Spectrum that you can exploit to make it easier to see your target?
- Spatial resolution vs. Area collected trade off

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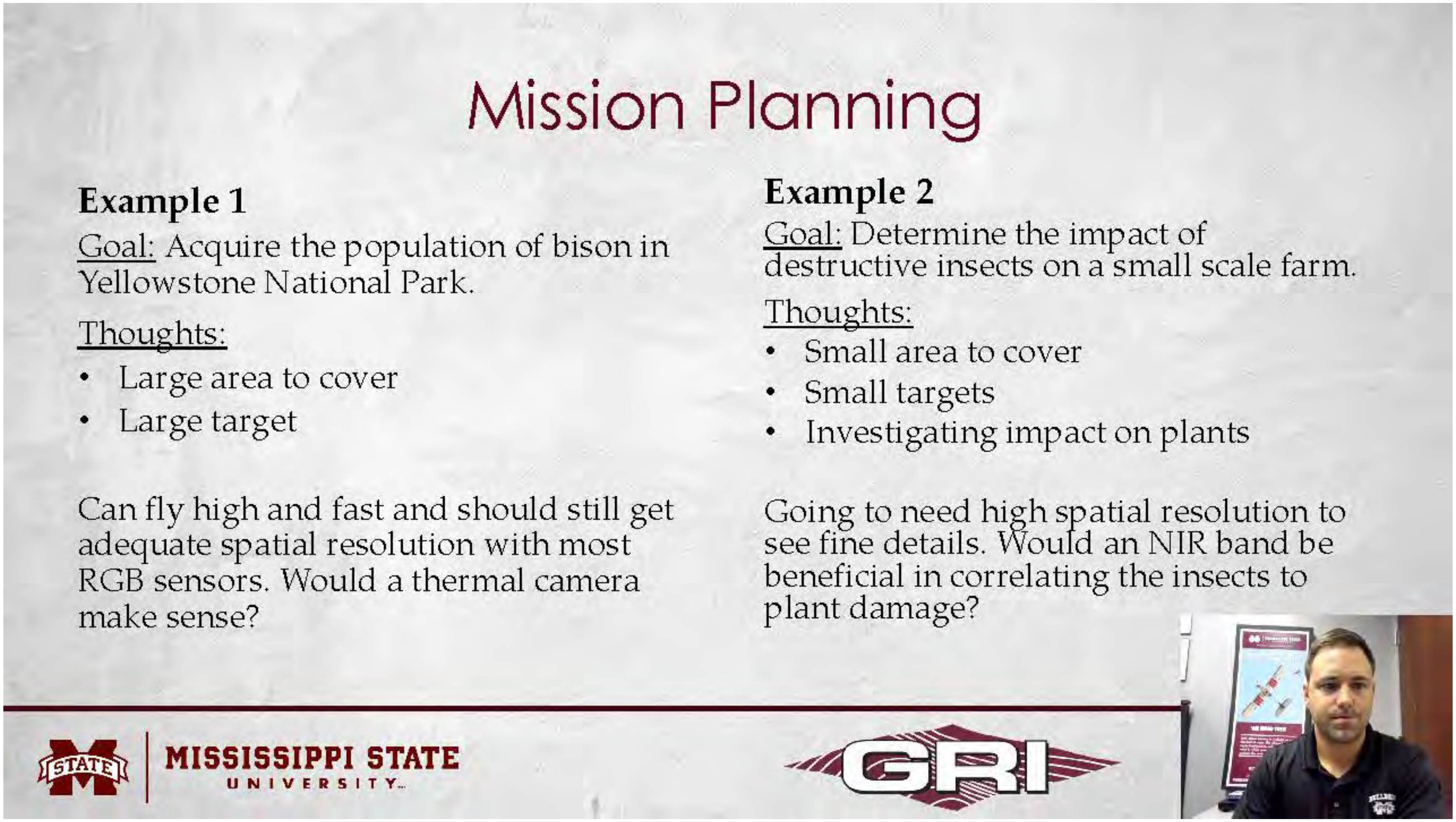
Mission Planning
Example 1
Goal: Acquire the population of bison in Yellowstone National Park.
Thoughts:
• Large area to cover
• Large target
Can fly high and fast and should still get adequate spatial resolution with most RGB sensors. Would a thermal camera make sense?
Example 2
Goal: Determine the impact of destructive insects on a small scale farm.
Thoughts:
• Small area to cover
• Small targets
• Investigating impact on plants
Going to need high spatial resolution to see fine details. Would an NIR band be beneficial in correlating the insects to plant damage?
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Case Studies

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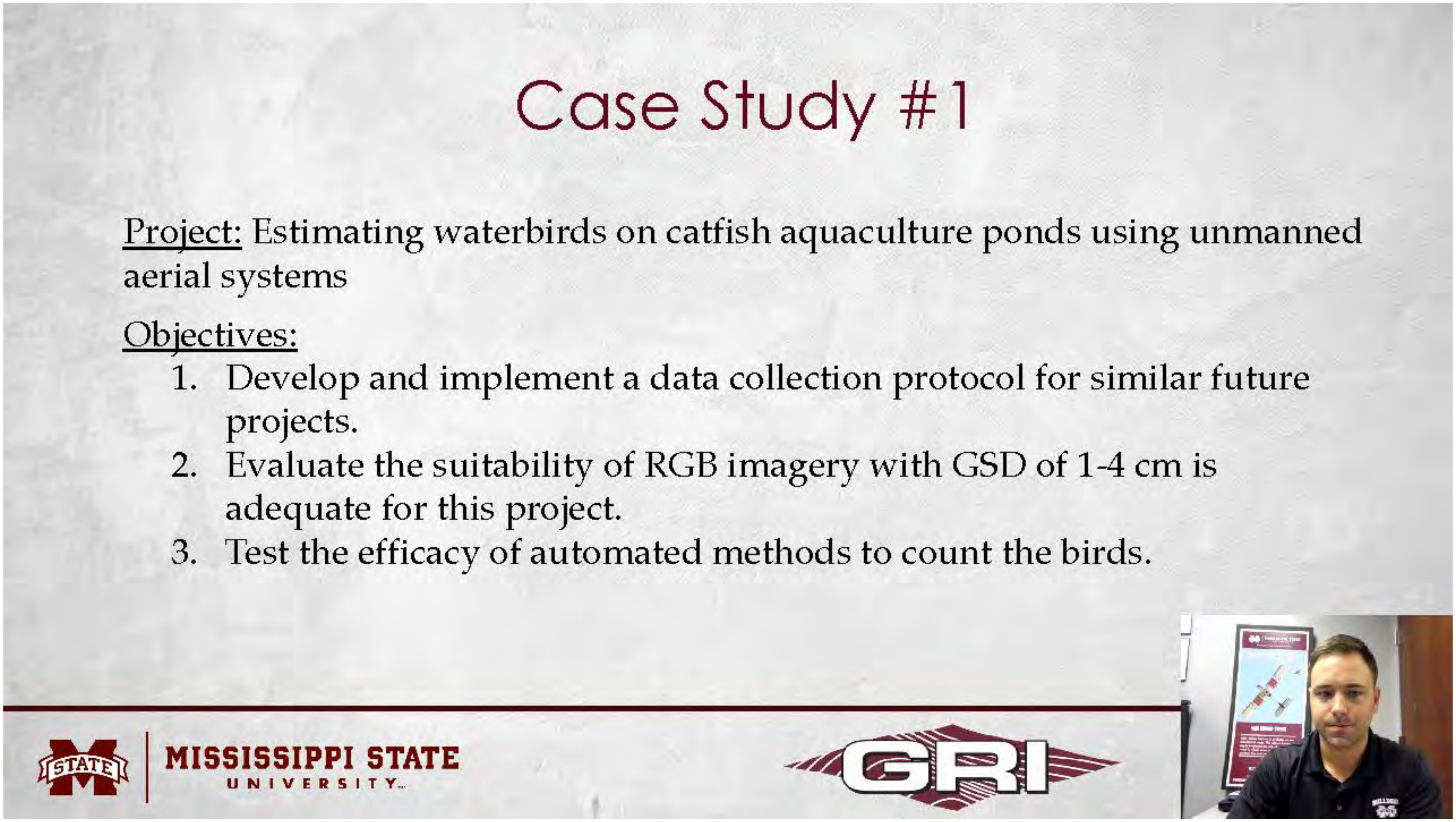
Case Study #1
Project: Estimating waterbirds on catfish aquaculture ponds using unmanned aerial systems
Objectives:
1. Develop and implement a data collection protocol for similar future projects.
2. Evaluate the suitability of RGB imagery with GSD of 1-4 cm is adequate for this project.
3. Test the efficacy of automated methods to count the birds.
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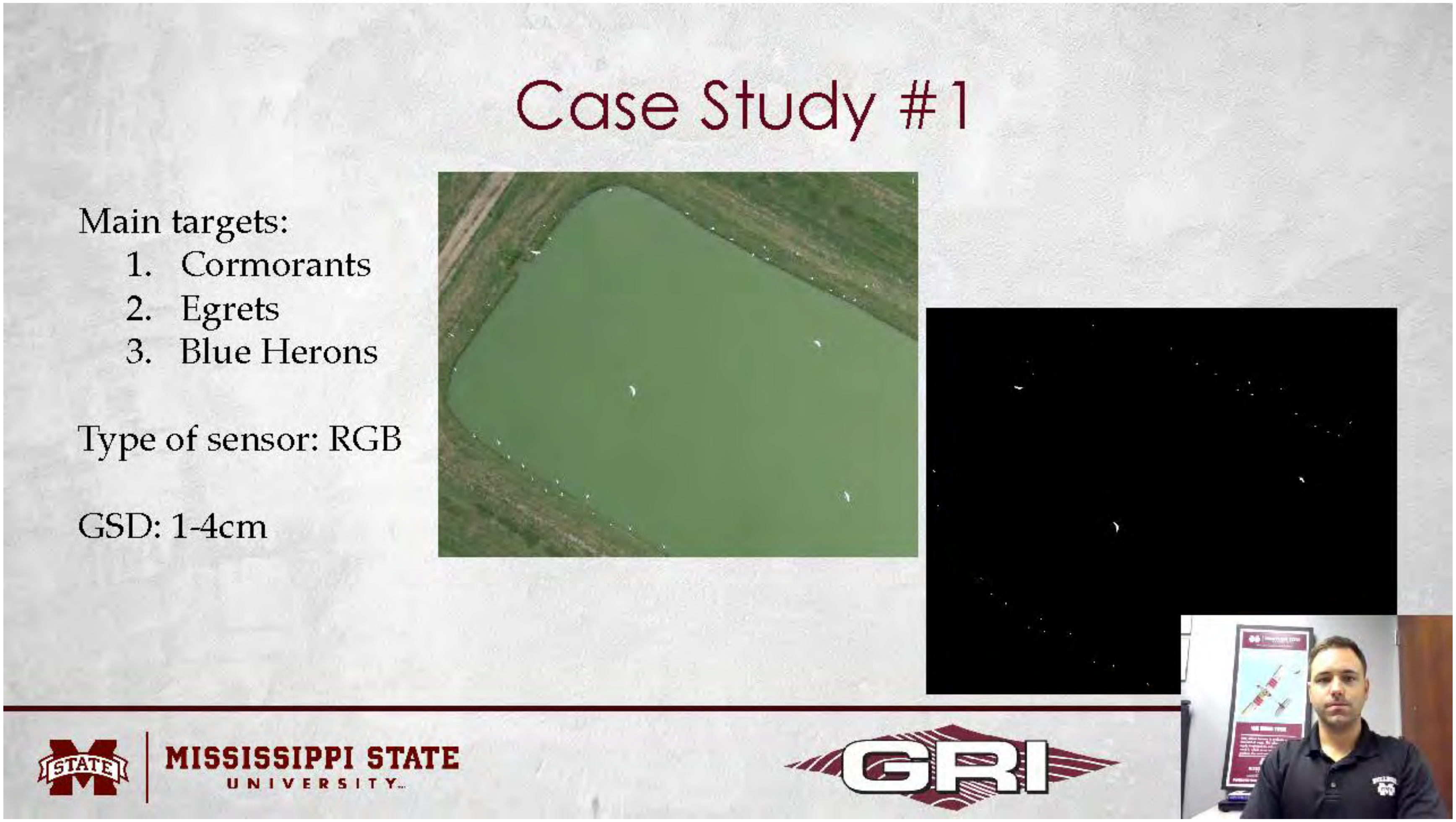
Case Study #1
Main targets:
1. Cormorants
2. Egrets
3. Blue Herons
Type of sensor: RGB
GSD: 1-4cm
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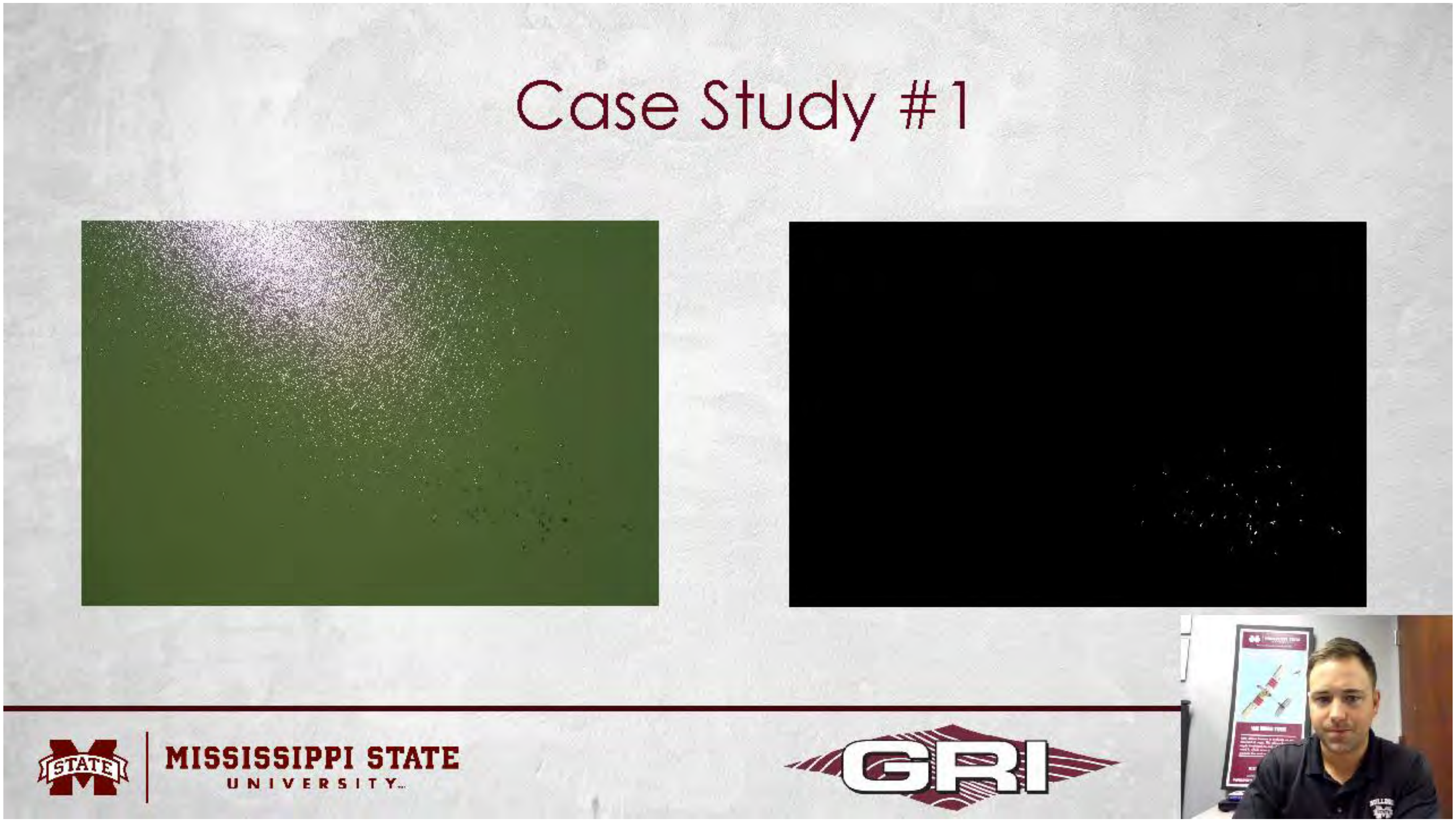
Case Study #1
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Case Study #2

Project: Quantifying Damage From Wild Pigs With Small Unmanned Aerial Systems

Objectives:

1. Obtain high resolution sUAS imagery over crops that are known to have a high wild pig presence.
2. Develop automated methods of determining the amount of area in production fields damaged by wild pigs.

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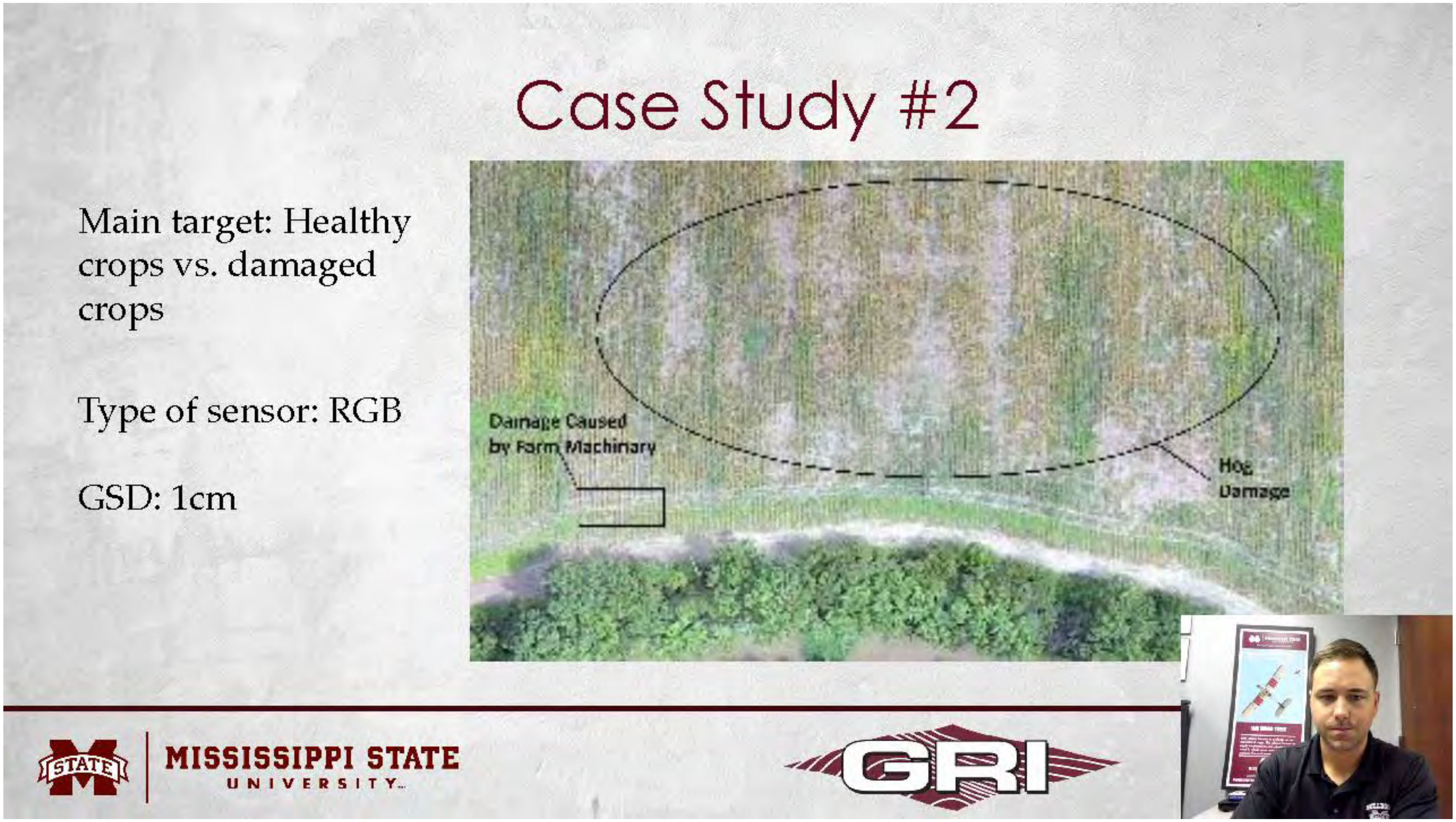
Case Study #2
Main target: Healthy crops vs. damaged crops
Type of sensor: RGB
GSD: 1cm
Damage Caused by Farm Machinary
Hog Damage
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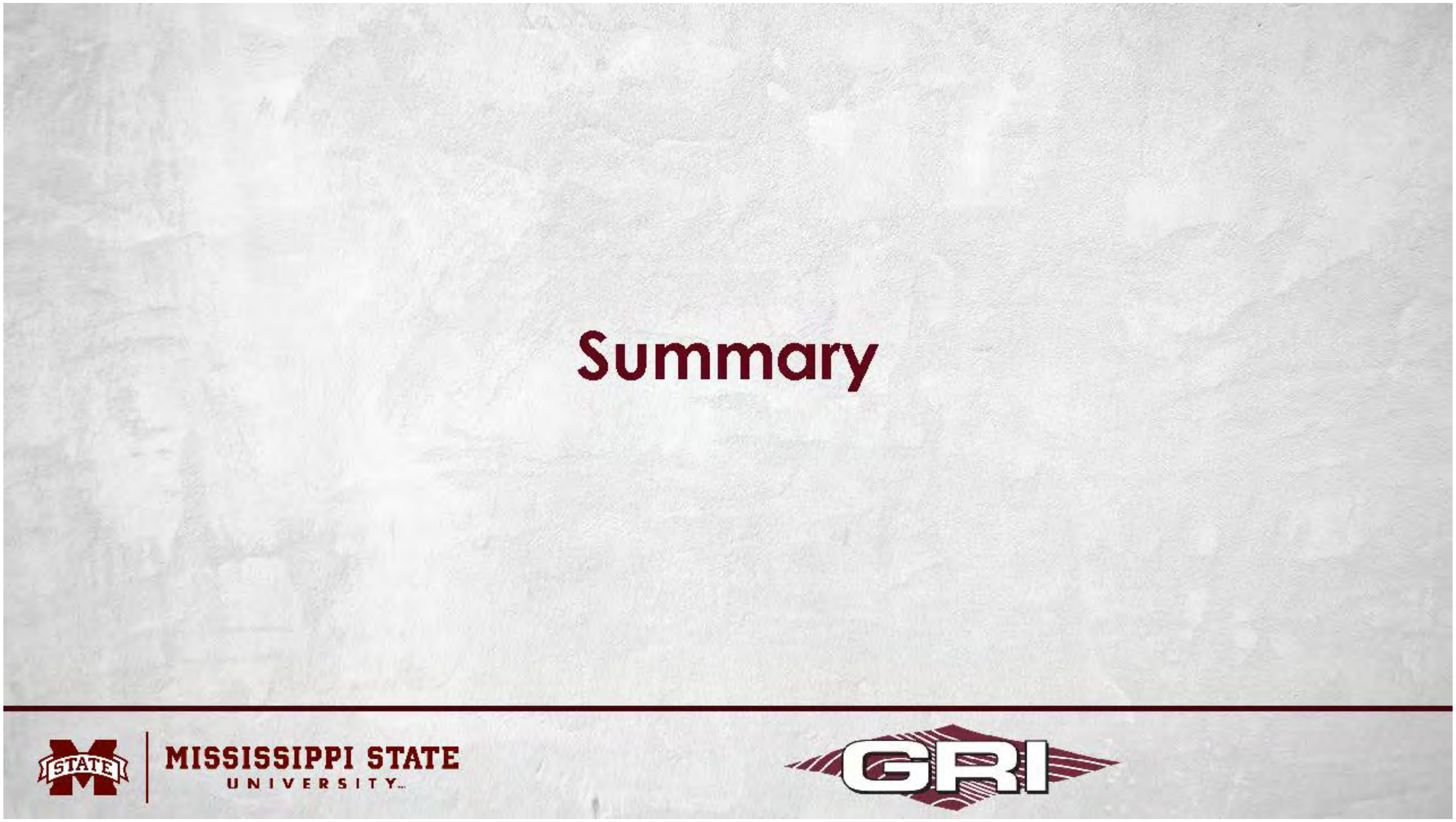
Summary
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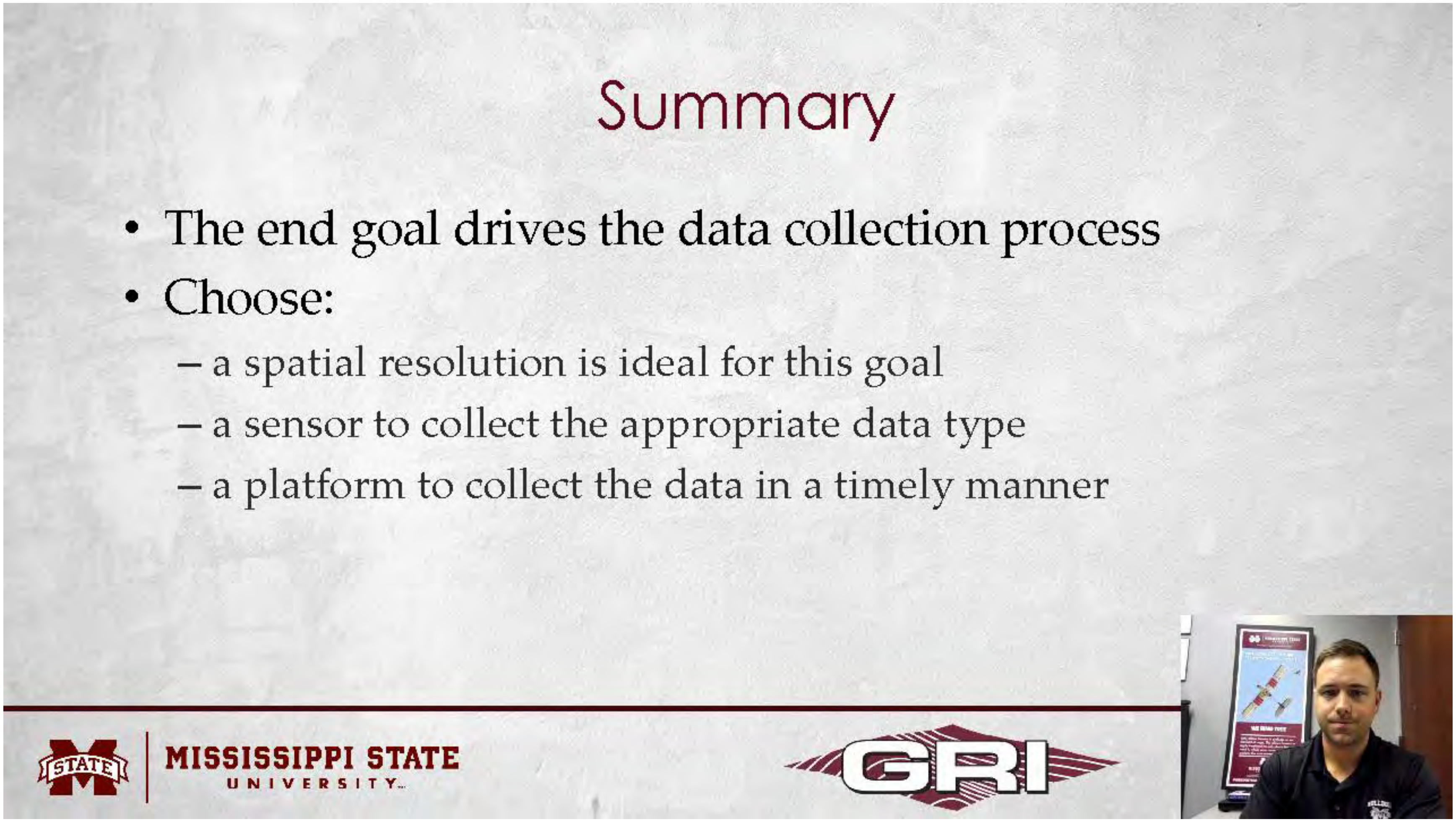
Summary
• The end goal drives the data collection process
• Choose:
– a spatial resolution is ideal for this goal
– a sensor to collect the appropriate data type
– a platform to collect the data in a timely manner
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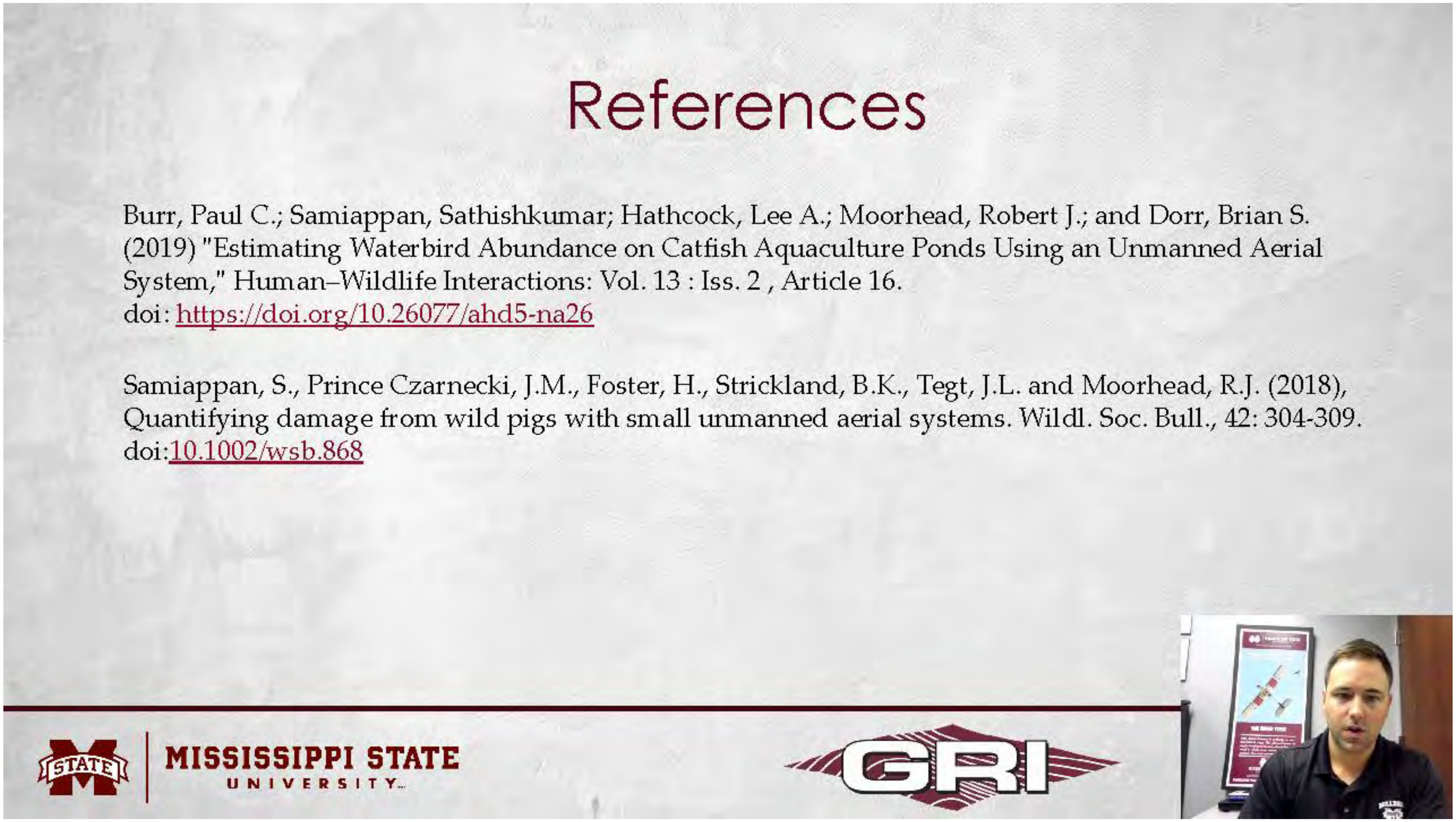
References
Burr, Paul C.; Samiappan, Sathishkumar; Hathcock, Lee A.; Moorhead, Robert J.; and Dorr, Brian S. (2019) "Estimating Waterbird Abundance on Catfish Aquaculture Ponds Using an Unmanned Aerial System," Human–Wildlife Interactions: Vol. 13 : Iss. 2 , Article 16.
doi: https://doi.org/10.26077/ahd5-na26
Samiappan, S., Prince Czarnecki, J.M., Foster, H., Strickland, B.K., Tegt, J.L. and Moorhead, R.J. (2018), Quantifying damage from wild pigs with small unmanned aerial systems. Wildl. Soc. Bull., 42: 304-309.
doi:10.1002/wsb.868
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Questions?
Office Hours: Friday, 2-3 p.m. EST
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Identifying Wildlife from Aerial Imagery Using CNNs

Sathish Samiappan* (sathish@gri.msstate.edu) and Meilun Zhou (* = *presenter*)

Aerial surveys and monitoring of wildlife using small unmanned aerial systems (sUAS) are cost-effective methods to assess changes in abundance, distribution, and species identification. The sUAS can be fitted with a variety of image sensors to detect light in both visible, near-infrared, and thermal wavelengths. High-resolution imagery collected from the sUAS enables new possibilities that are not available in the past. Manually analyzing sUAS collected imagery can be laborious and unfeasible in most scenarios, so automated assessment by computer models is desired. The supervised pattern classification algorithms such as convolutional neural networks (CNN) is shown to produce excellent classification of objects. Building a supervised learning framework for the recognition of wildlife involves a training step and a testing step. During training, features of the animals are learned from the training images or examples, which have already been labeled by an expert (a label is ground reference annotation). During the testing step, the trained model evaluates the incoming image and outputs a label or prediction. Deep learning approaches such as CNN for detecting and estimating animals from aerial imagery over large areas has gained popularity in the past 5 years. As object recognition models, deep learning algorithms such as CNN offer more accurate estimation compared to traditional statistical and other non-parametric approaches and is popular for wildlife survey. CNN's not only training the classification machine learning model but also includes the salient feature extraction step tailored to the problem. The key aspect in animal detection from the sUAS collected imagery is the representation of animal appearance heterogeneity due to different species, color, pose variations, motion blur due to animal and sUAS movements, scene illumination changes. CNN is proved to extract features that are invariant to the abovementioned constraints. This talk will cover the fundamentals of CNN architecture, open-source tools, and challenges.

Identifying wildlife from aerial imagery using CNNs

Sathish Samiappan
Assistant Research Professor
sathish@gri.msstate.edu

Meilun Zhou, and Robert Moorhead

TWS VIRTUAL
The Wildlife Society's 2020 Annual Conference

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Agenda

- Introduction
- Traditional Machine Learning Algorithms
- Artificial Neural Networks
- Convolutional Neural Networks
- Experimental Datasets
- Preliminary Results
- Discussion

1. What is a Convolutional Neural Network (CNN)? And How it is useful for classifying wildlife from any visible imagery?

2. What is deep learning and Why it is called deep learning?

3. How is deep learning CNNs are different from traditional Computer Vision Models

Simplification
Overloaded

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Introduction

Problem:

To identify/classify wildlife from aerial imagery

- Estimating abundance of free-ranging wildlife is a challenging problem
- Traditional methods produce variable results, and is labor intensive
- In recent years, deep learning-based computer vision models are proved to be better than legacy machine learning methods

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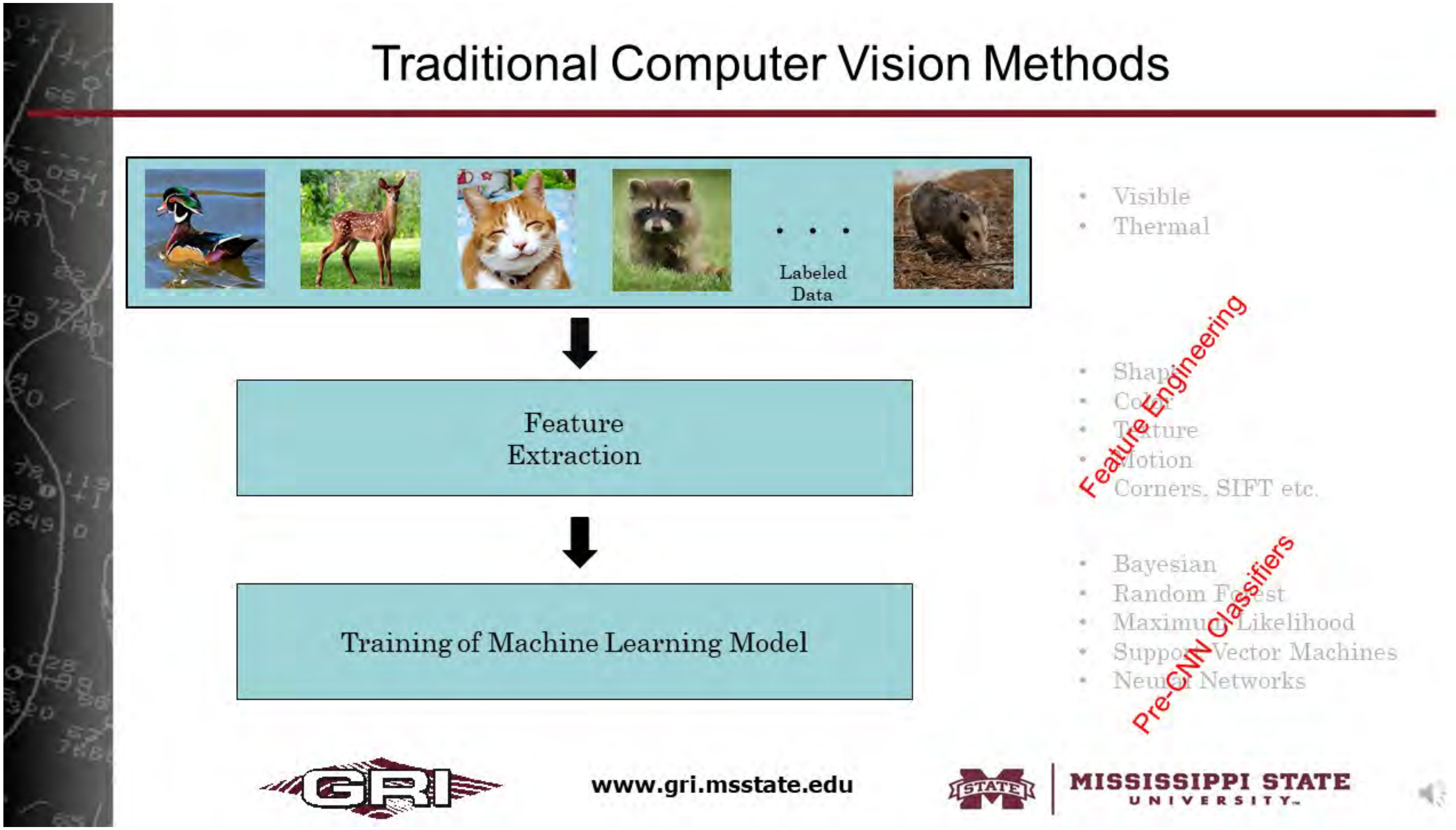
Traditional Computer Vision Methods
Labeled Data
Feature Extraction
Training of Machine Learning Model
Visible
Thermal
Feature Engineering
Shape
Color
Texture
Motion
Corners, SIFT etc.
Pre-CNN Classifiers
Bayesian
Random Forest
Maximum Likelihood
Support Vector Machines
Neural Networks
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Artificial Neural Networks

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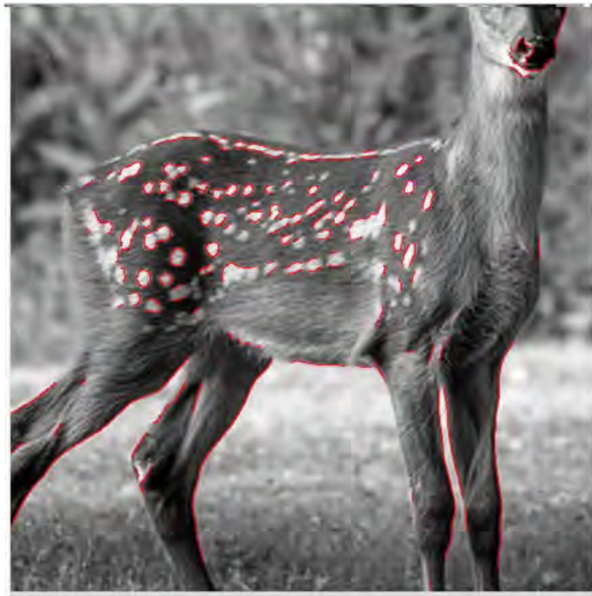
Convolution or Filtering



Canny Edge Detection Filters

Daubechies Wavelet Filters

Created using 2018 Image Processing Online Demonstration Tool, Swiss Federal Institute of Technology Lausanne

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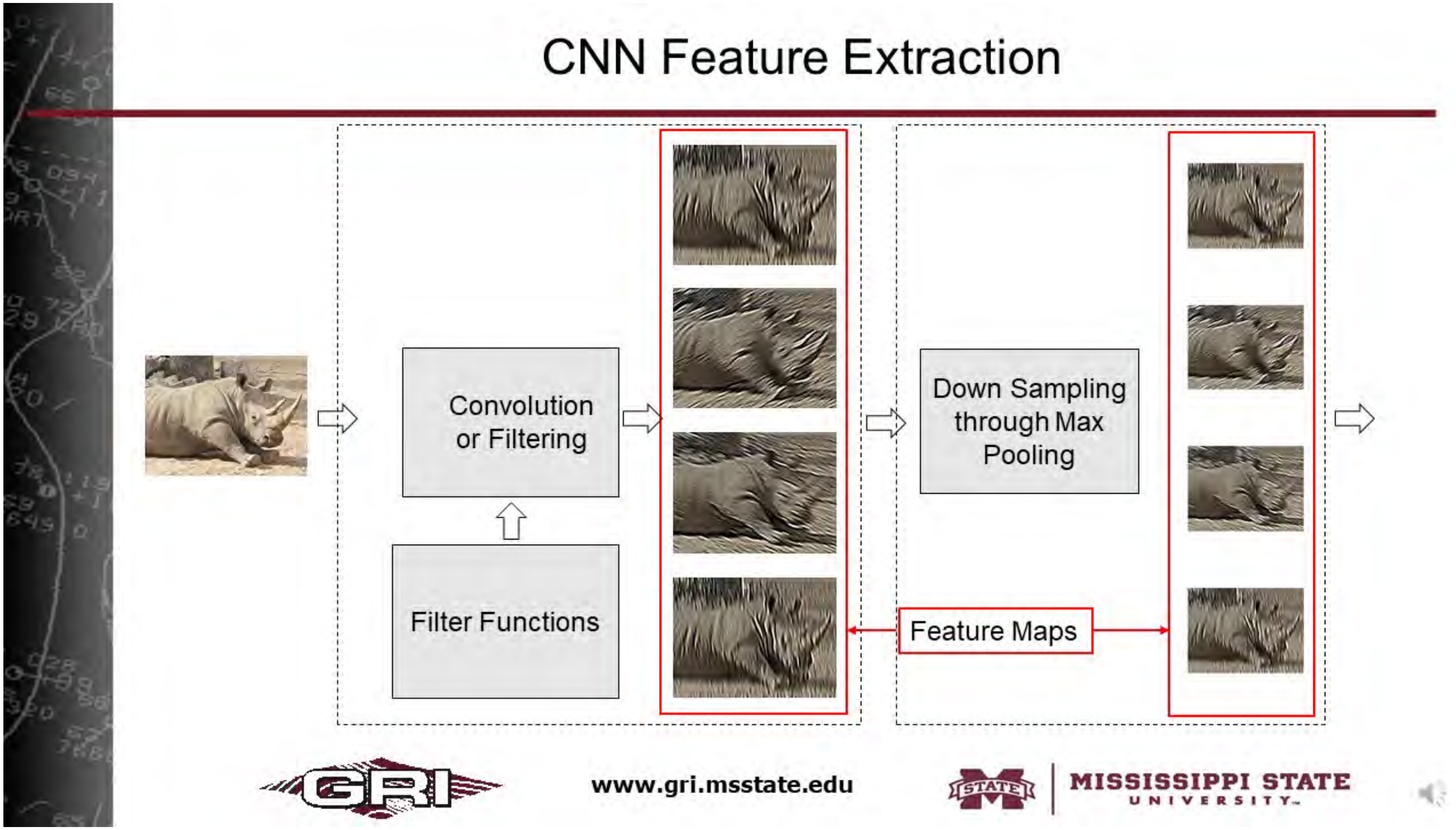
CNN Feature Extraction
Convolution or Filtering
Filter Functions
Down Sampling through Max Pooling
Feature Maps
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Convolutional Neural Network Architecture

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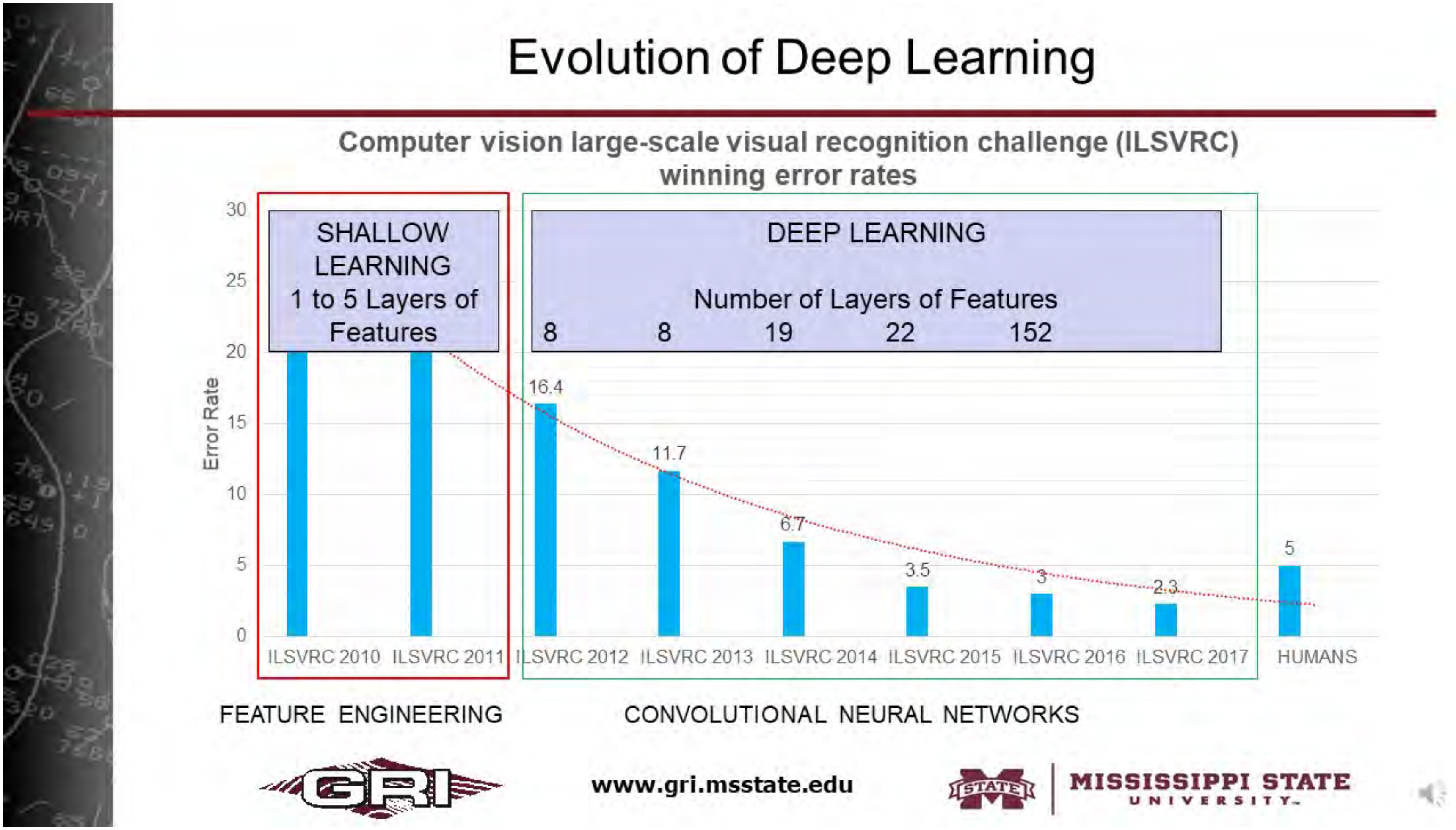
Evolution of Deep Learning
Computer vision large-scale visual recognition challenge (ILSVRC) winning error rates
SHALLOW LEARNING
1 to 5 Layers of Features
DEEP LEARNING
Number of Layers of Features
8
8
19
22
152
Error Rate
30
25
20
15
10
5
0
16.4
11.7
6.7
3.5
3
2.3
5
ILSVRC 2010
ILSVRC 2011
ILSVRC 2012
ILSVRC 2013
ILSVRC 2014
ILSVRC 2015
ILSVRC 2016
ILSVRC 2017
HUMANS
FEATURE ENGINEERING
CONVOLUTIONAL NEURAL NETWORKS
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Experimental Datasets

- CIFAR-10 – 60000 images -10 classes
- Caltech UCSD Bird 200 – 6033 images – 200 classes
- Animals with Attributes (AwA) – 37322 images – 50 classes
- Feline Classification data Kaggle Competition – 2700 images of cheetahs, hyenas and tigers

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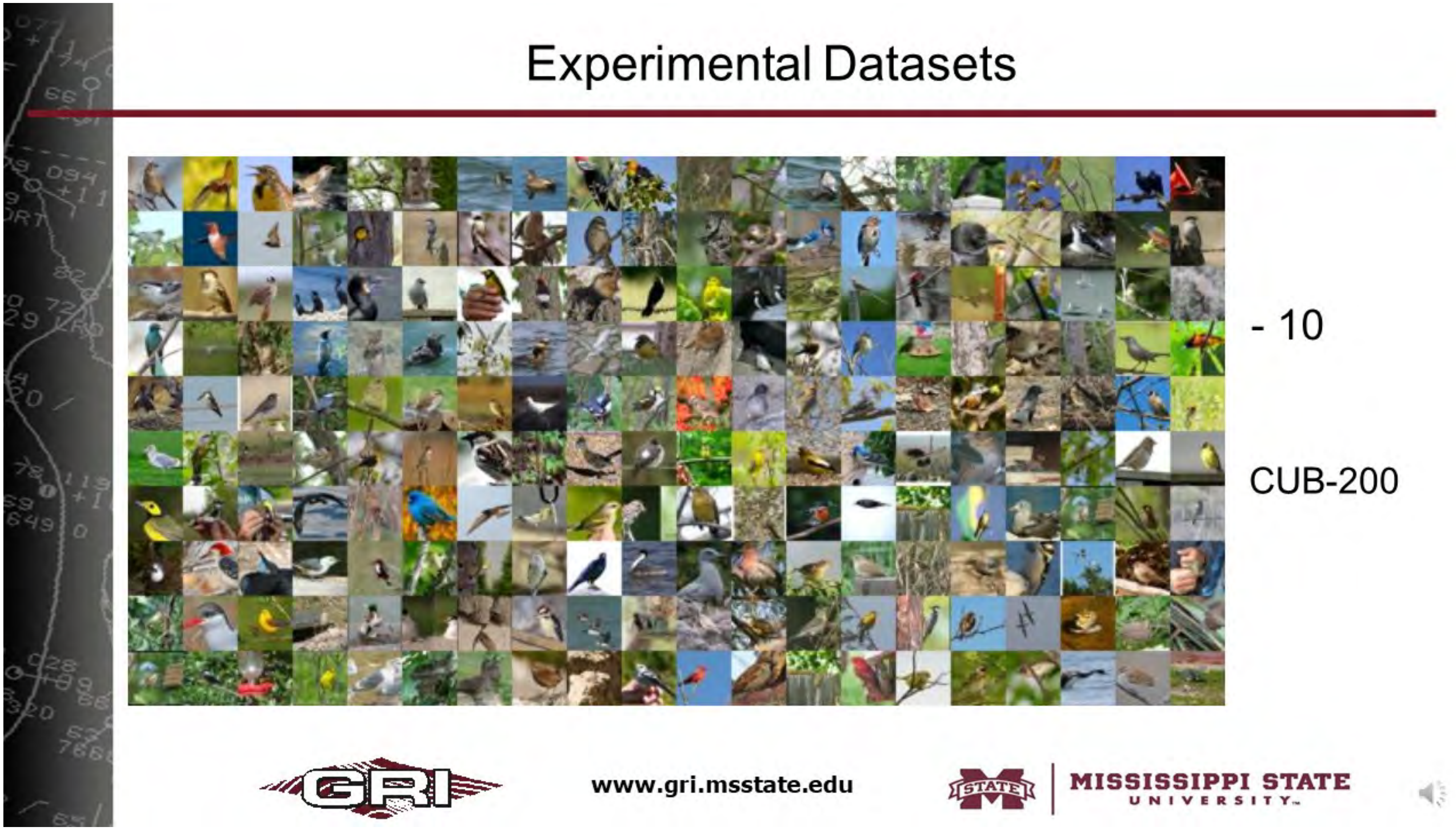
Experimental Datasets
- 10
CUB-200
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Preliminary Results

ResNets - CIFAR10

ResNet18: 93.33%
ResNet34: 92.92%
ResNet50: 93.86%

ResNets – CUB200

ResNet18: 72%
ResNet34: 76.9%
ResNet50: 77.2%

ResNets – AwA

ResNet18: 93.26%
ResNet34: 93.71%
ResNet50: 93.92%

ResNets – Feline

ResNet18: 99.06%
ResNet34: 99.37%
ResNet50: 93.54%

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Thank you!

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Standardized Protocol for Reporting Methods When Using Drones for Wildlife Research

Susan Ellis-Felege, Andrew Barnas* (Andrew.f.barnas@gmail.com), Dominque Chabot, Amanda Hodgson, David Johnston, and David Bird (* = *presenter*)

Drones are increasingly popular tools for wildlife research, but it is important that the use of these tools does not overshadow reporting of methodological details required for evaluation of study designs. The diversity in drone platforms, sensors, and applications necessitates the reporting of specific details for replication, but there is little guidance available on how to detail drone use in peer-reviewed articles. Here, we present a standardized protocol to assist researchers in reporting of their drone use in wildlife research. The protocol is delivered in six sections: (1) Project Overview; (2) Drone System and Operation Details; (3) Payload, Sensor, and Data Collection; (4) Field Operation Details; (5) Data Post-Processing; and (6) Permits, Regulations, Training, and Logistics. Each section outlines the details that should be included, along with justifications for their inclusion. To facilitate ease of use, we have provided two example protocols, retroactively produced for published drone-based studies by the authors of this protocol. Our hopes are that the current version of this protocol should assist with the communication, dissemination, and adoption of drone technology for wildlife research and management.

A Standardized Protocol For Reporting Methods When Using Drones For Wildlife Research

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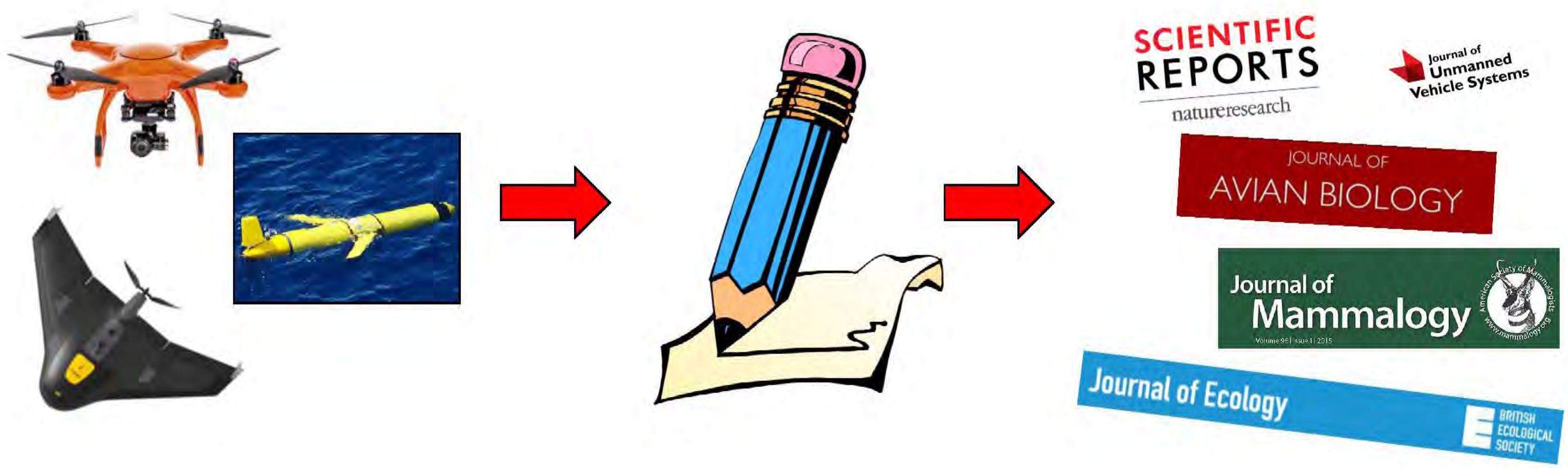


A Brief History of the Centrifuge

1695 Dutch scientist Christiaan Huygens derives the concept of centrifugal force

Mid **1800's** German café owner Antonin Prandtl uses a spinning device to separate milk from it's fat

1924 Swedish chemist Theodor Svedberg studies colloids and proteins, brings centrifuges into the laboratory

Idea

Novel Use

Practical Science!

A Brief History of the Centrifuge




- Today, centrifuges are an essential tool in wetlabs everywhere
- Centrifuges come in all shapes and sizes, with a range of functions
- Centrifuges play an essential role in everything from population genetics to the development of nuclear power!

New tools have the potential to revolutionize science!

Drones Are Popular Tools!

- We are in the middle of a technological revolution involving drones!
- Drone use in wildlife research is on the rise → **Increased publications**
- Drones first showed up in the early 2000's and became more popular in the last decade
- Since then they've been used for many different taxa and purposes

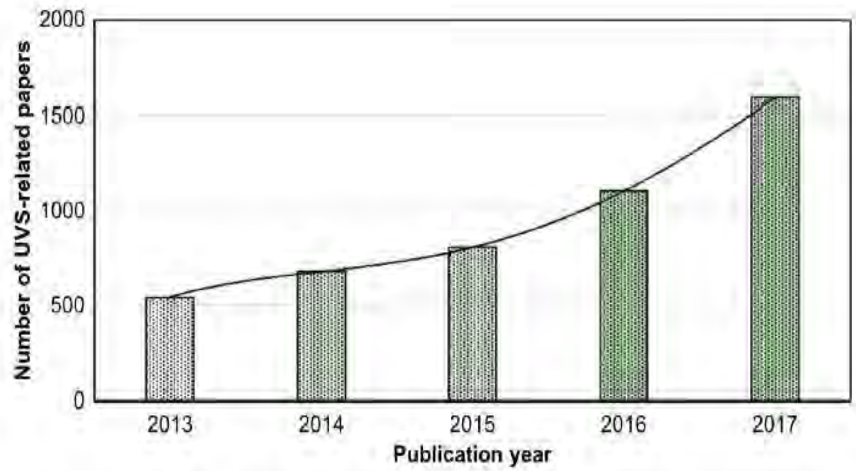


Figure 1. Chabot et al. (2018) Journal of Unmanned Vehicle Systems

But why have drones become so popular?

Diverse Applications of Drones

Habitat Assessment
Barnas et al. 2019 (*PLoS ONE*)

Collecting Biological Samples
Raudino et al. 2019 (*Ecosphere*)

Mitigating Human-Wildlife Conflict
Wang et al. 2019 (*Crop Protection*)

Counting Duck Nests With Thermal Imagery
Felege et al. (*In-Prep*)

Drones Are Popular Tools!

- Diversity of drone use is due to the breadth of platforms, sensors, flight patterns, etc.
- Different combinations allow different applications/questions
- We are seeing a gradual shift in publications from “proof-of-concept” to papers that simply use drones as data collection tools.

Tools not toys!

How Should We Write About Drones?

- While there are lots of recommendations on how to use drones for wildlife research, **there is little guidance on how to write about them *as methods*.**
- Since their use is relatively new (but widespread),when we submit for peer-review reviewers and editors may have different expectations on details to include
- Different expectations→ Inconsistent reporting in the literature!

If we want to promote drones as promising tools for wildlife research, we need to *facilitate methodological reporting* and the ability to *replicate our research*!

How Should We Write About Drones?

- Reporting all of the technical details of drone use is onerous, but necessary!
  - This can bog papers down with technical details.
- Other fields have overcome these reporting problems with standardized reporting protocols/methods:
  - ODD Protocol for Agent Based Models- Grimm et al. 2006, 2010
  - Regression Based Statistics – Zuur and Ieno 2016
  - ARRIVE Guidelines for Animal Research – Kilkenny et al. 2010

Drone-based wildlife research could benefit from a standardized reporting protocol!

Benefits of a Standardized Supplementary Protocol

If we consistently report drone details in a standardized way, this will:

1. Directly **helps authors write manuscripts** by informing what information should be included

2. **Facilitates peer-review** by allowing reviewers and editors to easily check if relevant information has been included

3. Helps interested readers **easily track down information** in consistent sections

4. Frees up main manuscript text by **outsourcing technical jargon** to supplementary materials

5. **Assists future drone users** by communicating what kind of work goes into using a drone, and **how they can replicate studies** in their own system.

Proposed Drone Reporting Protocol

Section	Information Provided
1. Project Overview	General overview of drone(s) purpose in the study
2. Drone System and Operation Details	Details of the actual drone(s) that was used
3. Payload, Sensor, and Data Collection	Details of the sensor used to collect data (or any other payload)
4. Field Operation Details	How many flights? What altitude? What environmental conditions?
5. Data Post-Processing	How was drone data processed before "main analysis"? Typically details on mosaicking process
6. Permits, Regulations, Training, and Logistics	Demonstrate regulatory compliance and due diligence

1. Project Overview

A brief description of the manuscript project and description of how the drone(s) was used to collect data for the study

- Since the protocol is intended to be included as supplementary material, this helps **contextualize the remaining sections**
- Allows reader to evaluate the document independently
- Formatted ideally as a short paragraph

2. **Drone System and Operation Details**

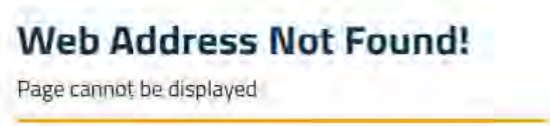
2.1 Platform Specifications

Identify the type of drone used, along with physical characteristics relevant to the study

- Drone styles are diverse! Identify exactly **which drone was used**, and consider including a photo!
- If using a commercially available drone, identify the technical specifications here
  - *Don't make the reader track down information on third party websites*
  - Often these details become quickly outdated and removed

DJI Phantom 4 webpage:

Trimble UX5 webpage:



2. Drone System and Operation Details

2.1 Platform Specifications

Identify the type of drone used, along with physical characteristics relevant to the study

Types of Characteristics to Report:

1) **Fixed-wing vs Multi-rotor-** FW generally have longer/higher flights, more appropriate for large scale studies, MR typically shorter targeted flights

2) **Drone size** (dimensions and weight)- informs on durability, potential invasiveness for wildlife

3) **Power source** (electric vs combustion)- informs on flight time and limitations for remote work

4) **Colour**- often overlooked, especially important for behavioural studies

2. **Drone System and Operation Details**

2.2 Takeoff and Retrieval

Describe the method and requirements of takeoff and landing for the drone.

- More relevant for fixed wing platforms, but still should be described for multi-rotor models
- Was any **specialized equipment** or areas required? E.g. landing pads, nets, "sky hooks"
- Not all takeoffs and landings for drones are the same! This is informative for readers in **understanding what goes into using a drone** for wildlife research.

Fig 2. Hodgson et al. 2017

This is all relevant for the replication of your study!

2. **Drone System and Operation Details**

2.3 Flight Planning and Method of Operation

How is the drone operated (manually, autonomous, semi-autonomous)? What is the flight design used in the study?

- This is essentially the **survey design details** of your drone use (may need to be provided in main text as well)
    - Parallel transects?
    - Fixed point surveys?
    - Custom flight designs?
- Describe any **flight planning software** used (names and version numbers!)
- Consider including a figure here!

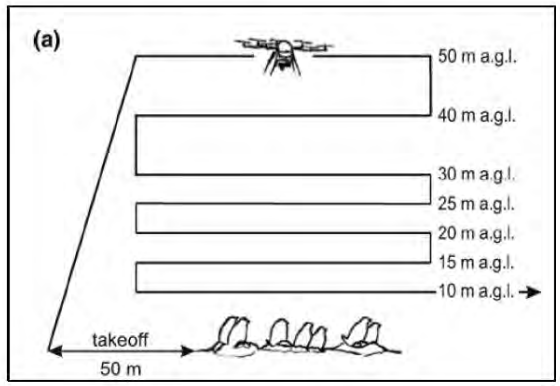
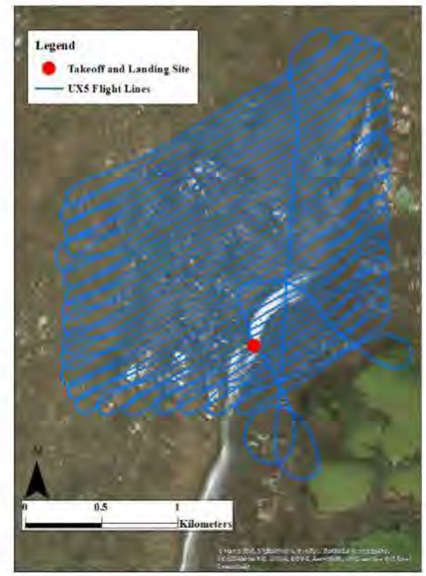


Fig 1 Rummler et al. 2015



Supplementary Figure. Barnas et al. 2020

3. Payload, Sensor, and Data Collection

3.1 Data Overview

What is the nature of the data being collected from the drone?

- This will be the most variable section! There are many types of data that can be collected by a drone:
  1) RGB Imagery
  2) Thermal Imagery
  3) Acoustic data
  4) Biological Samples
  5) Hyper/Multispectral Imagery
  6) Telemetry data
- Inform the reader **what is being collected**

- If you need to convince readers of data quality, consider submitting example raw data here:
- E.g. "Is it really possible to identify individual whales from drone imagery?" **Yes!**

Fig 4. Durban et al. 2015

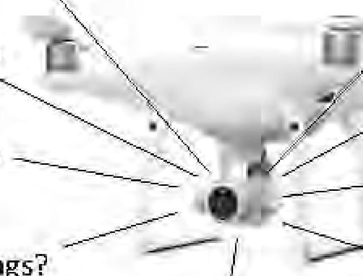
Note that **not all studies will use data collected by the drone**! E.g. Bait dispensers, drones as deterrents, behavioural responses! This section may be blank for some studies!

3. Payload, Sensor, and Data Collection

3.2 Payload or Sensor Description and Data Collection Methods

Describe the onboard sensor that is actually collecting the data. Which sensor parameters were specified that would be needed to replicate your study?

- This is the most technically tedious section, but **directly inform on how data was collected**!
- Highlights the importance of note taking during surveys, figuring out this information months after flights is painful



"We used the default camera settings"

- How is the reader supposed to know what those settings are?

4. Field Operation Details

The When/Where/What of how you actually used the drone in your study.
Provide a summary of flights conducted here.

- Often, studies will involve multiple drone survey flights
- But when multiple flights are performed, at different altitudes, with different drones, on different days…**it can be difficult to keep track of**!
- This is simply providing the spread of when/where your data came from!
- **May be done in table format** for more complex studies
- Specify summary differences in flight parameters

Example Summary Table

Date	Flight #	Drone	Altitude (m)
July 17th	1	Trimble UX5	100
July 17th	2	Trimble UX5	100
July 18th	3	Trimble UX5	120
July 19th	4	Phantom 4 Pro	45
July 19th	5	Phantom 4 Pro	45

5. Data Post-Processing

Describe any post processing done to drone data prior to the "main analysis".

- Primarily concerns mapping using georeferenced imagery
- Describe any software used to produce orthomosaics, and any relevant settings
- Consider **including a mosaic quality report**→ convince the reader that your mosaic is well produced!

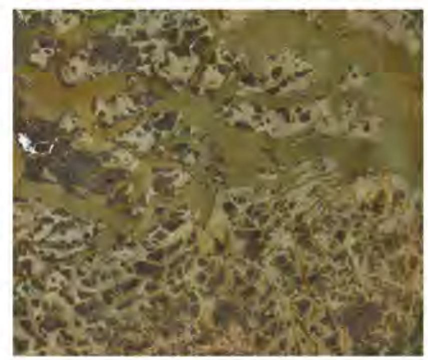
% Image overlap?
Ground Control Points?
Differences in aw vs final resolution?
Mosaic errors?

Raw Drone Imagery

Mosaic Software

PIX4D

Final Mosaic to be Analyzed!



6. Permits, Regulations, Training, and Logistics

What regulatory or logistic steps were required for using a drone in your study?

- Use of drones still remains questionable in the public eye, **we need to convince the world that scientists are responsible users**!
- Demonstrate responsible use by listing any permits, certifications, training courses, or other special considerations taken.
- Analogous information is included for other methodologies, drones are just under more scrutiny!

Convince the readers you have done your part in obeying local, regional, and federal air traffic regulations, animal welfare considerations, and privacy restrictions!

Discussion

- The current protocol does not (and cannot) cover everything!
- Changes in technology and applications happen quickly → Our goal is to **create a basic standard of reporting** in drone based studies
- We have provided **two example protocols as supplementary materials** to the open access paper on JUVS
- Some information in the protocol will **likely be duplicated in the main manuscript**, but that's ok! Its better to over-report than under-report.
- Any of this information could reasonably be requested by a reviewer or editor, and **authors should already have access to all of this information already!**

Example Protocol #1 Hodgson et al. 2017

Unmanned aerial vehicles for surveying marine fauna: assessing detection probability

Amanda Hodgson,[1,4] David Peel,[2] and Natalie Kelly[2,3]

[1]Murdoch University Cetacean Research Unit, School of Veterinary and Life Sciences, Murdoch University, South Street, Murdoch, Western Australia 6150 Australia
[2]CSIRO Data61, Castray Esplanade, Hobart, Tasmania 7000 Australia

Example Protocol #2 Barnas et al. 2018

Evaluating behavioral responses of nesting lesser snow geese to unmanned aircraft surveys

Andrew Barnas[1] | Robert Newman[1] | Christopher J. Felege[1] | Michael P. Corcoran[1] | Samuel D. Hervey[1] | Tanner J. Stechmann[1] | Robert F. Rockwell[2] | Susan N. Ellis-Felege[1]

Discussion

- Drones have likely secured their spot in the modern Wildlifer's toolkit…but their use as tools is only useful to the extent that we are able to communicate how and why we used them!

- Just as we don't see papers **about centrifuges**, we eventually wont see papers **about drones.**
- Our focus should **shift to how we are using drones as tools** for wildlife science!
- But this can only be done if we treat them with the same standard as other scientific methods!

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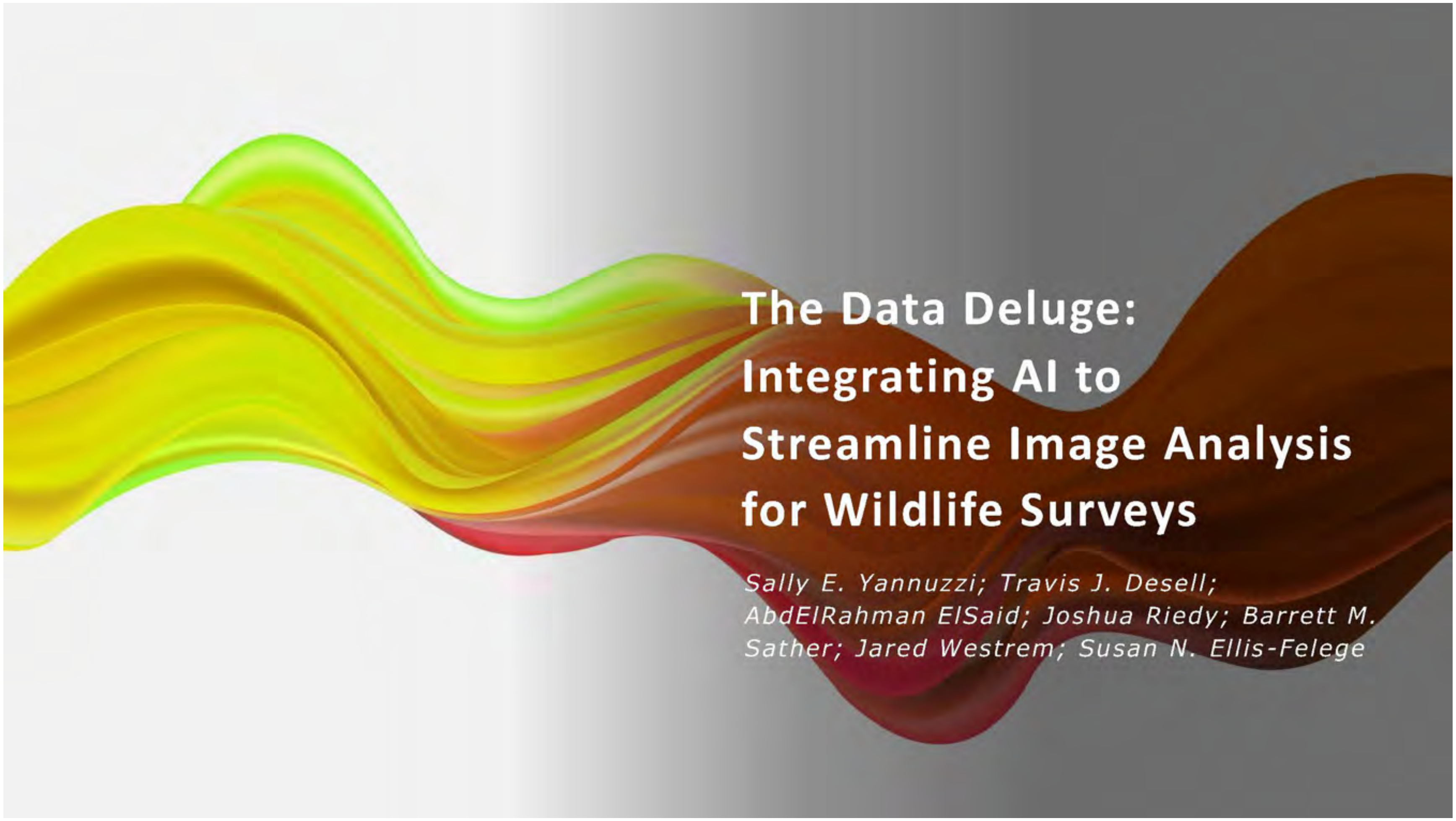
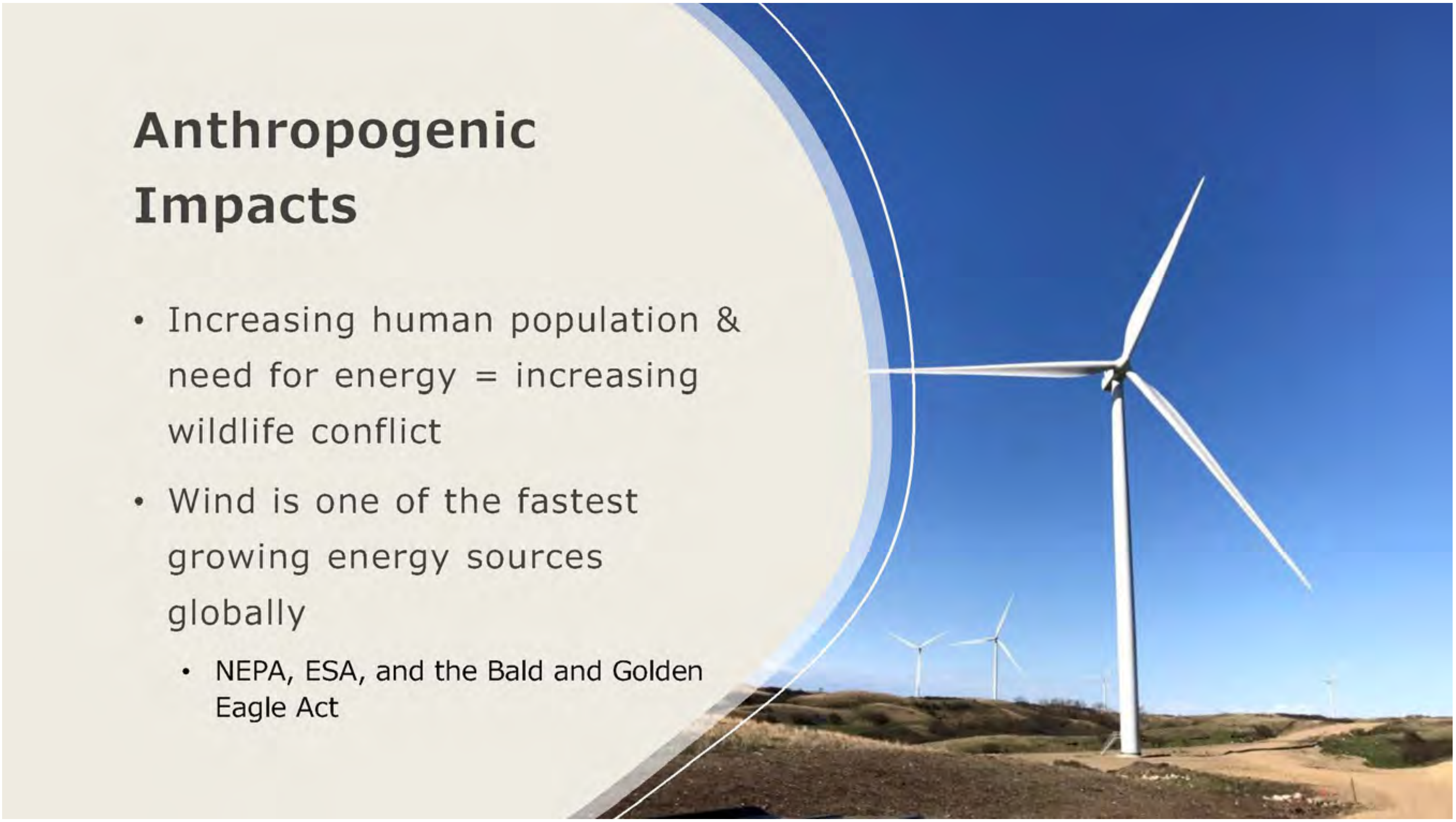
The Data Deluge: Integrating AI to Streamline Image Analysis for Wildlife Surveys

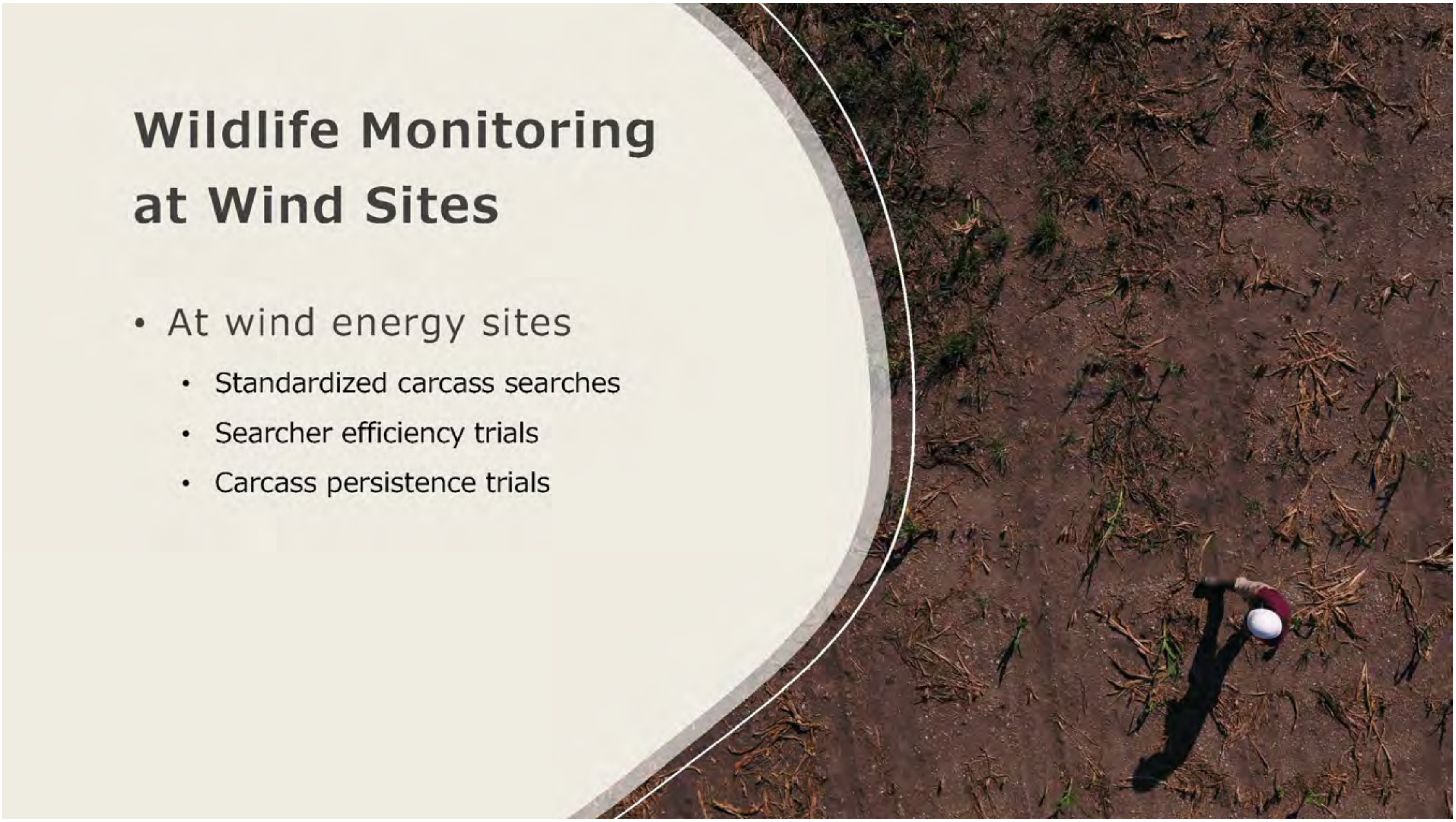
Sally Yannuzzi* (sara.yannuzzi@und.edu), Travis Desell, AbdElRahman ElSaid, Joshua Riedy, Barrett Sather, Jared Westrem, and Susan Ellis-Felege (* = *presenter*)

Wildlife surveys are vital to informing state and federal regulations, hunting seasons, management techniques, and population monitoring. However, their implementation, data quality, and prompt completion can be sacrificed as a result of time, money, accessibility, and surveyor fatigue and expertise. With technological advances such as drones, wildlife scientists have been able to improve data collection in many of these areas. However, reviewing imagery captured by drones can be a time intensive process in itself that is not void of detection error. While it has been shown that less experienced reviewers such as citizen scientists can effectively be used to aid in image processing, this still takes countless hours and can slow down data feeds. Integrating artificial intelligence through the use of a trained neural network can significantly speed up this data deluge. While initial training of the neural network can be time consuming, once completed, image reviewing can occur in real-life time. Through the application of this technique, wildlife data collection can be performed semi-autonomously and rapidly, producing higher quality data for less cost and increased efficiency.


The Data Deluge:
Integrating AI to
Streamline Image Analysis
for Wildlife Surveys
Sally E. Yannuzzi; Travis J. Desell;
AbdElRahman ElSaid; Joshua Riedy; Barrett M.
Sather; Jared Westrem; Susan N. Ellis-Felege


Why are wildlife surveys so important?
• Informs federal and state regulations
• Hunting seasons and bag limits
• Population monitoring
• Management techniques
• Anthropogenic impacts


Anthropogenic Impacts
• Increasing human population & need for energy = increasing wildlife conflict
• Wind is one of the fastest growing energy sources globally
• NEPA, ESA, and the Bald and Golden Eagle Act


Wildlife Monitoring at Wind Sites
• At wind energy sites
• Standardized carcass searches
• Searcher efficiency trials
• Carcass persistence trials

Traditional Data Collection Methods

- Time consuming
- Surveyor error and fatigue
- Requires expertise
- Expensive
- High risk

Integrating technology: UAS

- Unmanned aerial systems (UAS) used in a variety of applications:
  - Breeding bird surveys
  - Prescribed burns
  - Law enforcement
  - Energy infrastructure monitoring
  - Crop monitoring
- Applications are endless

Integrating technology: UAS Pros

- Collects enormous amounts of data
- Fast data collection
- Anyone can do it
- Safer for humans
- Often less invasive
- Repeatable

Integrating technology: UAS Cons

- Overwhelming amounts of data to analyze
  - 1,000/cleared plot =160,000/8 months
  - 75 turbines weekly = 2.4 mill/8 months
- Time consuming to review
  - ~30% currently reviewed
- Battery life
- Policy: line-of-sight, autonomous, night

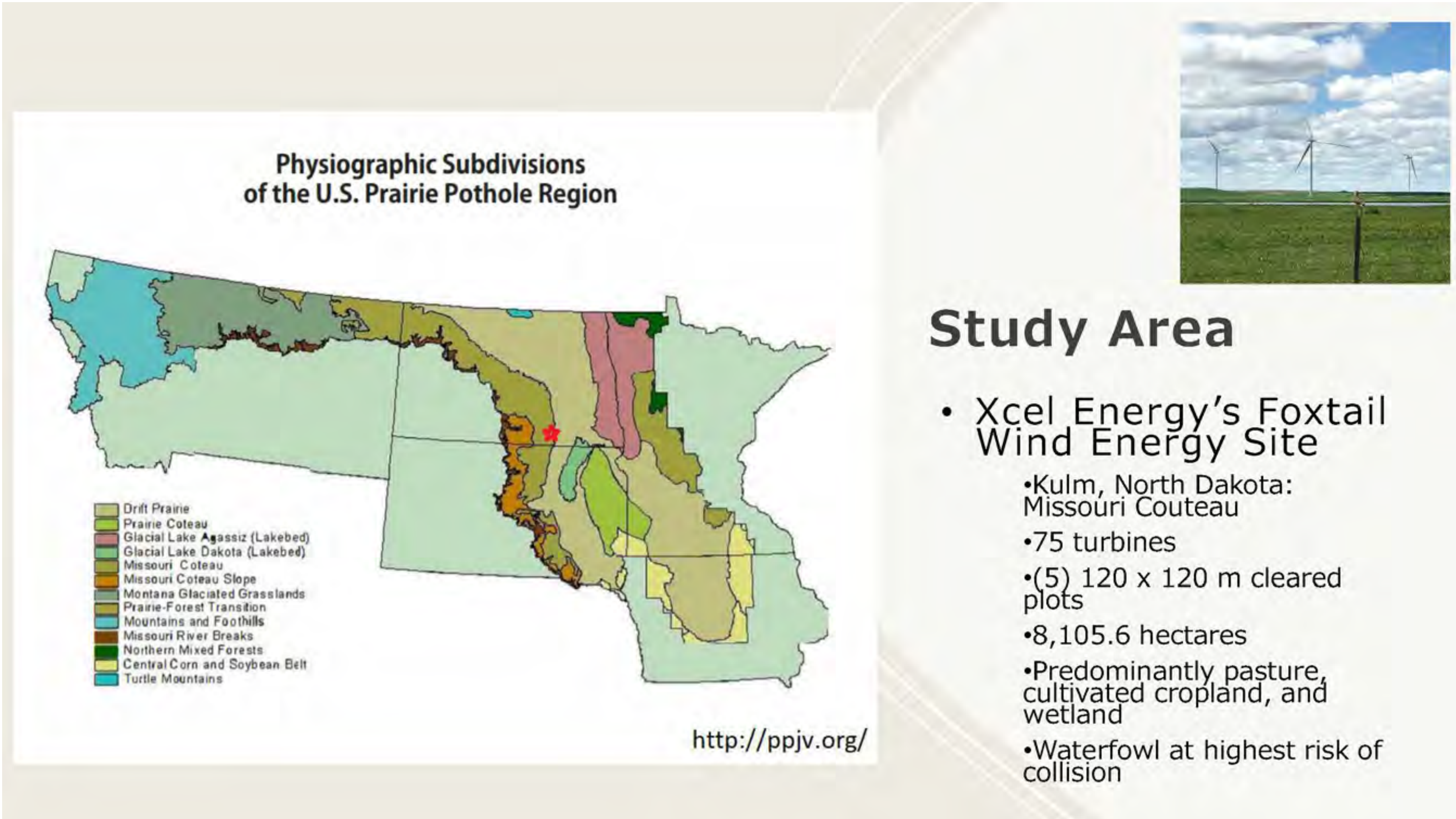
A solution?

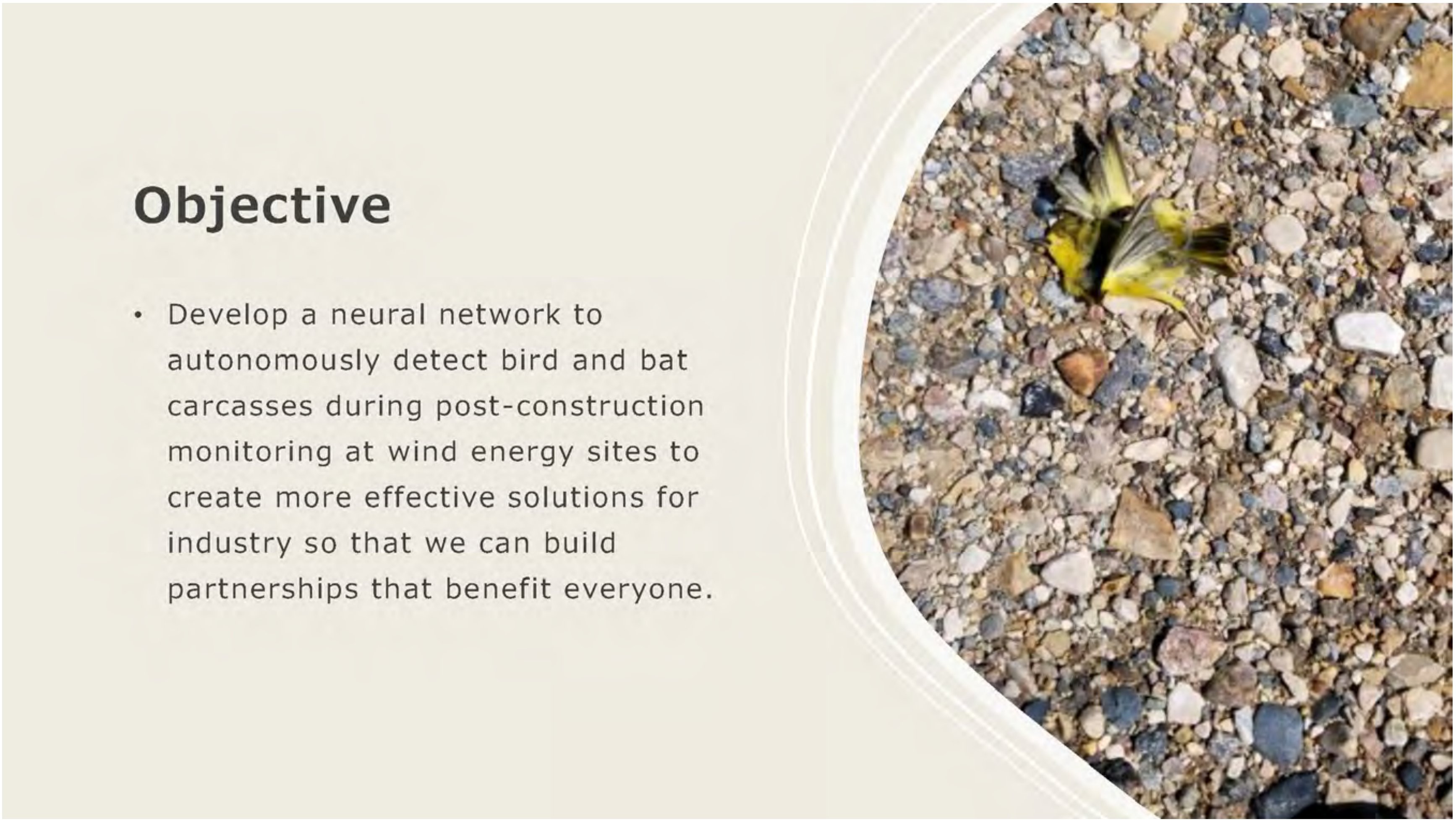
Convolution Neural Networks (CNN)

- Finds objects of interest in imagery
- Can be used for identifying or counting
- Requires training data

Wind Farms and Neural Networks

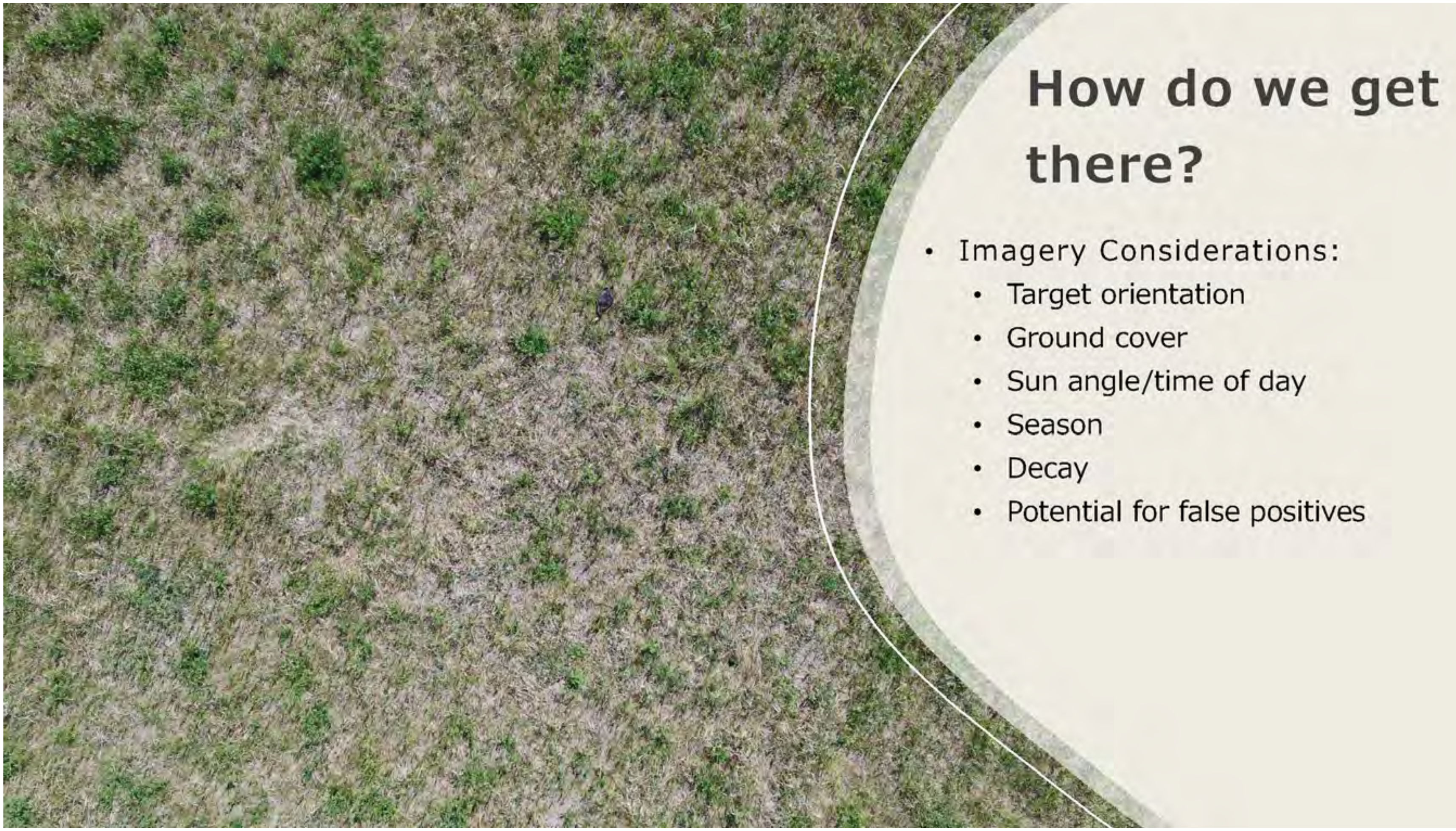
- UAS and neural network currently used to find wear/damage on energy infrastructure & deicing
- Integrating wildlife survey routines solves two problems in one package


Physiographic Subdivisions
of the U.S. Prairie Pothole Region
Drift Prairie
Prairie Coteau
Glacial Lake Agassiz (Lakebed)
Glacial Lake Dakota (Lakebed)
Missouri Coteau
Missouri Coteau Slope
Montana Glaciated Grasslands
Prairie-Forest Transition
Mountains and Foothills
Missouri River Breaks
Northern Mixed Forests
Central Corn and Soybean Belt
Turtle Mountains
http://ppjv.org/
Study Area
• Xcel Energy's Foxtail Wind Energy Site
•Kulm, North Dakota: Missouri Couteau
•75 turbines
•(5) 120 x 120 m cleared plots
•8,105.6 hectares
•Predominantly pasture, cultivated cropland, and wetland
•Waterfowl at highest risk of collision


Objective
• Develop a neural network to autonomously detect bird and bat carcasses during post-construction monitoring at wind energy sites to create more effective solutions for industry so that we can build partnerships that benefit everyone.

How do we get there?

- Build a training dataset
  - Labeled imagery of desired target


How do we get there?
• Imagery Considerations:
• Target orientation
• Ground cover
• Sun angle/time of day
• Season
• Decay
• Potential for false positives

How do we get there?

- Partnerships
  - Industry (software and energy companies)
  - University
  - ND Department of Commerce
  - State and federal wildlife agencies
- One product to meet multiple purposes

TensorFlow

What does it take to build a CNN?

CPU for tiling imagery

Model: Faster R-CNN

Platform: Tensor Flow

CUDA to speed up NVIDIA Tesla 30C GPU

- allows running on GPUs instead of graphics

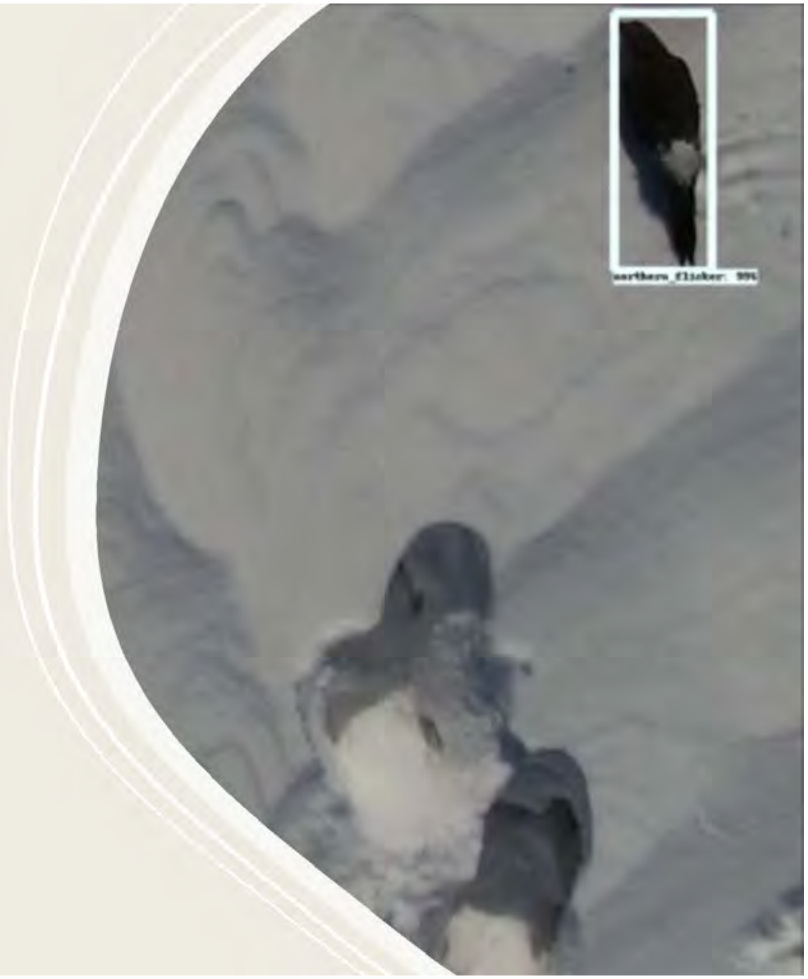
What does it take to build a CNN?

- Budgeting
  - CPU for tiling imagery = $5/day
  - GPU for training = $50/day

What does it take to build a CNN?

Steps and Time

- Data and file prep (~48 hrs)
- Tiling to preserve image quality(~24 hrs)
- Copy over to GPU (~24 hrs)
- Training (~5 days)



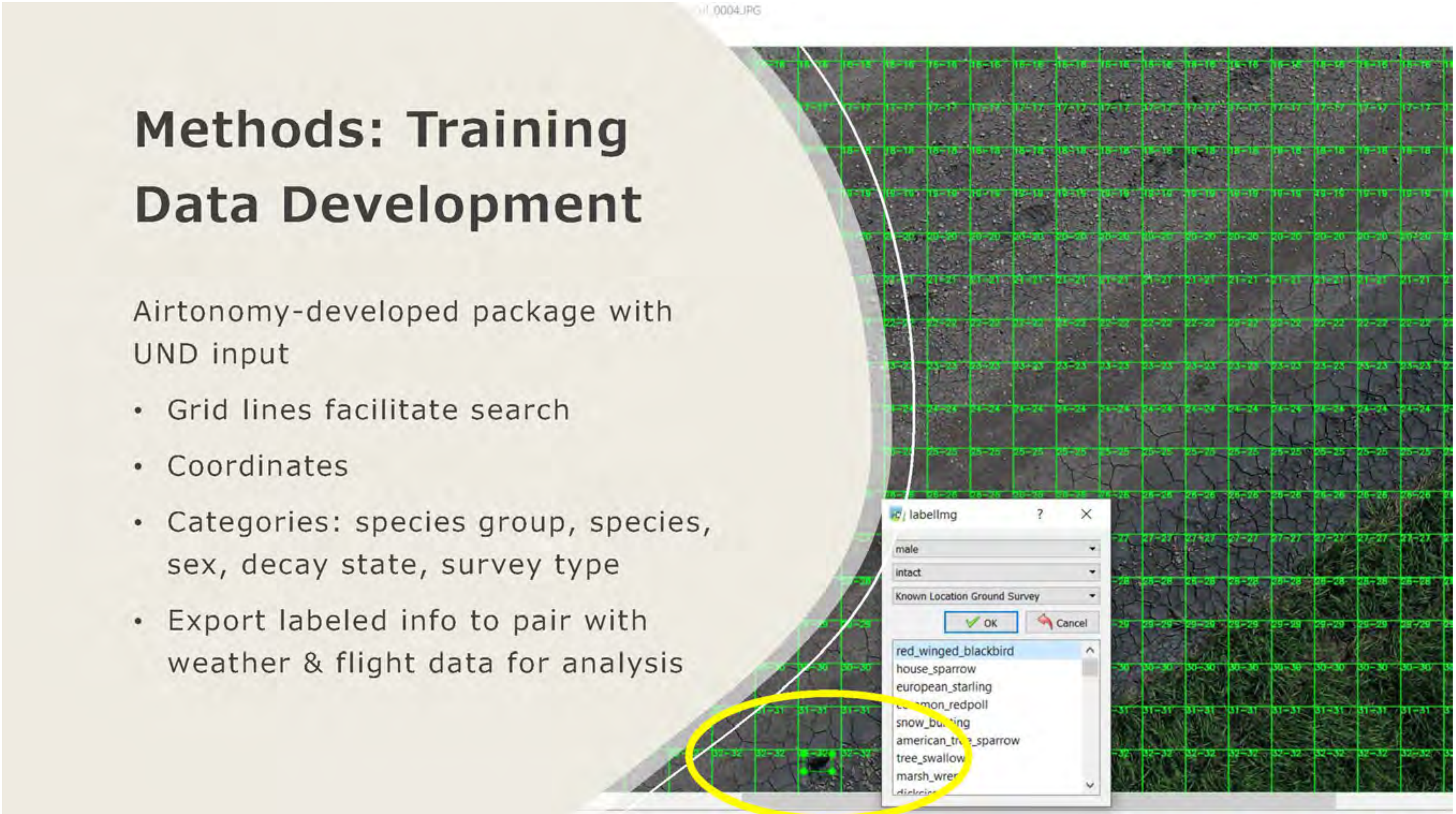
Methods: Equipment

- DJI M210 RTK v2
  - DJI Zenmuse X5S 15mm
  - 30 ft flight height
  - Below RSA
  - 50% overlap

Methods: Training Data Development

- Simulated data off-site
  - Bird and bat carcasses
    - Waterbird, waterfowl, woodpecker, songbird, cranes/rails, gulls/terns, pigeons/doves, raptors, shorebirds, upland gamebirds, bats
  - Variety of ground cover types
  - Collected ~2x monthly
  - March - November 2020
  - 0700-1900 hrs

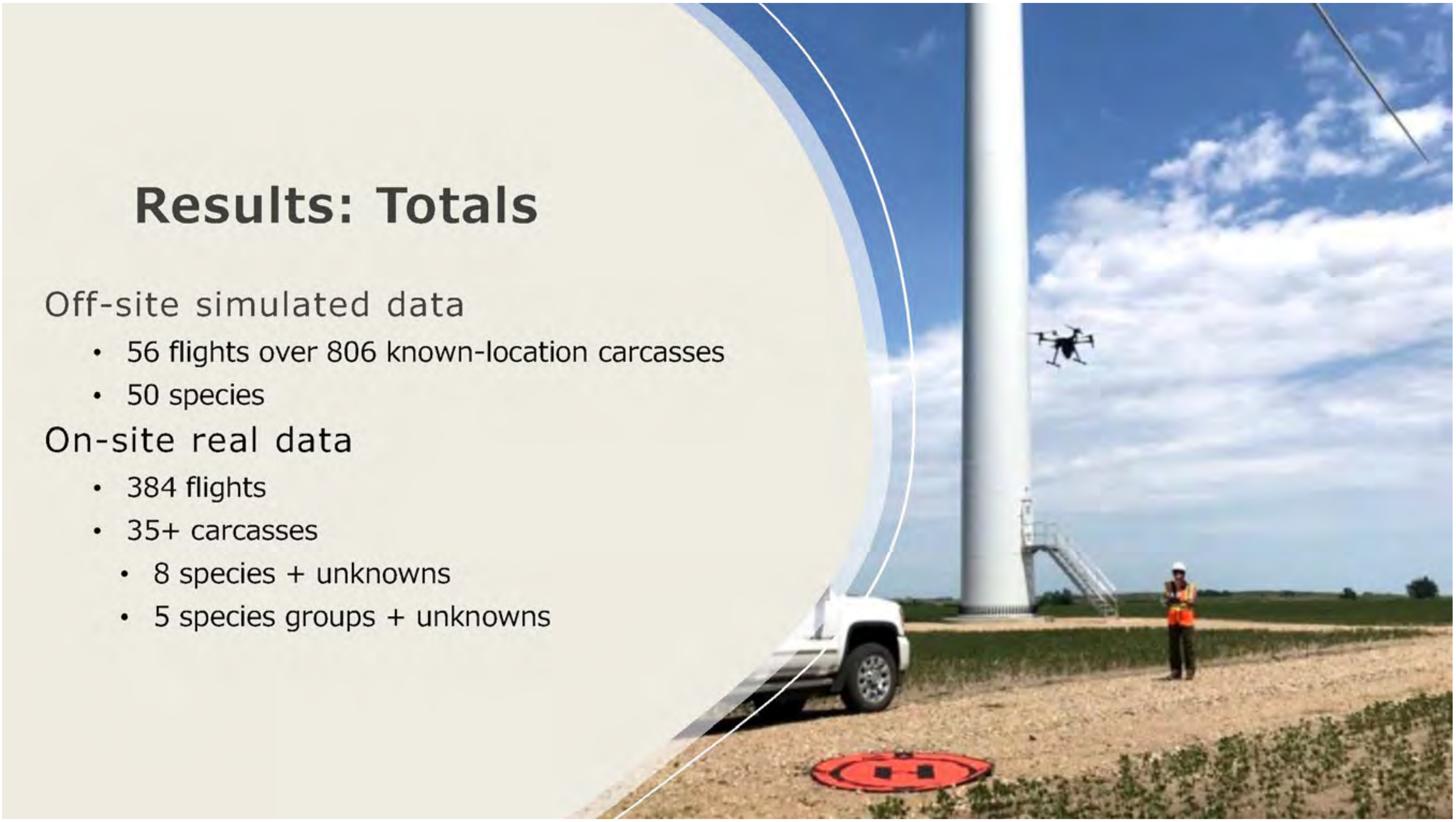

Methods: Training Data Development
• Real data on-site
• Weekly flights paired with standardized carcass searches of cleared plots
• April - November 2020
• 0700-1900 hrs
• Rotating cleared plot flight order weekly


Methods: Training Data Development
Airtonomy-developed package with UND input
• Grid lines facilitate search
• Coordinates
• Categories: species group, species, sex, decay state, survey type
• Export labeled info to pair with weather & flight data for analysis
labelImg
male
intact
Known Location Ground Survey
OK
Cancel
red_winged_blackbird
house_sparrow
european_starling
tree_swallow

Methods: Training Data Development

Labeling imagery

- Species, sex, condition
- “Garbage”
- More technicians the merrier


Results: Totals
Off-site simulated data
• 56 flights over 806 known-location carcasses
• 50 species
On-site real data
• 384 flights
• 35+ carcasses
• 8 species + unknowns
• 5 species groups + unknowns

Results: Neural Network

- Overall detection:
  - 95% recall (# found/total # birds)
  - 96% precision (# found/# guesses)
- Species-level detection:
  - 60% recall
  - 60% precision

Results: Neural Network

- Determine sources of error and provide targeted training data and protocols to mitigate this
  - Parts of bird
  - Obscured by vegetation
  - Cracks/shadows
- Increased training and labeling of undesirable targets likely to reduce false positives


Future Directions
Work with regulatory agencies to make direct comparisons and needs for adoption of this method to improve post-construction monitoring


Future Directions
UAS and neural network technologies provide the platform for integration of many sectors..
• Oil spills
• Disease outbreak
• Vehicle-collision mortalities
• Airports
Streamlining applications leads to better data and time spent for all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NORTH Dakota | Commerce
Be Legendary.
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Xcel Energy
UND
NORTH DAKOTA GAME AND FISH
Microsoft
ROCHESTER INSTITUTE OF TECHNOLOGY
RIT
1829


Questions?