DRONE SYMPOSIUM:
DRONE APPLICATIONS IN WILDLIFE AND SPATIAL ECOLOGY

Abstracts and Presentations – Part 3

NOVEMBER 10, 2022

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Sponsored by:
TWS Drone Working Group

and

Spatial Ecology & Telemetry Working Group

Organizers: Rick Spaulding, ManTech Advanced Systems International, Bainbridge Island, WA; Chair, TWS Drone Working Group; rick.spaulding@ManTech.com.

Jeff Jenness, Jenness Enterprises, GIS Analysis and Application Design, Flagstaff, AZ; Chair, TWS Spatial Ecology & Telemetry Working Group; jeffj@jennessent.com.

Abstract: Wildlife biologists are relying on an ever-increasing suite of tools to answer questions and solve problems related to wildlife ecology, management, and conservation. The use of unoccupied aerial vehicles, UAVs or drones, has exploded in popularity in ecological studies in general, and in wildlife biology in particular. Drones have many advantages over traditional research techniques. They eliminate safety risks associated with fixed-wing and helicopter surveys, reduce cost and disturbance, increase accuracy, and allow the collection of high-resolution data over large or otherwise inaccessible areas. Some of the major areas of application of drones that have emerged in wildlife ecology include, but are not limited to: (1) population surveys, including breeding colonies and non-breeding aggregations and the use of different types of sensors (e.g.); (2) nest monitoring; (3) radio-tracking surveys; (4) acoustic surveys; (5) wildlife habitat research and monitoring; (6) the use of different drone sensors (e.g., visible, thermal IR, multi- and hyperspectral); and (7) wildlife dispersal, either for nuisance or invasive species or to deter from hazards. This symposium provides highlights of the use of drones in wildlife and spatial ecology and a forum for discussion among both experts and potential users of drones that may result in future research collaborations between wildlife biologists in academic, government, and private sectors.

LIST OF PRESENTATIONS

PART 1

Introduction to the Drone Working Group and Spatial Ecology & Telemetry Working Group – Spaulding & Jenness
Developing a Drone Program for Wildlife and Habitat in an Academic Setting – Perotto-Baldivieso et al.
Overview of the University of Florida Uncrewed Aircraft Systems Research Program (UFUASRP): Two Decades of Drones for Natural Resource Applications – Carthy et al.
Drones and Computer Vision as a Potential Method for Bird Carcass and Bird Nest Detection at Solar Energy Facilities – Gerringer et al.
Using Drones & AI for Wildlife Surveys: Detecting Avian Carcasses & Desert Tortoises – M. Bandy
UAS as Wildlife Hazing Tools: Considerations for Reducing Negative Human-Wildlife Interactions – Pfeiffer & Blackwell
Using Drones to Detect and Quantify Wild Pig Damage and Yield Loss in Corn Fields Throughout Multiple Growth Stages – Friesenhahn* et al.

PART 2

- *Spraying Drones: Efficacy of Applying an Avian Repellent to Elicit Blackbird Flock Dispersion in Commercial Sunflower Fields* – Duttenhefner* et al.
- *Benefits and Limitations of Using an Uncrewed Aerial Vehicle to Survey Large Mammals in Forest Fragments* – Magee* et al.
- *Evaluation of UAS Surveys for Ungulates in South Texas Rangelands* – Foley et al.
- *White-tailed Deer Surveys with Thermal Drones and Distance Sampling* – Massey* et al.
- *Controllable Factors Affecting Accuracy of Human Identification of Birds in Images Obtained during UAS Surveys* – Jones et al.
- *AI for Detection and Classification of Wildlife from sUAS Imagery* – Boopalan et al.
- *A Systematic Map of Utilizing Small Unoccupied/Uncrewed Aircraft Systems (UAS) to Monitor Wildlife* – Elmore et al.
- *Measuring Bat Occupancy and Abundance Using Drone-based Line Transect Surveys* – Bishop-Boros et al.

PART 3

- ***Guidelines to Sampling Aerial Canopy Arthropods with UAVs*** **– Madden et al.**
- ***Small Uncrewed Aircraft Systems and Artificial Intelligence: A New Approach for Monitoring Waterfowl Response to Wetland Restoration*** **– Loken* & Ringelman**
- ***Drones, Structure from Motion, and the Digital Twin: Lessons Learned Trying to Model Spring Habitats*** **– Jenness et al.**
- ***Using 3D Photogrammetry to Measure Vegetation Recovery and Gopher Tortoise (Gopherus polyphemus) Response to Re-Introduction on Reclaimed Mine Lands*** **– Hancock* et al.**
- ***Hornets, Bats & Bears: Real-time Drone Radio-telemetry for Wildlife and Invasive Species Managers*** **– D. Saunders**
- ***Re-Inventing VHF Tracking: How to Avoid the Pitfalls of Aerial Wildlife Monitoring*** **– C. Muller***
- ***Use of Drones to Advance and Scale Invasive Species Eradications on Islands*** **– Sullivan et al.**

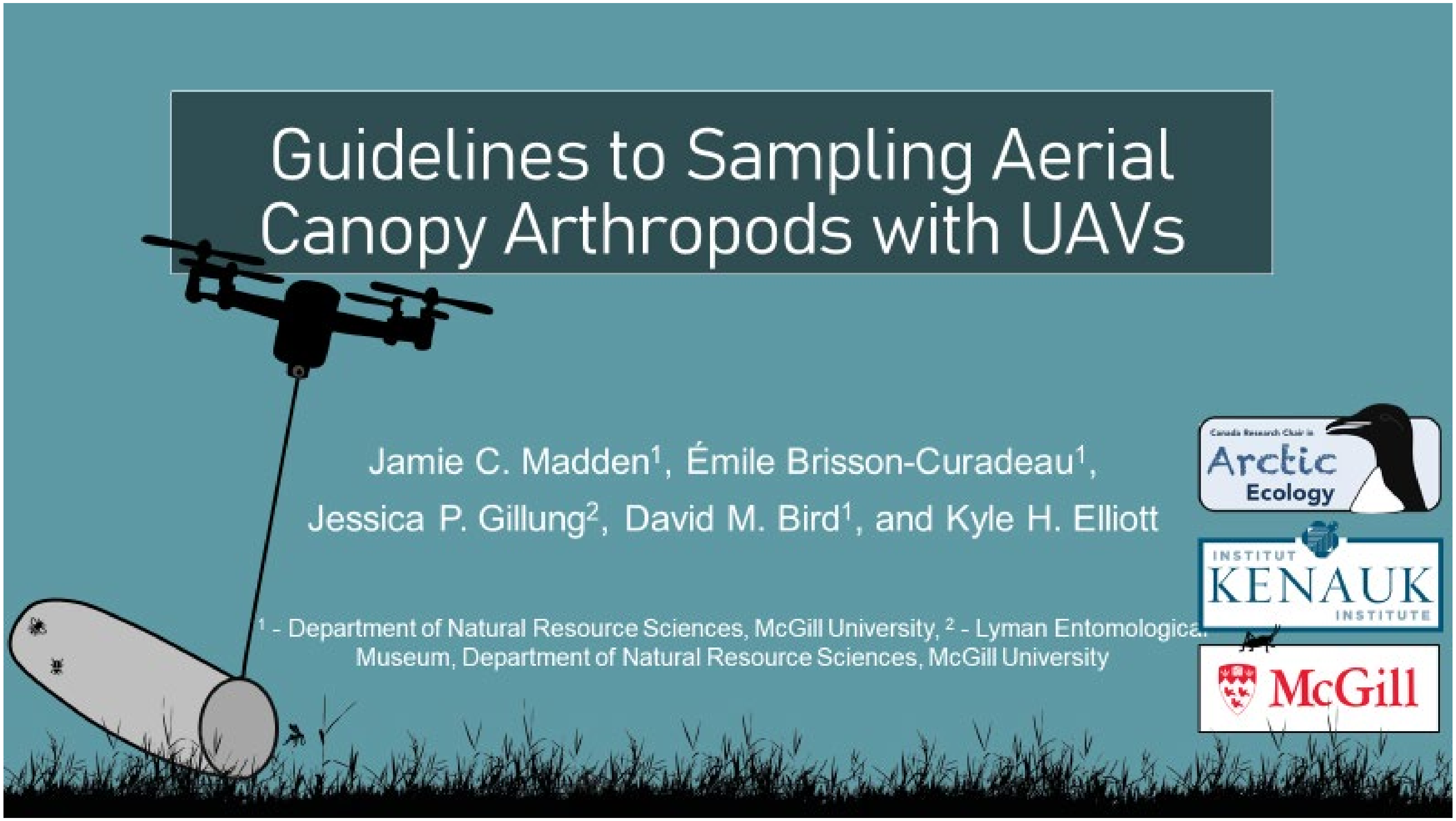
*Student presentation.

(*Note*: presenters in **bold**)

Guidelines to Sampling Aerial Canopy Arthropods with UAVs

Jamie C. Madden[1], Émile Brisson-Curadeau[1], Jessica P. Gillung[2], **David M. Bird[1]**, and Kyle H. Elliott[1]
[1]Department of Natural Resource Sciences, McGill University, Montreal, Quebec, Canada; jamie.madden@mail.mcgill.ca
[2]Lyman Entomological Museum, Department of Natural Resource Sciences, McGill University

The growing field of aeroecology is limited by difficulties associated with sampling in the air column. Aerial insects are particularly hard to sample, despite being the main prey in the air column, with some recent studies attempting to use drones as a collection method. We conducted a study to determine the optimal drone settings for collecting insects above the canopy, where drones are seldom used. By attaching a net to the body of a small, commercial drone, we tested yield from different height, speed, and net settings in wetlands, as well as compared insect diversity across different habitat canopies. Height was the most important setting; grazing the canopy yielded significantly more insects than flying one meter above it. Speed, drone type, and net size did not influence the number of insects caught per trial. Wetland canopies had higher abundance, diversity, and species richness in its arthropod populations compared to forest canopies or lakes. Compared to the yield of Lindgren funnels – a traditional sampling method in entomology – drones captured higher diversity and abundance of insects in a fraction of the time. This study confirms that drones are an efficient and accurate way to collect canopy arthropods.


Guidelines to Sampling Aerial Canopy Arthropods with UAVs
Jamie C. Madden[1], Émile Brisson-Curadeau[1],
Jessica P. Gillung[2], David M. Bird[1], and Kyle H. Elliott
[1] - Department of Natural Resource Sciences, McGill University, [2] - Lyman Entomological Museum, Department of Natural Resource Sciences, McGill University
Arctic Ecology
INSTITUT KENAUK INSTITUTE
McGill

Aeroecology: a growing field

The aerosphere is studied extensively in meteorology, but often ignored as a natural domain

Exclusion extended into research and policy

Complicated logistics of sampling in the air column = little knowledge about the ecology of the airspace

1

Canopy insects

- Understudied due to logistical difficulties
- Reaching the canopy requires complicated infrastructure

Insects:

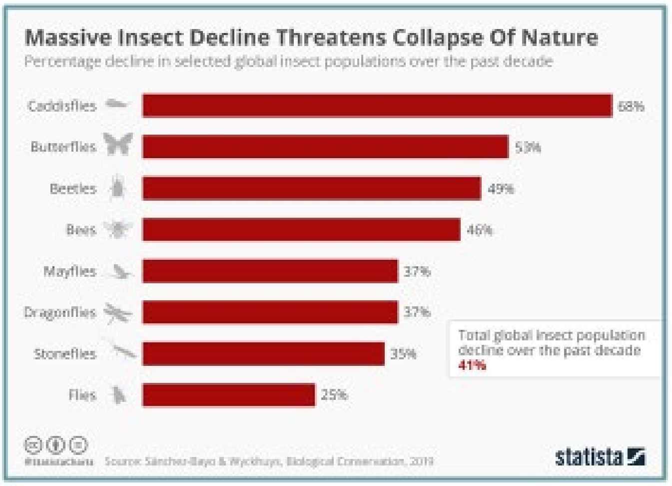
- Provide important **ecosystem services**
- Serve as **bioindicators** of habitat health
- Both herbivores and predators in **food chain**

An important source of food for aerial insectivores!

2

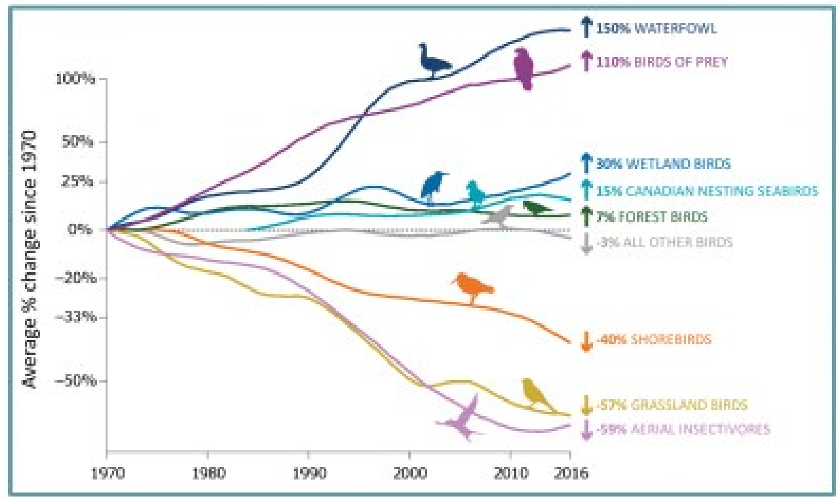
Canopy insects as a prey source for aerial insectivores

40% of insects in **decline** worldwide



Massive Insect Decline Threatens Collapse Of Nature [Digital image]. Retrieved April 08, 2022, from https://www.statista.com/chart/16960/percentage-decline-in-selected-global-insect-populations/

Aerial insectivores in **decline** in North America



North American Bird Conservation Initiative Canada. 2019. The State of Canada's Birds, 2019. Environment and Climate Change Canada, Ottawa, Canada. 12 pages. www.stateofcanadasbirds.org

3

How can we sample the canopy efficiently, cost-effectively, and quickly?

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Drones in Research

Advantages:

- Study species in less accessible environments
- Collect samples and take pictures remotely
- Safer, greener, less costly and potentially less stressful to wildlife than traditional methods

$2500-$4000/hr

$500-$3000/hr

$1000 to own

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Drones for Insect Collection

To date, 6 studies have used drones to collect insects

- Ryu et al. 2022
- Mulero-Pázmány et al. 2022
- Fahrentrapp et al. 2021
- Locken et al., 2020
- Neufeld et al., 2019
- Kim et al., 2018

None have examined optimal drone settings

None have targeted collecting insects directly above the canopy

Objectives

Objective 1: Optimal UAV settings

Find the most efficient method for sampling insects over the forest canopy with a Mavic 2 drone and a sweep net

Objective 2: Arthropod diversity & abundance

Describe canopy arthropod populations in Quebec in a replicable way, sampling different forest types, wetlands, and lakes

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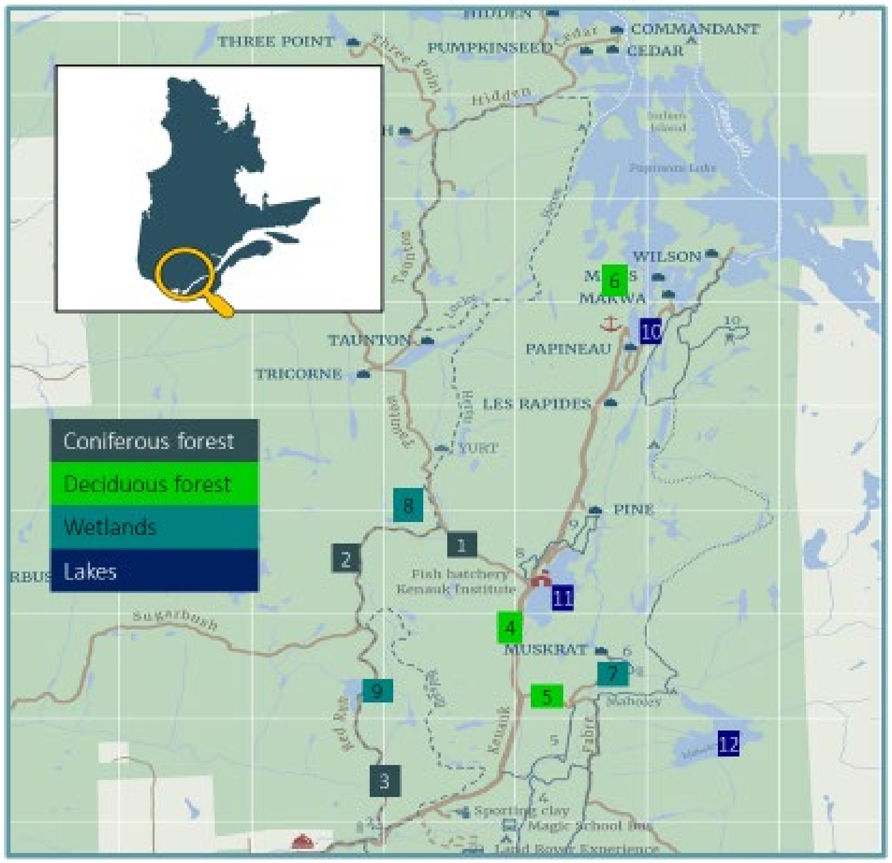
Kenauk Nature Reserve, Montebello, Quebec



Study design:
Arthropod diversity

12 Sites:

- 3 coniferous forests (1,2,3)
- 3 deciduous forests (4,5,6)
- 3 wetlands (7,8,9)
- 3 lakes (10,11,12)

12 days of sampling

All 12 sites were sampled 4 separate times over the 12 days of sampling (4 sites a day)

Each day, order of sampling was randomly chosen

8

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Arthropod diversity

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All 12 sites were sampled 4 separate times over the 12 days of sampling (4 sites a day)

Each day, order of sampling was randomly chosen

Lindgren funnels at each site for 7 days to compare to traditional collection techniques

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Study design:
Optimal UAV settings

2 wetland sites

Simultaneous flights with 2 drones

- Phantom pro
- Mavic 2

Controlled for:

Height

- 1m above canopy vs 0m (grazing)

Speed

- 10km/hr vs 20km/hr

Net diameter

- 12 vs 18 inches

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Methods: Sampling procedure

- Flew drone randomly around site for 3 minutes
    - Used a spotter to ensure good canopy contact


Photo credit: Elena Tranze-Drabinia

- Caught net and closed opening before landing the drone

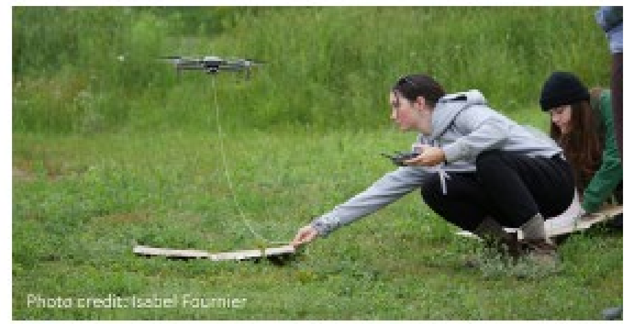
Photo credit: Isabel Fournier

- Collected all insects inside into ethanol-filled tubes


Photo credit: Elena Tranze-Drabinia

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Results & Discussion
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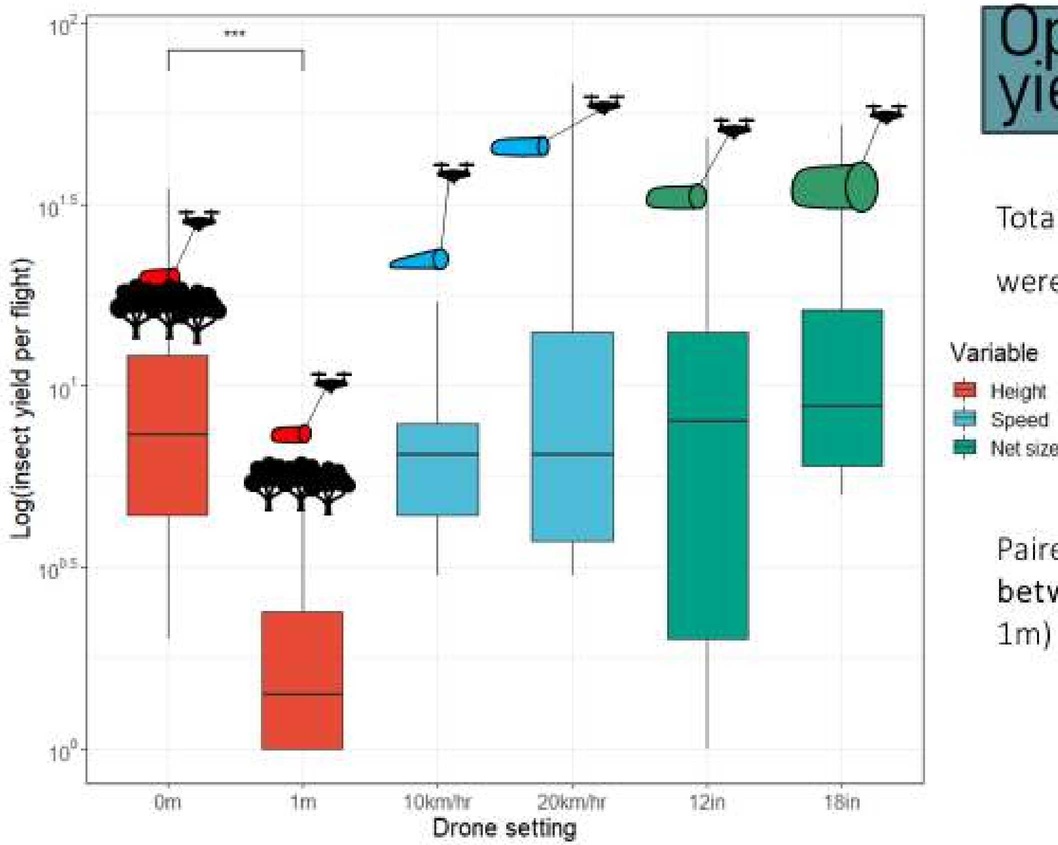

Figure 2: *Average arthropod yield per 3-minute flight per UAV setting*

Optimal settings: yield

Total of 167 insects in 8 different orders were collected

Paired student's t-tests: **significant difference between yields of different heights** (0m vs 1m) ($p<0.001$, df =7, t=4.9)

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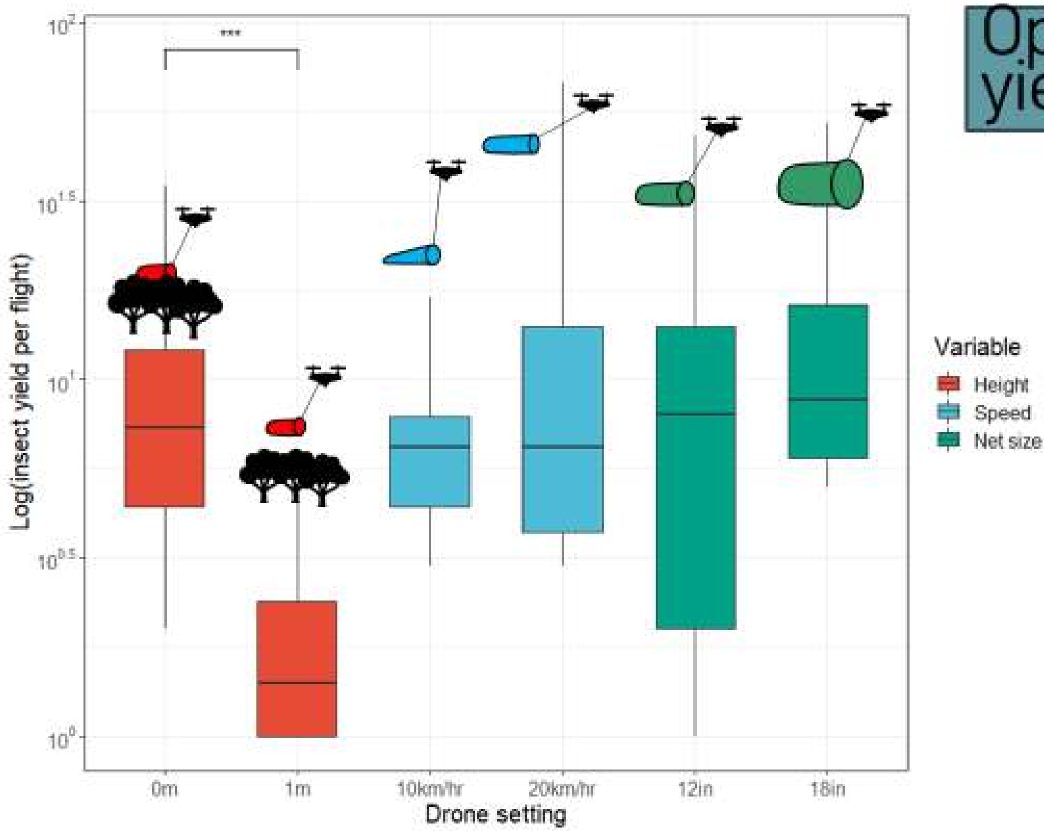

Figure 2: *Average arthropod yield per 3-minute flight per UAV setting*

Optimal settings: yield

	One meter above	Grazing
Aerial insects in flight **above** the canopy	✓	✓
Aerial insects in flight **within** the canopy		✓
Aerial insects at **rest** on the canopy		✓
Terrestrial insects on the canopy		✓

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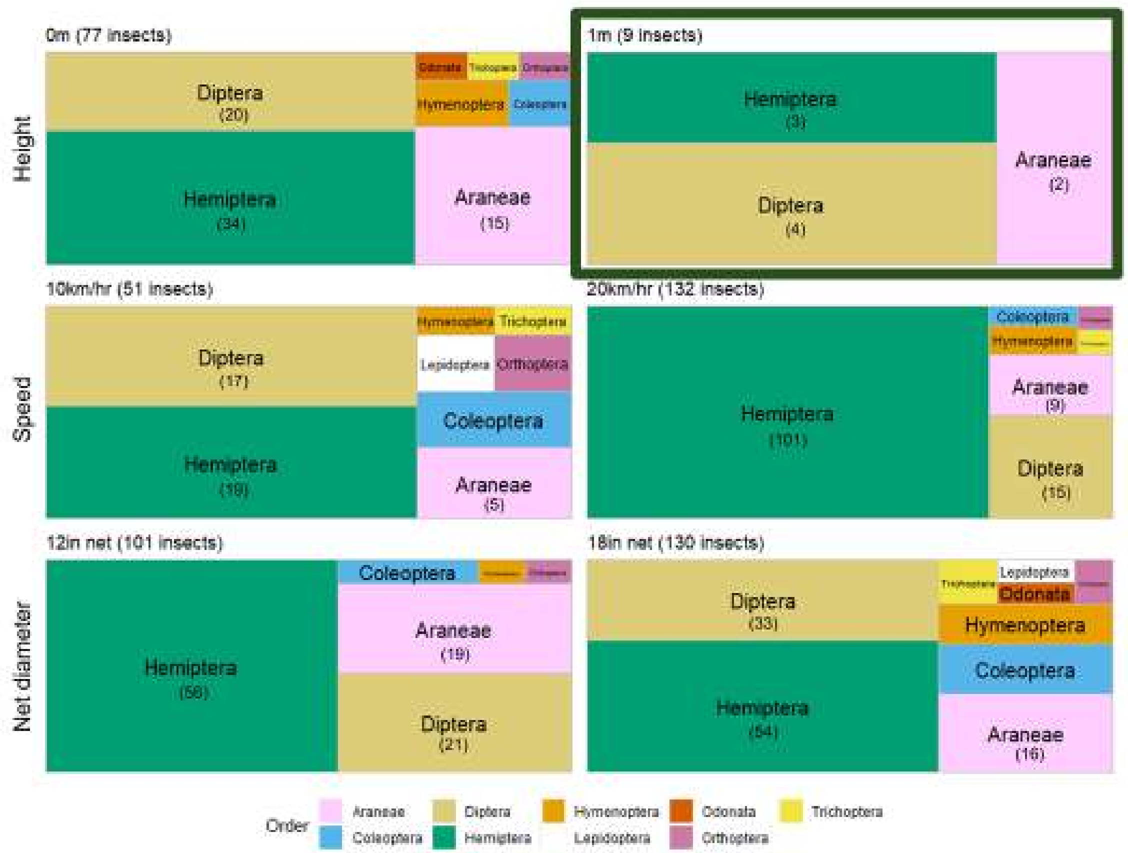
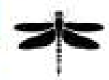
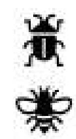


Optimal settings: diversity



2 of only 3 total Odonata were caught when flying with the 18-inch net

20km/hr showed the highest proportion of Hemiptera (77%, 101 insects), compared with other settings.



Flying at one meter was the only setting which captured no insects of order Coleoptera or Hymenoptera

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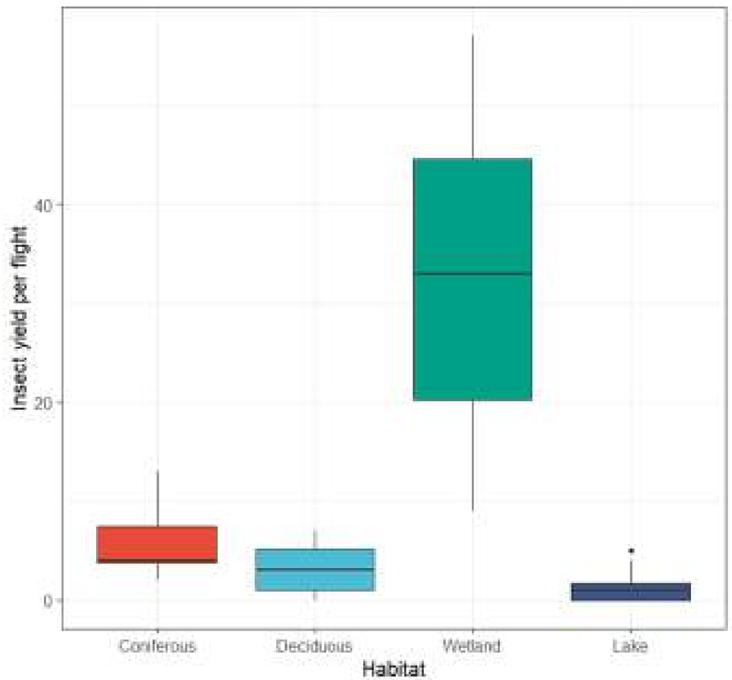
Habitat comparisons



516 insects in 67 families and 11 orders

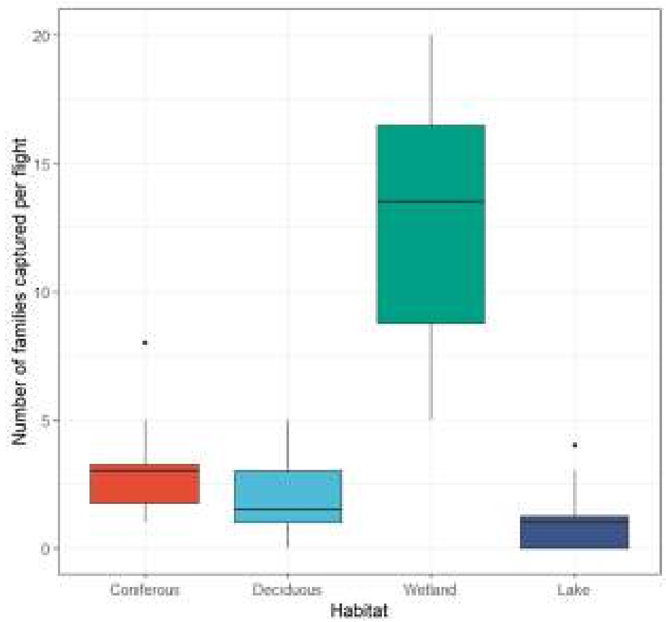
Factors potentially affecting insect yield:

- Habitat
- Temperature
- Humidity
- Time of day

AIC Model selection:

Model	K	AICc	ΔAICc	AICcWt	Cum.Wt	LL
Habitat*Humidity	8	251.36	0.00	0.88	0.88	-115.01
Habitat + Temperature	5	256.70	5.33	0.06	0.95	-122.35
Habitat + Temperature + Humidity	6	257.61	6.25	0.04	0.98	-121.36
Habitat+Humidity	5	260.74	9.38	0.01	0.99	-124.37
Habitat*Temperature	8	261.02	9.66	0.01	1.00	-119.84
Habitat	4	339.37	88.01	0.00	1.00	-165.22
Null	1	952.31	700.94	0.00	1.00	-475.11

16



Habitat comparisons

Wetlands have highest diversity and species richness

Lakes have highest evenness

Habitat	Shannon.index	Simpson.index	Species.richness	Pielous.evenness
Coniferous	2.27	0.820	21	0.746
Deciduous	2.69	0.910	19	0.913
Wetland	3.35	0.940	59	0.823
Lake	2.23	0.886	10	0.969

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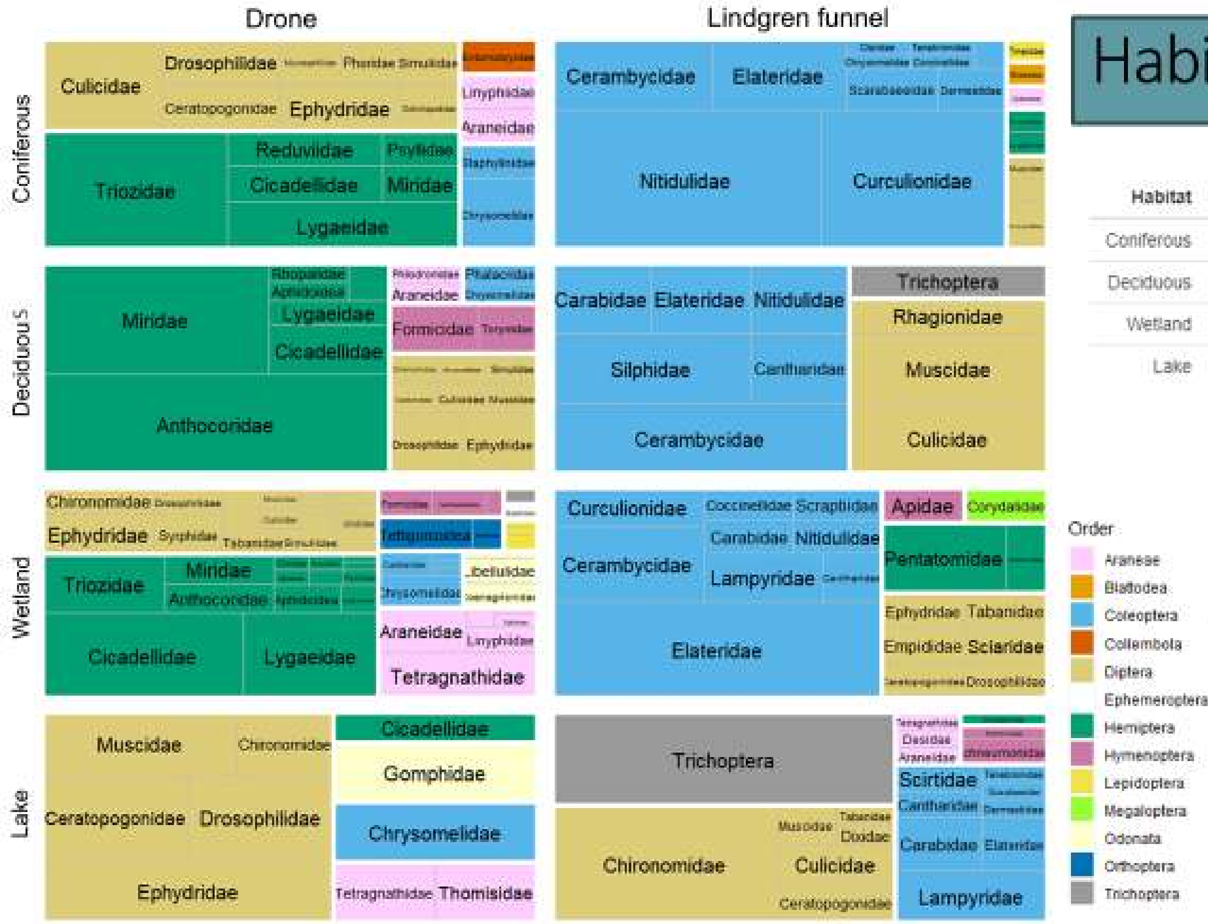

Habitat comparisons

Habitat	Drone.Shannon.index	Lindgren.Shannon.index
Coniferous	2.27	2.21
Deciduous	2.69	1.99
Wetland	3.35	2.53
Lake	2.23	2.26

Drones collected higher diversity samples at 3 out of 4 habitats compared to Lindgren funnels

Lindgren funnels attract Coleoptera above all else

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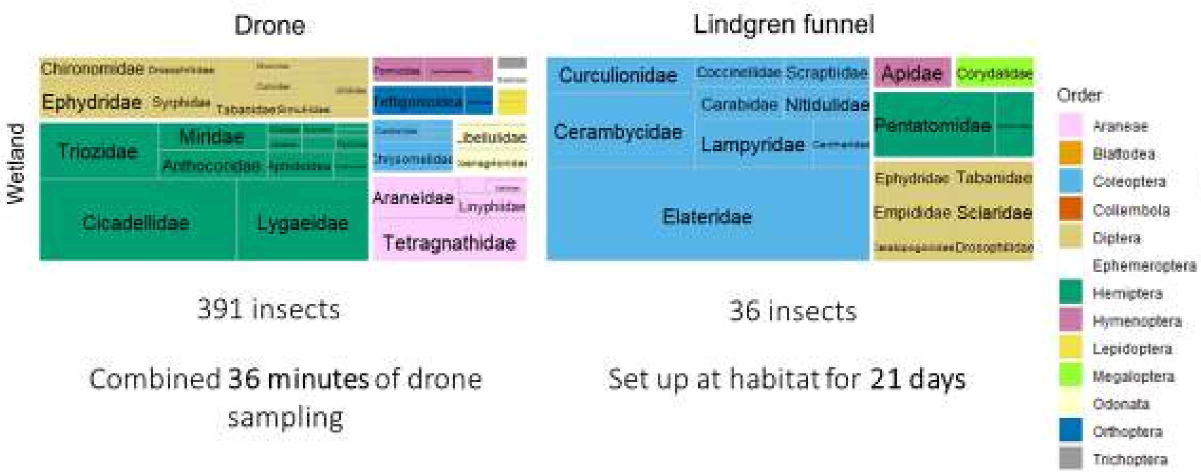
Habitat comparisons

Habitat	Drone.Shannon.index	Lindgren.Shannon.index
Coniferous	2.27	2.21
Deciduous	2.69	1.99
Wetland	3.35	2.53
Lake	2.23	2.26



391 insects

Combined **36 minutes** of drone sampling

36 insects

Set up at habitat for **21 days**

Drones collected higher diversity samples at 3 out of 4 habitats compared to Lindgren funnels

Lindgren funnels attract Coleoptera above all else

Drones are the more efficient method of insect collection

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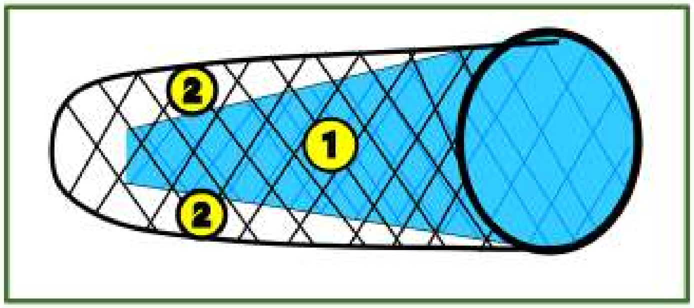
Effectiveness of net design



Net used

- Held open by welded steel frame
- Two layers of netting
  - One in a cone shape in the interior
  - On descent: Insects kept inside

Over 24 flights:

84% of insects were found within the second layer of the net

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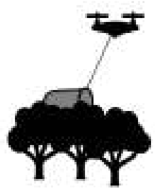
Summary: main findings



Height is the most important drone setting affecting insect yield

Flying while grazing the canopy yields the most insects

Wetlands have the highest diversity and abundance of canopy arthropods

Compared with forests and lakes

Drones capture a higher diversity of insects in most habitats compared to Lindgren funnel controls

Using drones with the new net design is an efficient way to sample the canopy

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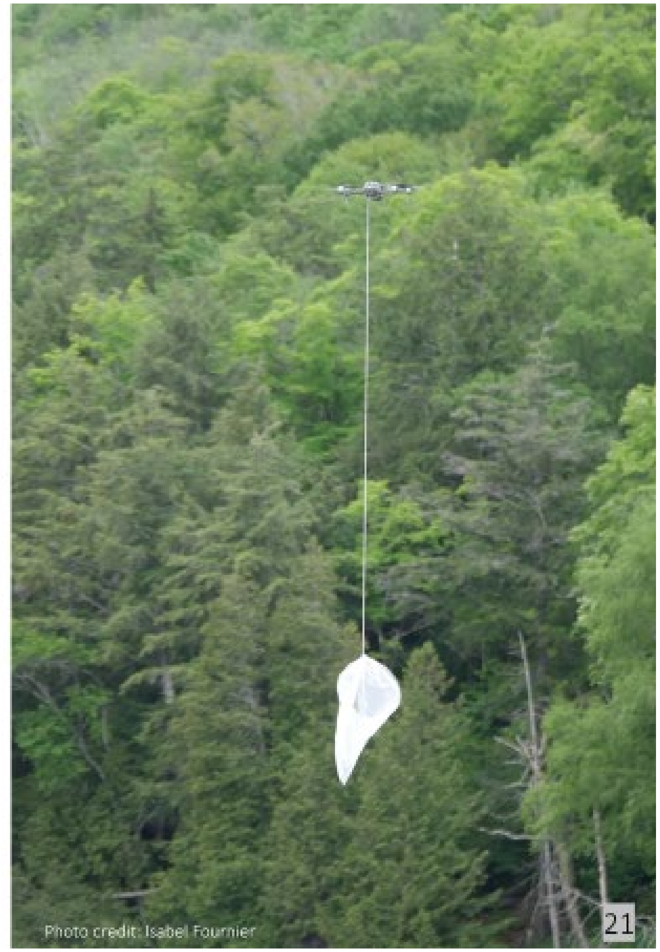
Implications

- Canopy studies can be done more often, for less money, and more safely with drones
  - Provide insight on aerial insect trends
  - Inform on conservation issues of both insects and aerial insectivores

- Future research can use and build on these guidelines to customize drone settings for studies of different insects
  - Wider net for dragonflies (Odonata)
  - Faster speed for true bugs (Hemiptera)



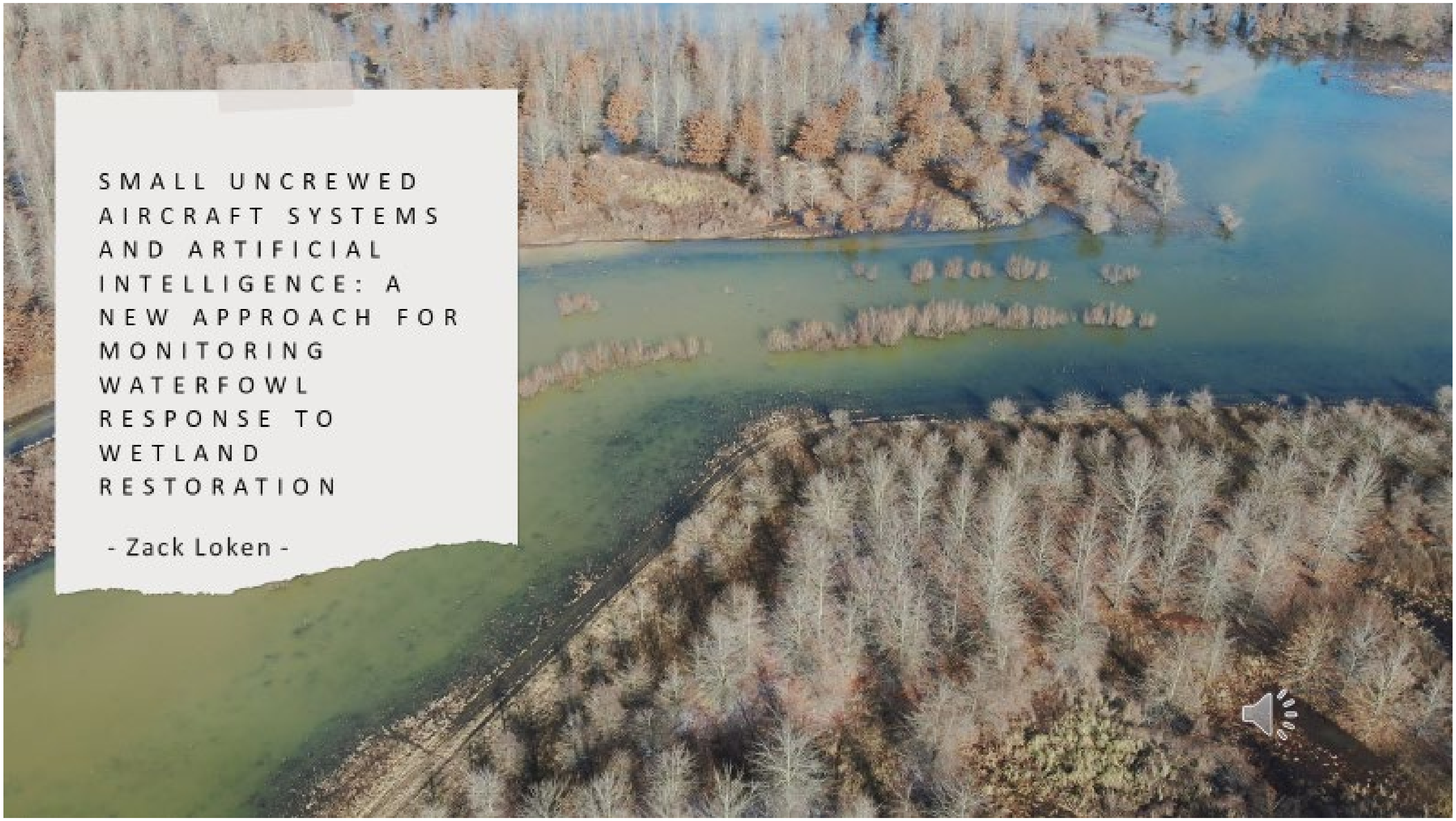
QUESTIONS?

Thank you to the Arctic Ecology Lab, the Lyman Museum, and the Kenauk Institute 22

Small Uncrewed Aircraft Systems and Artificial Intelligence: A New Approach for Monitoring Waterfowl Response to Wetland Restoration

Zack Loken* and Kevin Ringelman*
*Ringelman Lab, School of Renewable Natural Resources, Louisiana State University, zloken1@lsu.edu

Understanding how waterfowl respond to habitat restoration and management activities is crucial for evaluating and refining conservation delivery programs. However, site-specific waterfowl monitoring is difficult, especially in heavily forested systems such as the Mississippi Alluvial Valley (MAV) - a primary wintering region for ducks in North America. To address this need, we developed and implemented a monitoring protocol using a small uncrewed aircraft system (sUAS) equipped with high-resolution thermal and optical cameras to survey wintering waterfowl on wetland restoration easements in the MAV. To enumerate waterfowl by species and assess general behaviors (i.e., foraging, loafing), we developed and trained deep residual neural network (ResNet) models in a PyTorch machine learning framework using the images and videos acquired by sUAS. We compared the mean average precision of each ResNet model at two different complexity levels (34 and 50 identity mapping layers) to assess model performance. Although there was minimal difference in performance between models at counting waterfowl, ResNet-50 outperformed ResNet-34 at identifying species present and assessing general habitat use behaviors. These results suggest that the ResNet-50 model may be a practical algorithm for performing both tasks. By investigating the efficacy of sUAS and artificial intelligence technologies at quantifying waterfowl site use, this study facilitates the development of monitoring protocols necessary for comparing relative waterfowl use on lands enrolled in conservation programs. As such, these results provide managers with the most efficient and cost-effective means to count waterfowl on project sites, thereby improving their capacity to evaluate waterfowl response to restoration efforts.


SMALL UNCREWED AIRCRAFT SYSTEMS AND ARTIFICIAL INTELLIGENCE: A NEW APPROACH FOR MONITORING WATERFOWL RESPONSE TO WETLAND RESTORATION
- Zack Loken -

ACKNOWLEDGEMENTS

- Funding: provided by Ducks Unlimited through the National Fish and Wildlife Foundation
- LSU major professor: Dr. Kevin Ringelman
- Partners: Anne Mini (American Bird Conservancy; LMVJV), Dale James (Ducks Unlimited), and Aaron Pierce (Ducks Unlimited)
- Fieldwork logistics: Nick Smith (Ducks Unlimited) and Mike Mitchell (Ducks Unlimited)
- Field housing: Cache River NWR and Tensas River NWR (USFWS)
- Technicians: Grant Rhodes and Grace Rosseau

DUCKS UNLIMITED

NATIONAL FISH AND WILDLIFE FOUNDATION

NFWF LSU

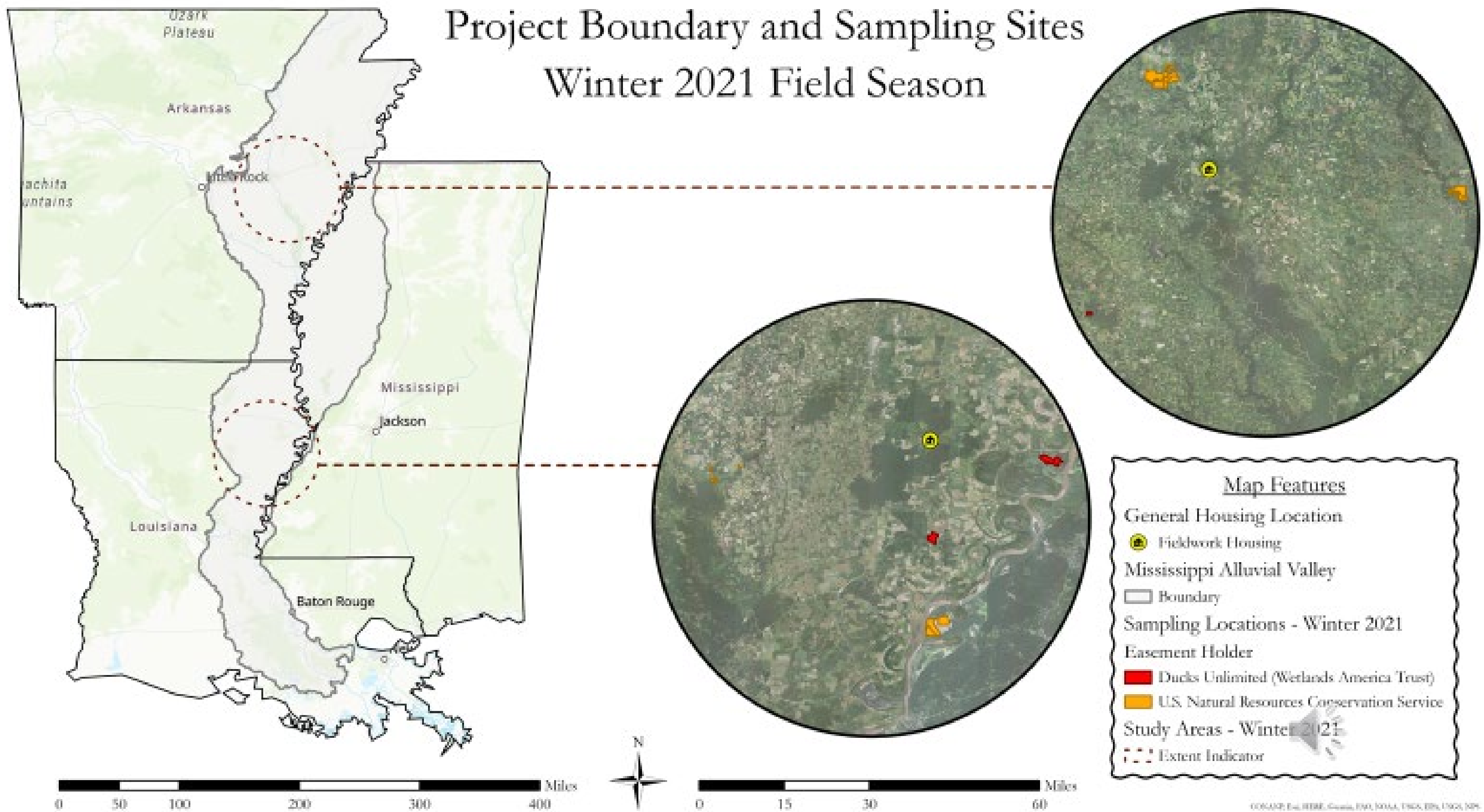
College of Agriculture
School of Renewable
Natural Resources

BACKGROUND

- LMVJV needs to evaluate wintering waterfowl habitat use to determine bioenergetic demand in the MAV
- However, site-specific monitoring is difficult—especially in heavily forested systems
- Site-specific waterfowl monitoring can shed light on which areas and management activities are most used by waterfowl
- Understanding how ducks respond to habitat management is key to delivering effective conservation programs

OBJECTIVES

- General: design and implement a new monitoring protocol for wintering waterfowl using drones equipped with high-resolution thermal and optical cameras
- Advanced: Make computers do the heavy lifting!
  - Develop drone image and video object detection programs to:
    - Automatically detect waterfowl
    - Localize detections with species labels and confidence scores
    - Track waterfowl across frames
    - Determine habitat use behaviors

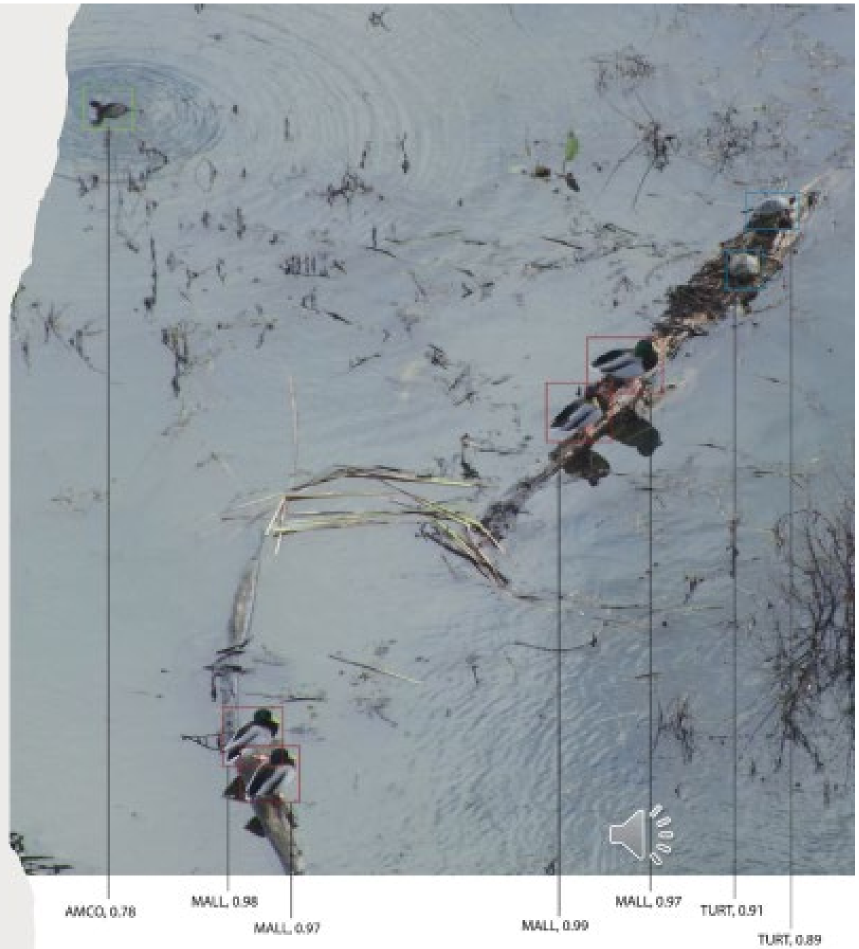

Project Boundary and Sampling Sites
Winter 2021 Field Season
Ozark Plateau
Arkansas
Mississippi
Jackson
Louisiana
Baton Rouge
Map Features
General Housing Location
Fieldwork Housing
Mississippi Alluvial Valley
Boundary
Sampling Locations - Winter 2021
Easement Holder
Ducks Unlimited (Wetlands America Trust)
U.S. Natural Resources Conservation Service
Study Areas - Winter 2021
Extent Indicator
Miles
0 50 100 200 300 400
N
Miles
0 15 30 60

FIELD METHODS

- Surveyed from 30 minutes before sunrise until ~ 11 am, and ~ 4 pm until sunset
- Launched drone from adjacent upland
- Opportunistic approach – flew to where we thought the ducks would be
- Began recording once ducks were spotted
- Recorded at 225 ft above ground level
- Tilted camera vertically downward 25° to 40°
- Surveys lasted ~ 1 hour
- Repeat at next site

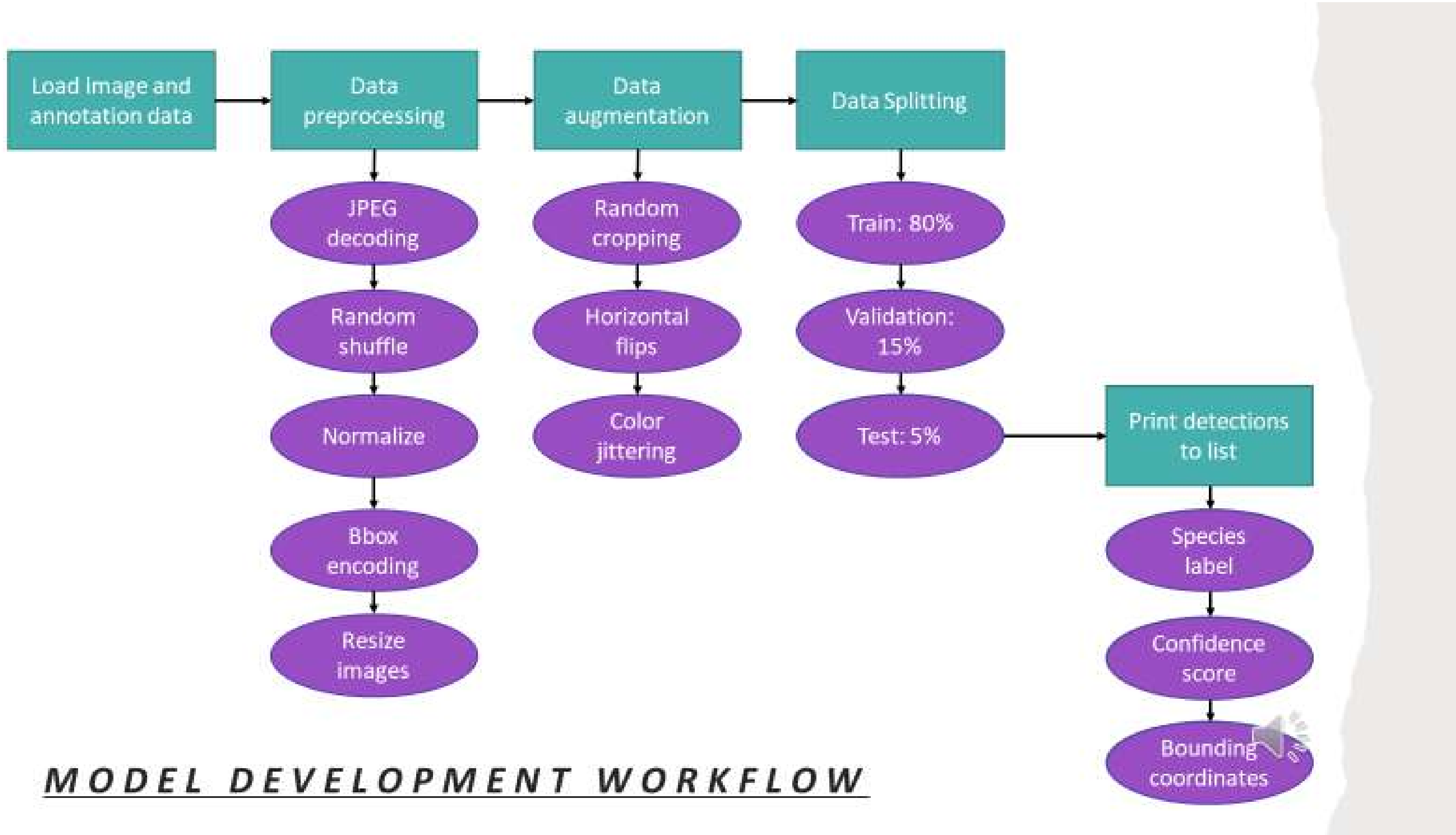
ANALYTICAL METHODS

- Develop, train, and evaluate two object detection models
- PyTorch machine learning framework
- Model 1: Image object detection model
    - Single Shot MultiBox Detector (SSD)
    - Deep Residual Neural Network (ResNet) backbone for classification
- This model will:
    - Detect waterfowl
    - Localize each duck's location (i.e., draw bounding box)
    - Label bounding box with species name and confidence score



ANALYTICAL METHODS, CONTINUED

- Model 2: Video object detection model
  - FairMOT multiple-object tracker for detection and re-identification
  - Deep motion modeling network (DMMN) for motion detection
  - ResNet backbone for classification
- This model will:
  - Detect waterfowl
  - Localize each duck's location
  - Label bounding box with species name and confidence score
  - Track objects across frames
  - Determine habitat use based on motion (motionless—loafing, motion—foraging)


Load image and annotation data
Data preprocessing
Data augmentation
Data Splitting
JPEG decoding
Random shuffle
Normalize
Bbox encoding
Resize images
Random cropping
Horizontal flips
Color jittering
Train: 80%
Validation: 15%
Test: 5%
Print detections to list
Species label
Confidence score
Bounding coordinates
MODEL DEVELOPMENT WORKFLOW

PRELIMINARY RESULTS

- Compared two ResNet models of different complexity (34 and 50 identity mapping layers) at their ability to determine whether a species is present in an image
- Mean precision across tests was used to assess model accuracy at each complexity level
- ResNet-50 outperformed ResNet-34 at identifying the species present

DISCUSSION & NEXT STEPS

- ResNet-50 is a practical algorithm for species classification
- Next steps:
  - Annotate drone imagery
  - Train image object detection model (1) from scratch
  - Evaluate fully trained model
  - Tune hyperparameters to optimize performance
  - Develop a video object detection model (2)
  - Train video model using optimized weights from image model
  - Evaluate trained video model
  - Compile models into one program
  - Deploy web application

CONCLUSION

- This study facilitates the development of monitoring protocols for comparing site-specific relative waterfowl use by investigating drone and AI technologies' efficacy
- These results will give managers the most efficient and cost-effective means to count waterfowl on project sites
- This project can improve managers' capacity to evaluate waterfowl response to restoration efforts
- As such, we will guide how monitoring should be conducted within future habitat management frameworks by determining the best monitoring strategy

QUESTIONS?

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Photo credit: Mike Furtman

Drones, Structure from Motion and the Digital Twin: Lessons Learned Trying to Model Spring Habitats

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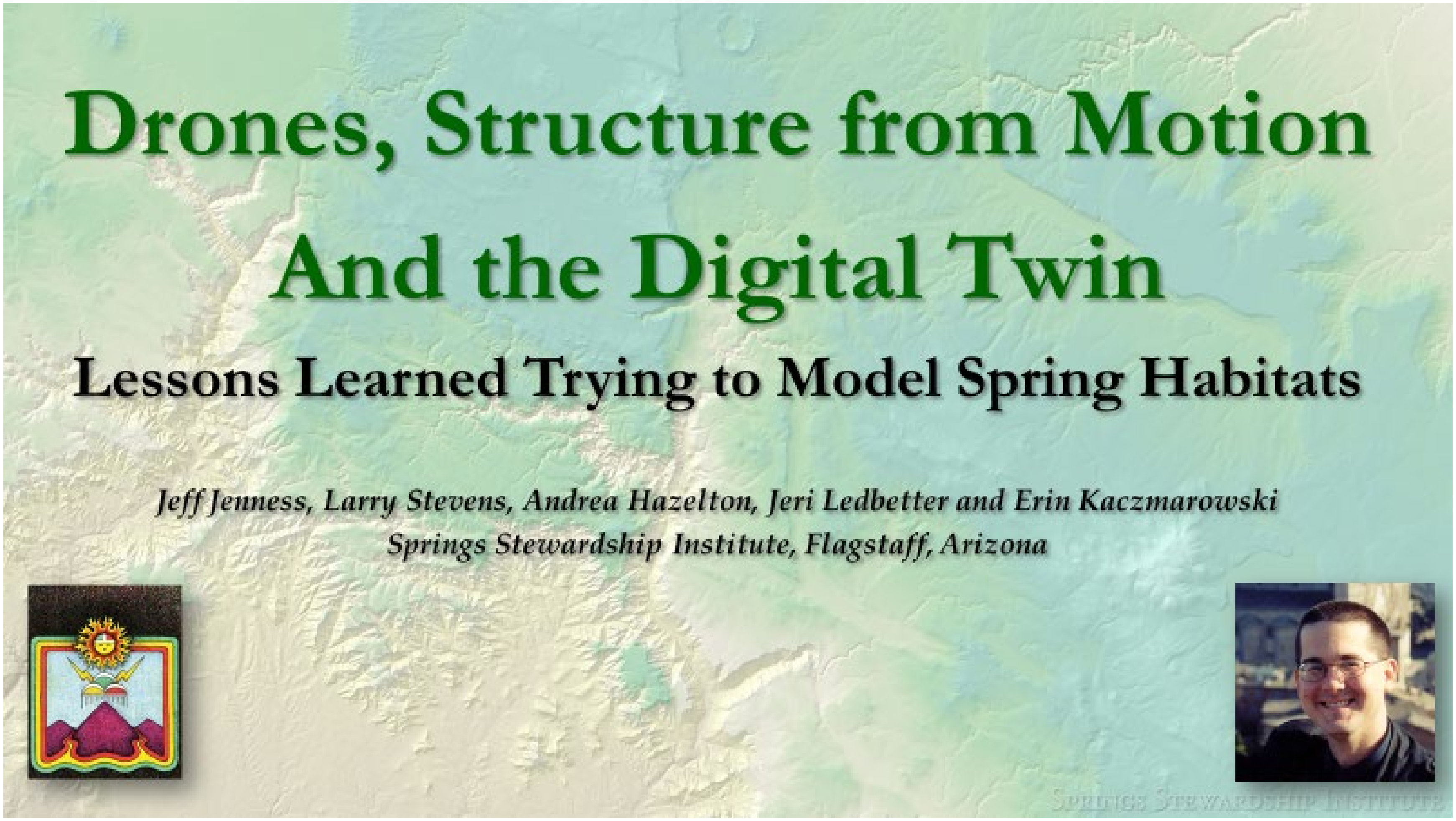
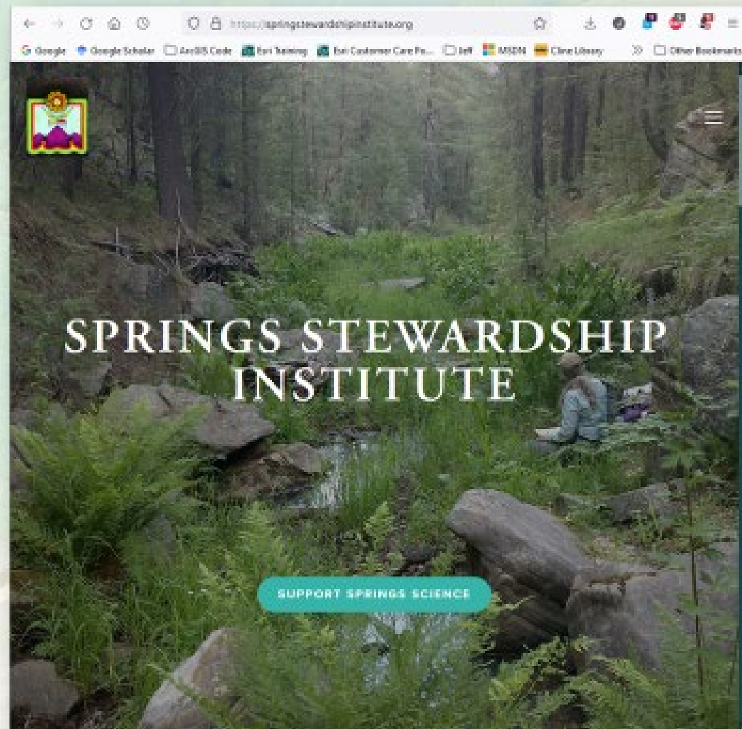
[1]Springs Stewardship Institute, Flagstaff, AZ; jeff@springstewardship.org
[2]Museum of Northern Arizona, Flagstaff, AZ

Spring ecosystems are among the most biologically diverse and ecologically vital ecosystems on the landscape, and even more so in dry habitats such as the Southwestern US. Comprehensive surveys of these spring habitats give us a unique perspective into larger ecosystem dynamics. Unfortunately, some aspects of springs can be difficult to measure and describe. It is easy enough to record elevation, slope and aspect at a location, for example, but it is considerably more difficult to precisely describe the complex topographic shape of the surrounding area. We can map the outflow path, but it is harder to describe the shape of the land that produces that path. Furthermore, some springs can be difficult or dangerous to reach, such as hanging gardens high on a cliff. Here we describe lessons learned from some attempts to use relatively inexpensive drone imagery, along with the free open-source software package OpenDroneMap, to describe habitat characteristics of hard-to-reach spring locations and to apply structure-from-motion tools to generate 3D maps of local topography from drone-based images.


Drones, Structure from Motion
And the Digital Twin
Lessons Learned Trying to Model Spring Habitats
Jeff Jenness, Larry Stevens, Andrea Hazelton, Jeri Ledbetter and Erin Kaczmarowski
Springs Stewardship Institute, Flagstaff, Arizona
SPRINGS STEWARDSHIP INSTITUTE

Background

- Springs Stewardship Institute



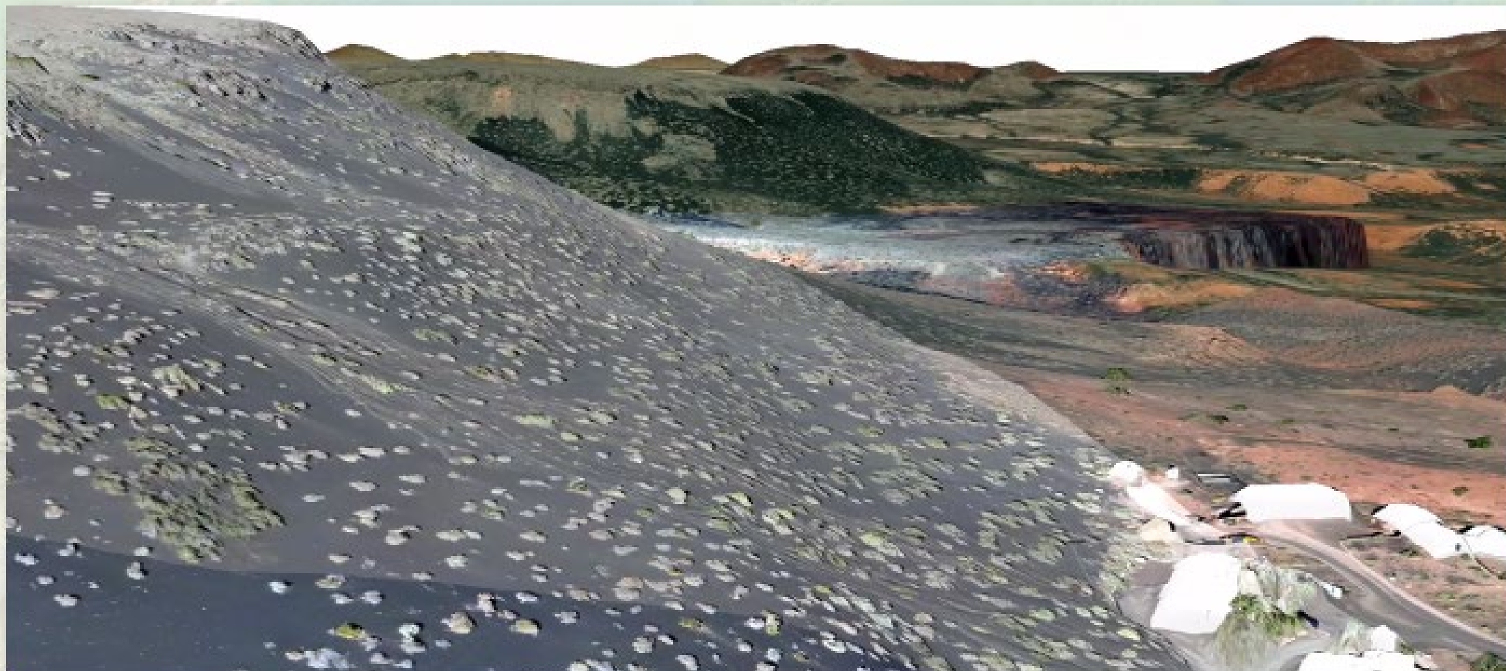
Background

- Springs Stewardship Institute
- Springs Online

Springs Stewardship Institute

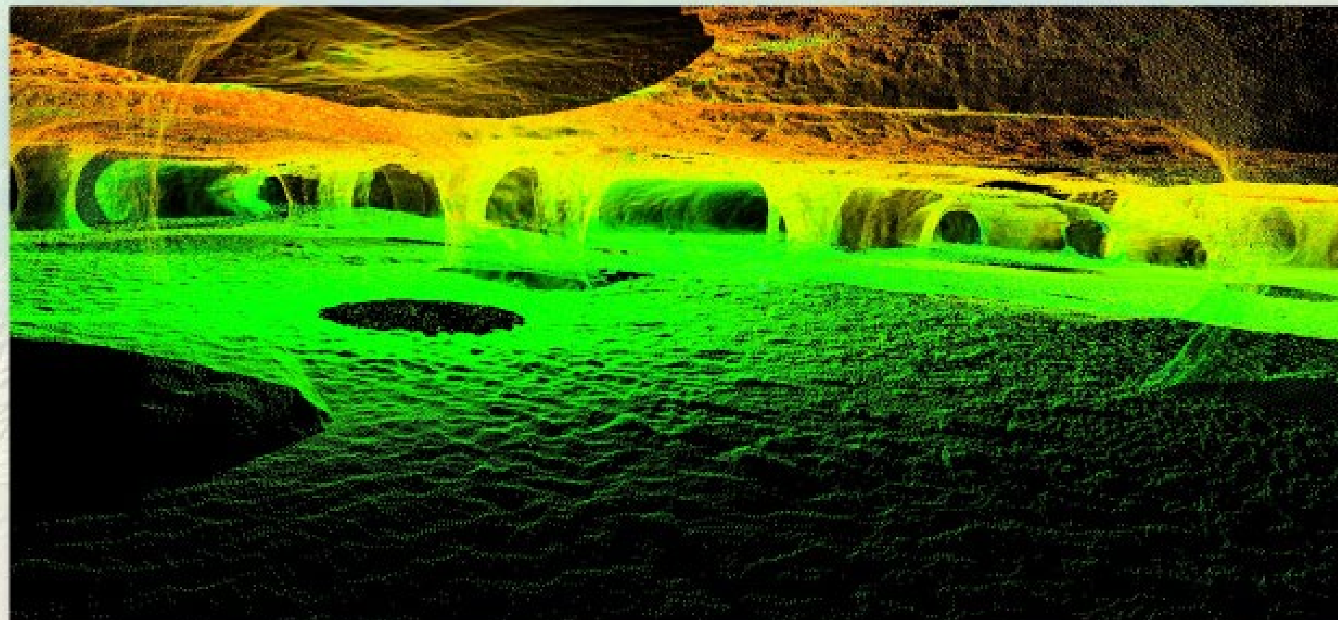
Background

- The “Digital Twin”



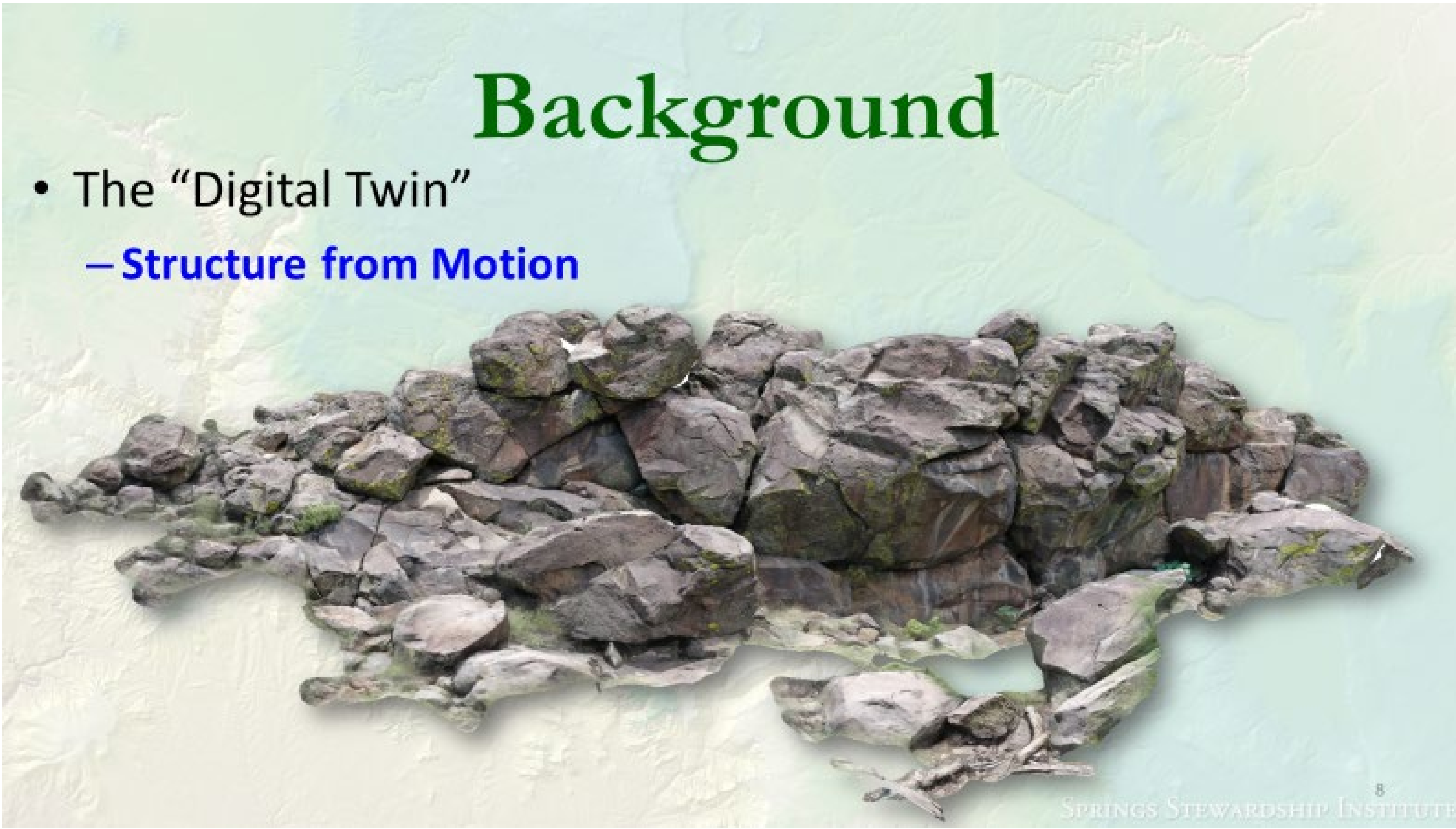
Background

- The "Digital Twin"
  - LiDAR



adventuresindigitalarchaeology.wordpress.com/2014/05/06/rescue-lidar-in-southern-jordan/


Background
• The "Digital Twin"
– Structure from Motion


Background
• The "Digital Twin"
– Structure from Motion
8
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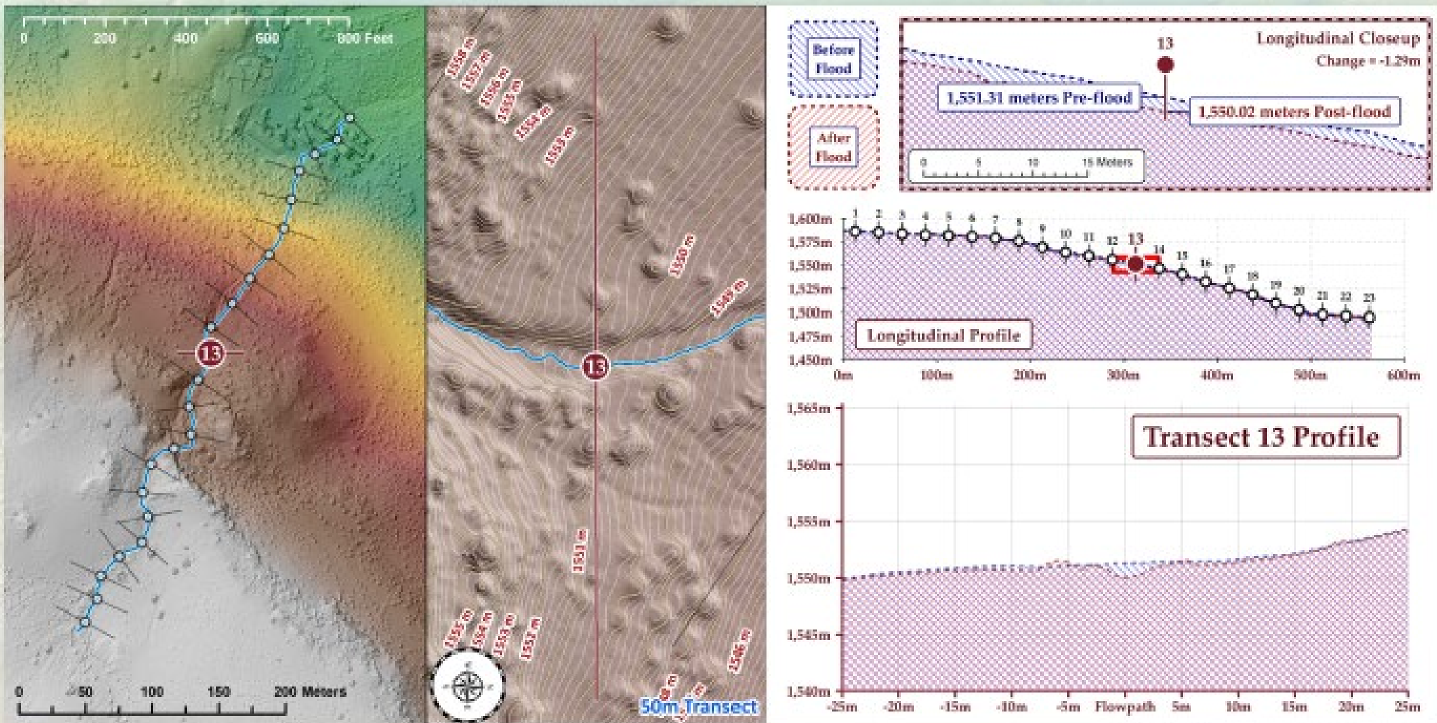
Applications for Springs Stewardship
• Hard-to-Reach Areas
With thanks to Rich Rudow for the photo!
9

Applications for Springs Stewardship

- 3D Models



10

Methods

- LiDAR not an Option
- Structure-from-Motion

DJI Mavik 2 Pro drone

12

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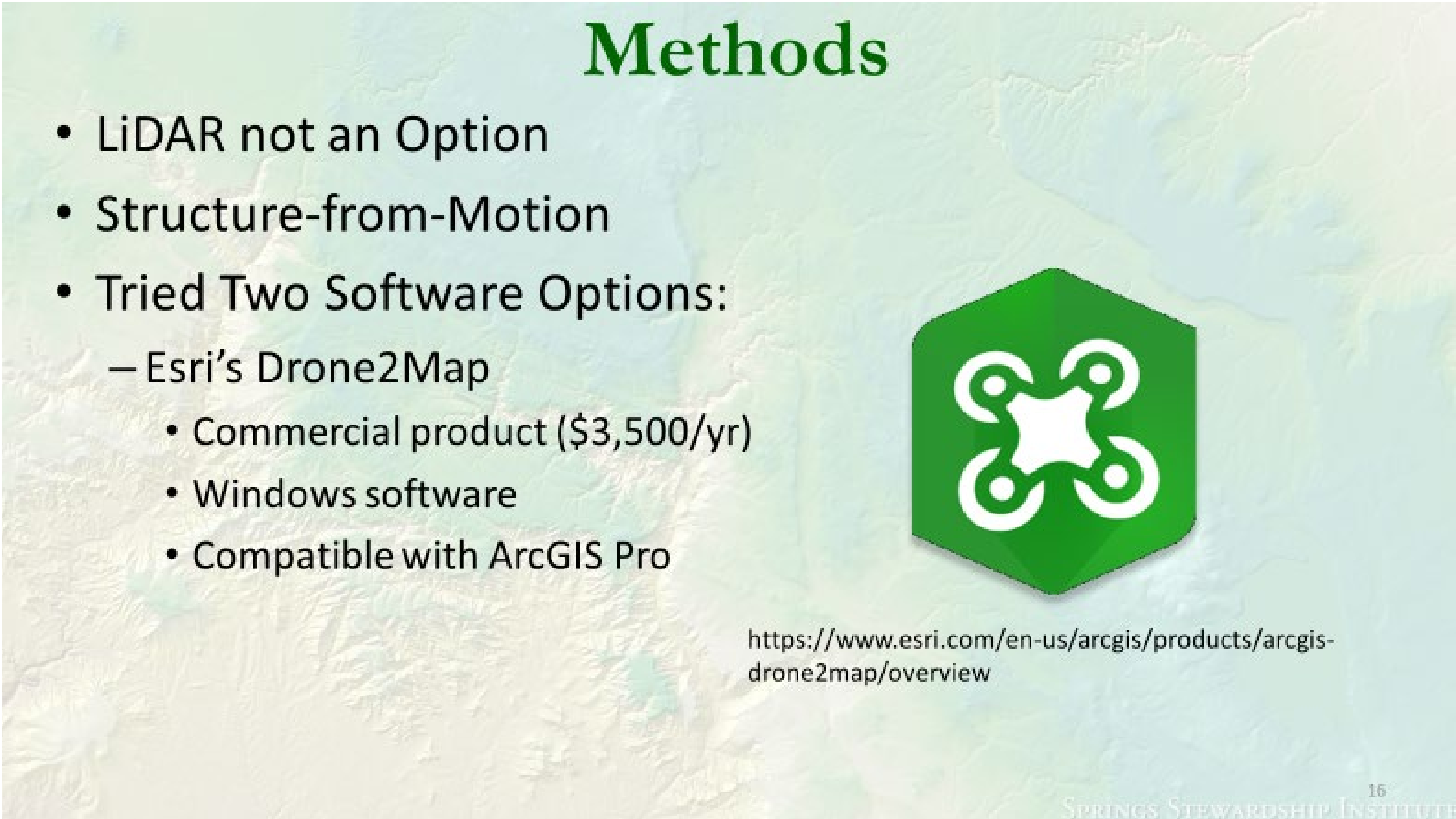
Methods
• LiDAR not an Option
• Structure-from-Motion
• Tried Two Software Options:
– Esri's Drone2Map
• Commercial product ($3,500/yr)
• Windows software
• Compatible with ArcGIS Pro
https://www.esri.com/en-us/arcgis/products/arcgis-drone2map/overview
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Methods

- LiDAR not an Option
- Structure-from-Motion
- Tried Two Software Options:
  - OpenDroneMap
    - Free and Open Source
    - Runs on Linux

ODM

https://www.opendronemap.org

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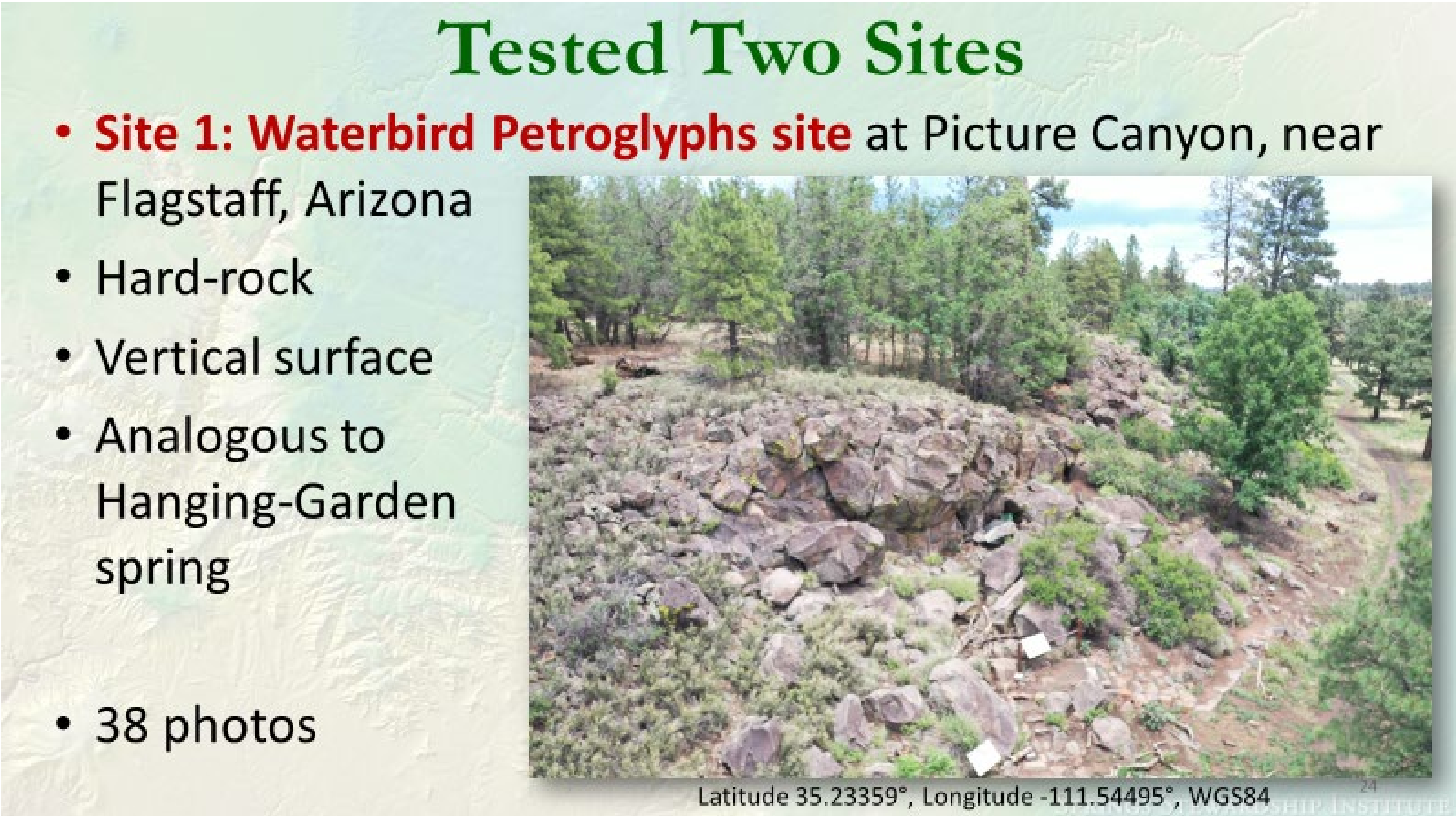
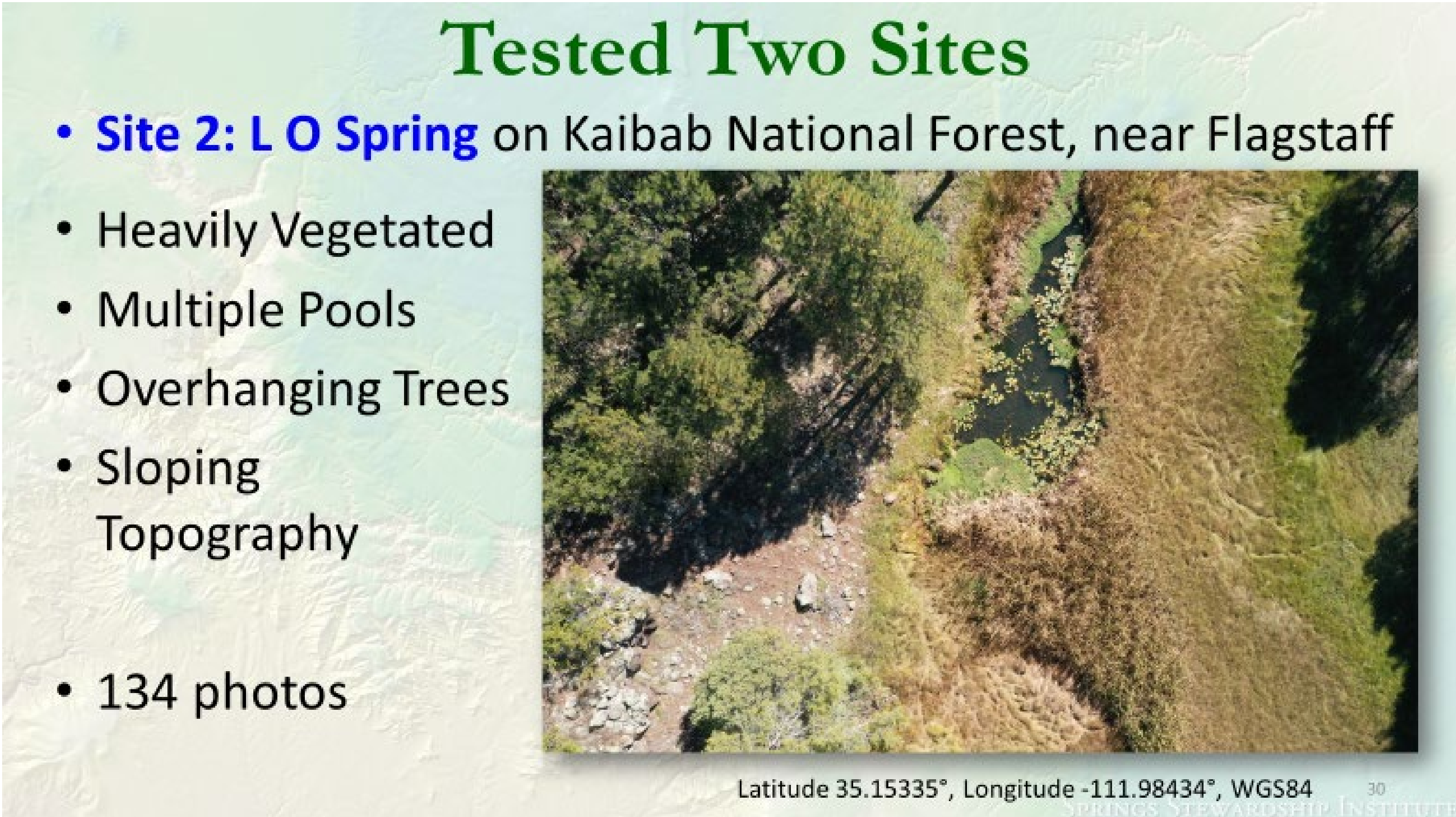

Tested Two Sites
• Site 1: Waterbird Petroglyphs site at Picture Canyon, near Flagstaff, Arizona
• Hard-rock
• Vertical surface
• Analogous to Hanging-Garden spring
• 38 photos
Latitude 35.23359°, Longitude -111.54495°, WGS84
24


Tested Two Sites
• Site 2: L O Spring on Kaibab National Forest, near Flagstaff
• Heavily Vegetated
• Multiple Pools
• Overhanging Trees
• Sloping Topography
• 134 photos
Latitude 35.15335°, Longitude -111.98434°, WGS84
30
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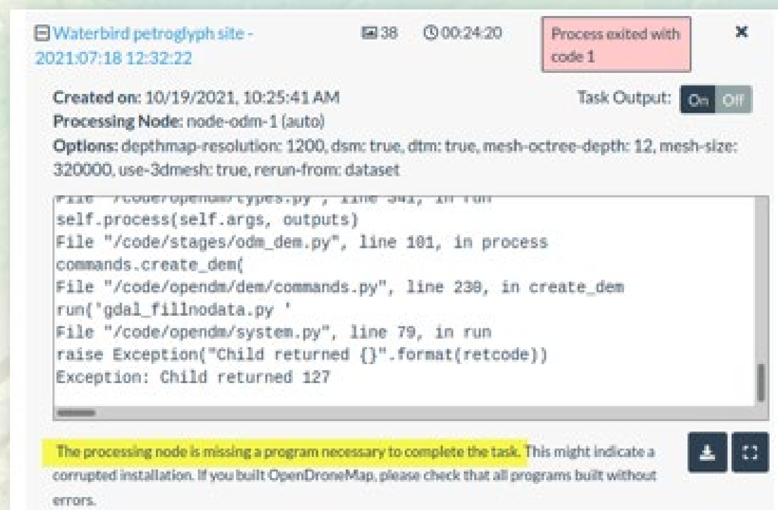
Results

- Comparison of **Drone2Map** with **OpenDroneMap**
  - Drone2Map worked better in most respects
  - Both took roughly the same amount of time to work

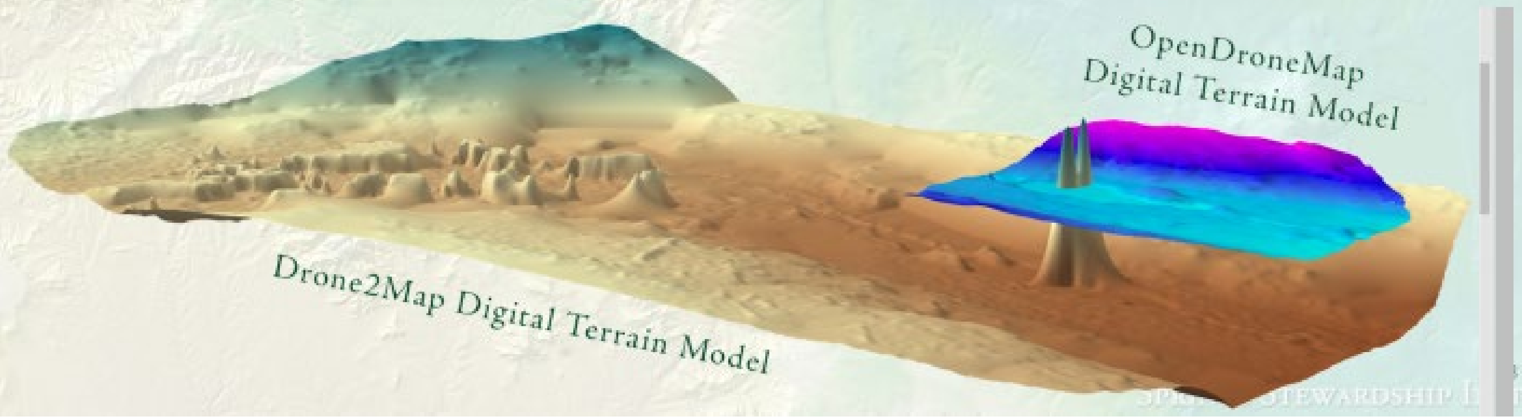
Results

- Comparison of Drone2Map with OpenDroneMap
  - OpenDroneMap:
    - Problems we were unable to figure out.
    - Wouldn't work on Picture Canyon at all…



Results

- Comparison of Drone2Map with OpenDroneMap
  - OpenDroneMap:
    - Problems we were unable to figure out.
    - Wouldn't work on Picture Canyon at all…
    - Worked at L O Spring, but only on a small portion of it.
      - That small portion was better than Drone2Map's output, though.



Results

- Comparison of Drone2Map with OpenDroneMap
  - OpenDroneMap:
    - Problems we were unable to figure out.
    - Wouldn't work on Picture Canyon at all…
    - Worked at L O Spring, but only on a small portion of it.
      - That small portion was better than Drone2Map's output, though.
    - 3D Model not compatible with ArcGIS
      - Uses local coordinate system
    - Did fine with 3D Point clouds, Digital Terrain and Surface Models, and Orthophotos

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Results

- Comparison of **Drone2Map** with **OpenDroneMap**
  - **Drone2Map:**
    - Successfully generated 3D Models, point clouds, Terrain and Surface models and orthophotos
    - Outputs compatible with ArcGIS
    - Able to post outputs as web maps
    - L O Springs Web Scene: https://jennessent.maps.arcgis.com/apps/webappviewer3d/index.html?id=a4201f9f848949b5acedd80aa04afb87

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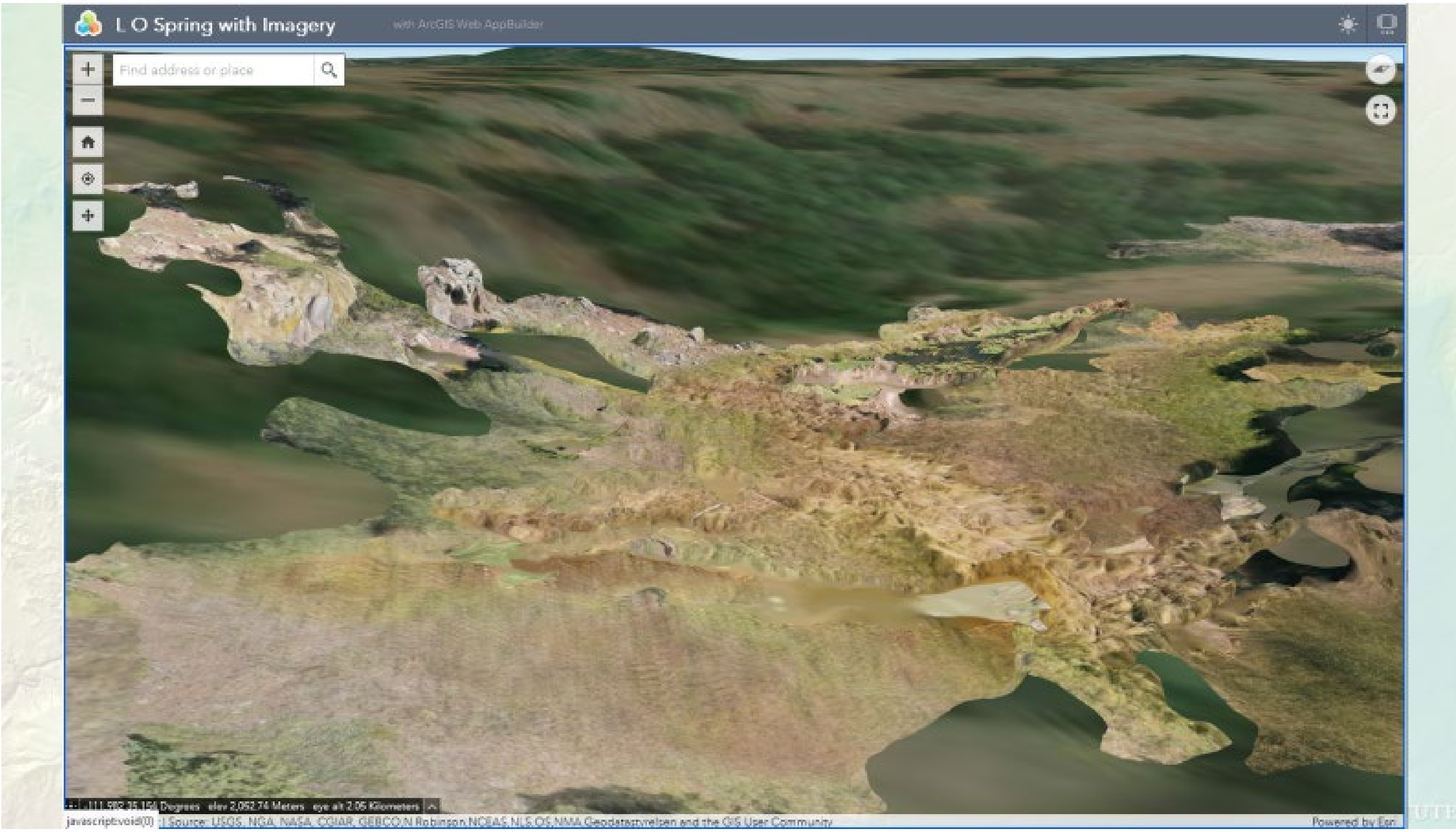
L O Spring with Imagery
with ArcGIS Web AppBuilder
Find address or place
Degrees elev 2,052.74 Meters eye alt 2.05 Kilometers
javascript:void(0)
Source: USGS, NGA, NASA, CGIAR, GEBCO,N Robinson,NCEAS,NLS,OS,NMA,Geodatastyrelsen and the GIS User Community
Powered by Esri

Results

- Comparison of **Drone2Map** with **OpenDroneMap**
  - **Drone2Map:**
    - Successfully generated 3D Models, point clouds, Terrain and Surface models and orthophotos
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    - L O Springs Web Scene: https://jennessent.maps.arcgis.com/apps/webappviewer3d/index.html?id=a4201f9f848949b5acedd80aa04afb87
    - Picture Canyon Web Scene: https://jennessent.maps.arcgis.com/apps/webappviewer3d/index.html?id=c340e6051c9d4316b4f0b18029865d67

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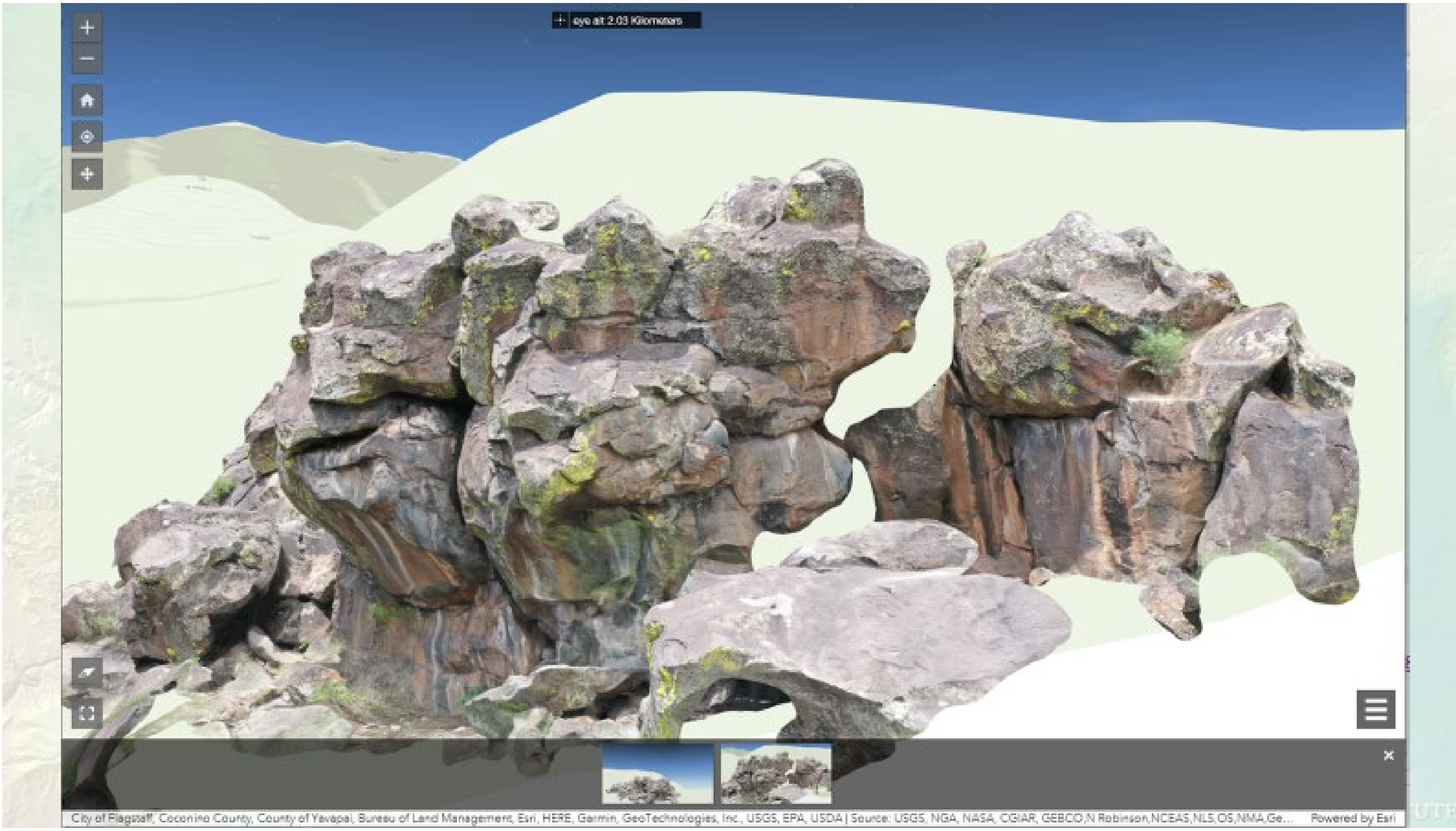
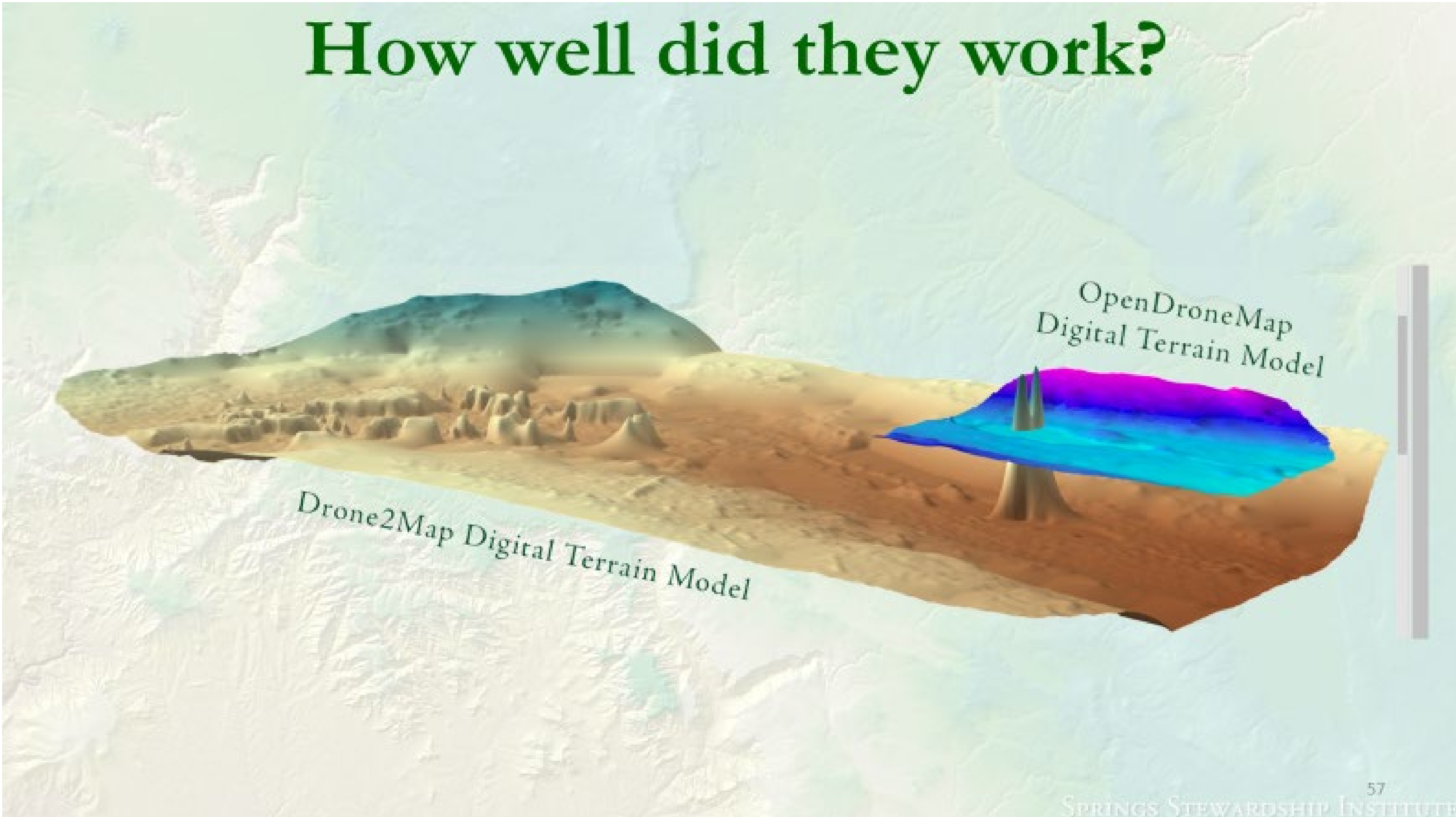

eye alt 2.03 Kilometers
City of Flagstaff, Coconino County, County of Yavapai, Bureau of Land Management, Esri, HERE, Garmin, GeoTechnologies, Inc., USGS, EPA, USDA | Source: USGS, NGA, NASA, CGIAR, GEBCO,N Robinson,NCEAS,NLS,OS,NMA,Ge...
Powered by Esri

How well did they work?

- Picture Canyon much better than L O Spring
  - Found petroglyphs in 3D Model we had never actually seen while at the site
- L O Spring output was unusable
  - Probably because of dense vegetation cover
- OpenDroneMap and Drone2Map outputs were offset 5m horizontally and 15m vertically


How well did they work?
OpenDroneMap
Digital Terrain Model
Drone2Map Digital Terrain Model
57
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How well did they work?

- Picture Canyon much better than L O Spring
  - Found petroglyphs in 3D Model we had never actually seen while at the site
- L O Spring output was unusable
  - Probably because of dense vegetation cover
- **OpenDroneMap** and **Drone2Map** outputs were offset 5m horizontally and 15m vertically
- Drone was great at general pictures and videos

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Thanks for listening!
– Questions?
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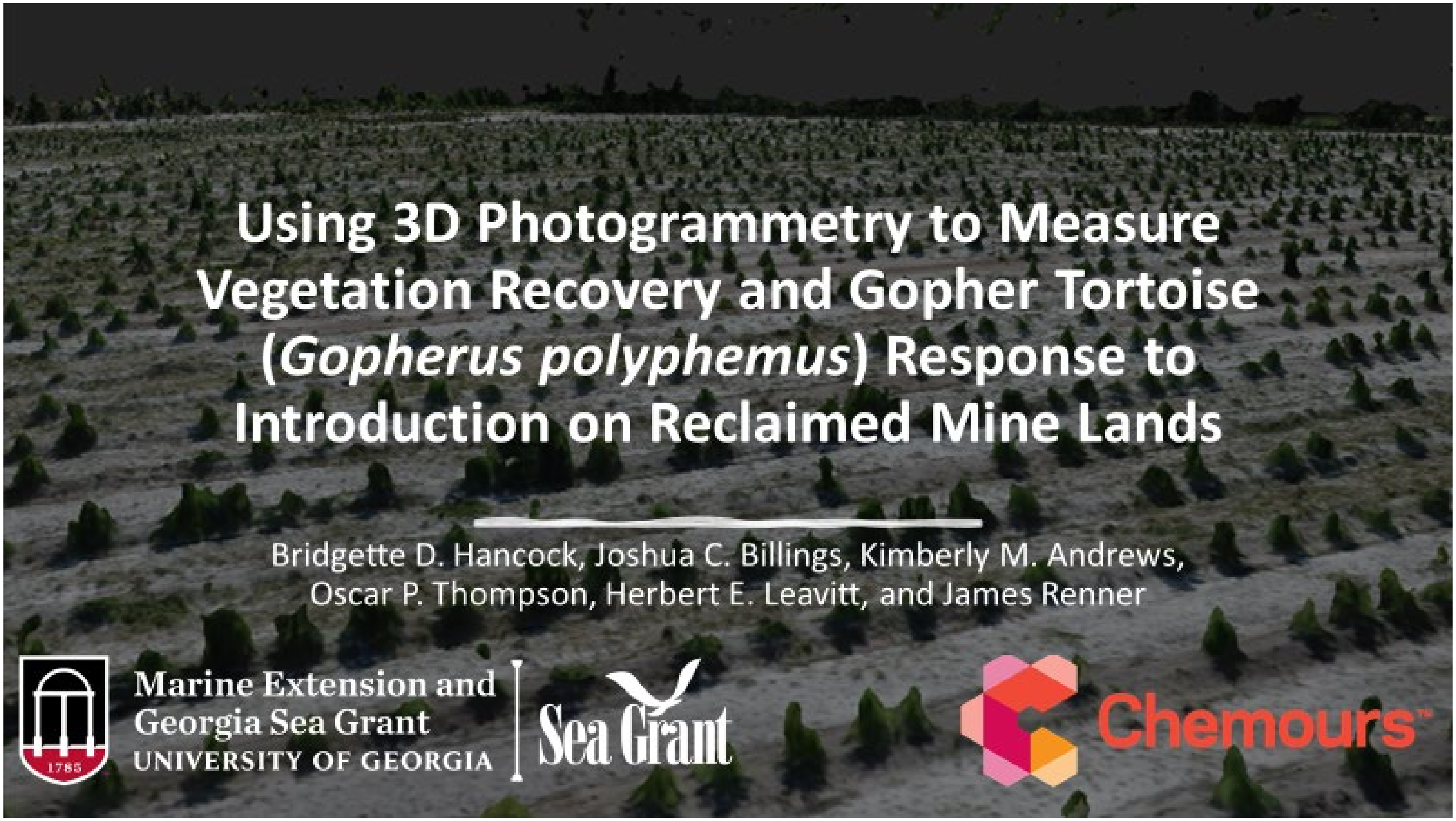
Using 3D Photogrammetry to Measure Vegetation Recovery and Gopher Tortoise (*Gopherus polyphemus*) Response to Introduction on Reclaimed Mine Lands

Bridgette D. Hancock[1], Joshua C. Billings[1], Kimberly M. Andrews[1], Oscar P. Thompson[1], Herbert E. Leavitt[2], and James Renner[3]
[1]Marine Extension and Georgia Sea Grant-Coastal Ecology Lab, University of Georgia; bridgette.hancock@uga.edu
[2]University of Louisiana at Lafayette
[3]The Chemours Company FC, LLC

As part of an ongoing study on the success of gopher tortoise (*Gopherus polyphemus*) introduction onto reclaimed mineral sand lands, we monitored vegetation recovery and post-release tortoise behaviors in southeastern Georgia. To assess habitat quality, we used drones and 3D photogrammetry to measure vegetation density and growth progression. Additionally, we sampled quadrats around both occupied and unoccupied tortoise burrows, as well as plots not containing any burrow, to determine vegetation composition. Drone images were taken of a subset of these vegetation plots in addition to an overview flight of the entire site. To monitor tortoise movements in relation to vegetation patterns, each tortoise within this study was equipped with a VHF transmitter and GPS logger. Herbaceous cover was reduced in areas with thinner topsoil and vegetation composition varied with elevation. Tortoise burrows were distributed unevenly with reduced occupancy in areas of either sparse or extremely dense vegetation. Despite less herbaceous forage, tortoises generally clustered in areas of higher elevation, continuously switching occupancy among the same subset of those burrows and avoided wetter locations that were lower quality for burrow construction. Following their release onto reclaimed mine lands, burrow distribution was clustered in a smaller area and multiple occupancy was more common, a pattern that continued through the first winter. These results are key to determining whether reclaimed mine lands can support tortoise populations and reduce the need for long-distance animal translocations. Successful habitat reclamation also could aid in restoring populations of the many commensal species associated with tortoise burrows.


Using 3D Photogrammetry to Measure Vegetation Recovery and Gopher Tortoise (*Gopherus polyphemus*) Response to Introduction on Reclaimed Mine Lands
Bridgette D. Hancock, Joshua C. Billings, Kimberly M. Andrews,
Oscar P. Thompson, Herbert E. Leavitt, and James Renner
Marine Extension and
Georgia Sea Grant
UNIVERSITY OF GEORGIA
1785
Sea Grant
Chemours™

Project Background

- Ongoing, initiated in 2020 in southeastern Georgia
- Viability of reclaimed mine lands as recipient sites for gopher tortoise relocations
  - Do they have proper habitat to forage, construct burrows, and reproduce?
- Forage quality
  - Variation in vegetation/growth progression
- Tortoise response to seasonal and successional changes in vegetation

Gopher Tortoise

- The gopher tortoise (*Gopherus polyphemus*) is a primarily herbivorous, egg-laying and terrestrial species
- Range in southern portions of southeastern United States
- Keystone species and ecosystem engineer
- Prefer sandy soils
  - Longleaf pine forests and sandhill habitats
- Often switch and abandon burrows

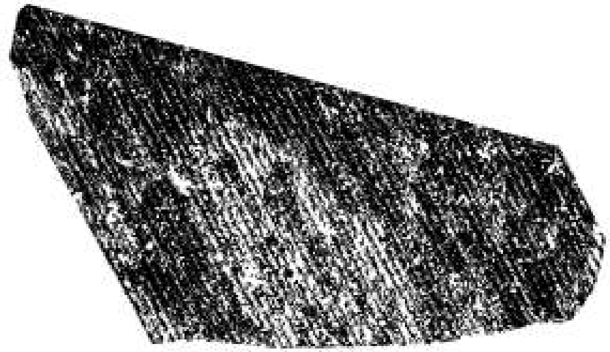
Range map from gophertortoisecouncil.org

Methods—Vegetation Research

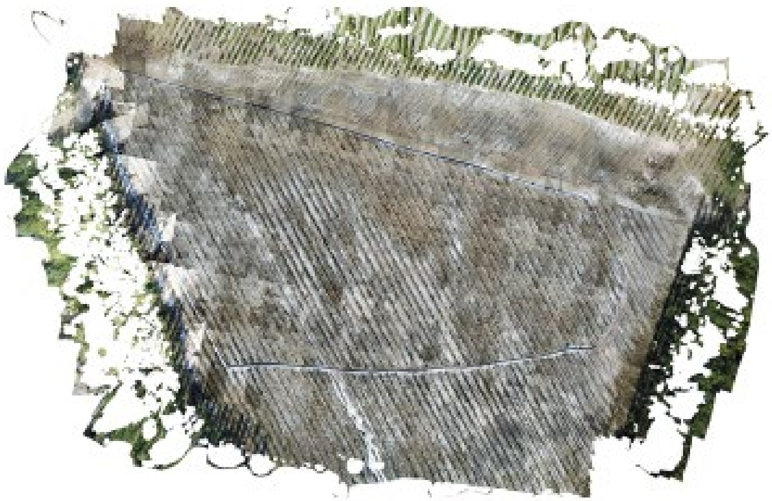
- Utilize drones (DJI Mavic Pro) to assess vegetation and habitat quality
- Vegetation surveys conducted quarterly
  - Overview flight of entire ~4 ha (10 ac)
  - 5x5m plots
- Selected vegetation and drone photo plots based on burrow occupancy (Occupied, unoccupied, and random)
  - Occupied (n=15) = tortoise present in burrow
  - Unoccupied (n=15) = tortoise not present in burrow and no signs of activity present
  - Random (n = 30) = Randomly selected plot with no burrow present
- Classified vegetation into groups and identified priority species

Methods—Data Analysis

- Vegetation Composition and Recovery
  - Agisoft Metashape Professional to process orthophotogrammetry
  - Image J to calculate percent coverage of vegetation from orthophotos and overhead plot photos
  - JMP statistical analysis
- Spatial
  - ArcGIS
  - Agisoft Metashape Professional (elevation/orthophotos)

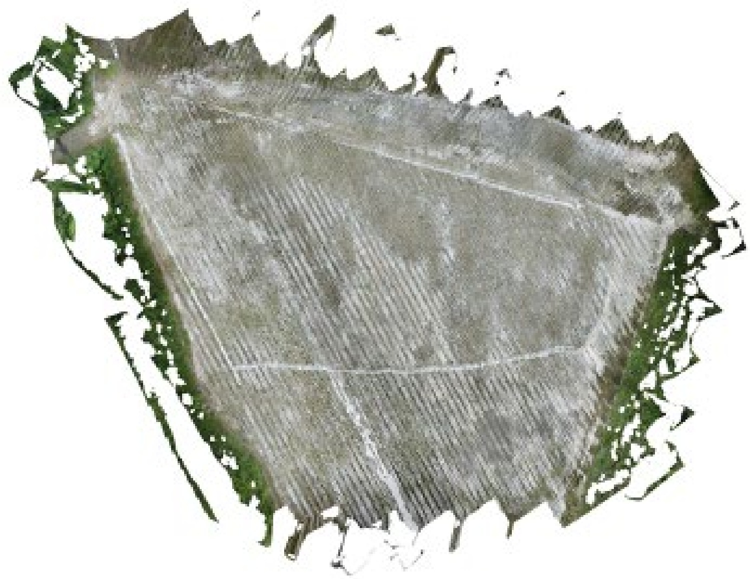


Vegetation Recovery Results to Date



January 2021
Vegetation % Coverage: 16.12%

January 2022
Vegetation % Coverage: 36.76%



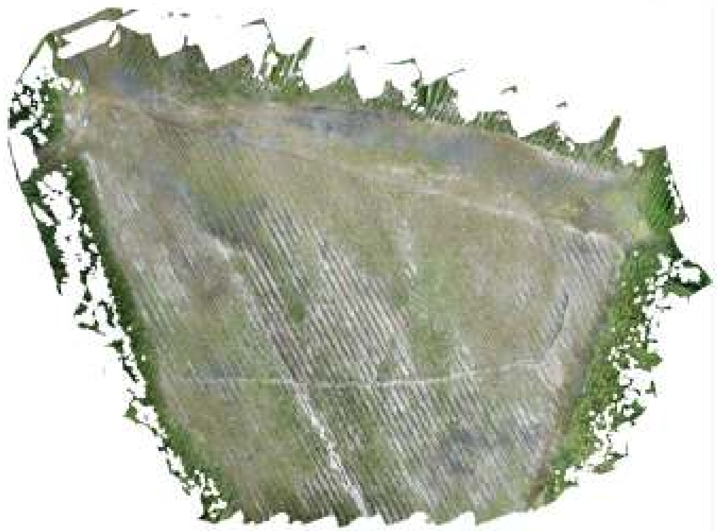
Spring 2021
Vegetation % Coverage: 33.41%

Spring 2022
Vegetation % Coverage: 45.05%

Summer 2021
Vegetation % Coverage: 42.48%

Summer 2022
Vegetation % Coverage: 43.45-46.14%

Vegetation Recovery Results to Date



Fall 2021
Vegetation % Coverage: 51.32%

Fall 2022 data still to come!

- Overall increase in % vegetation coverage over a year's time
- Highest overall % cover of pen in November 2021, following heavy rainfall and some flooding.
- Challenges:
  - Avoiding shadow casts in summer sessions

Quadrat Progression: An Example

Spring 2021
24.80% Cover

Summer 2021
61.41% Cover

Fall 2021
22.95% Cover

Winter 2021
4.17% Cover

Summer 2022
43.22% Cover

Unoccupied burrow % cover progression:

- Quarterly samples: 15 occupied, 15 unoccupied, 30 random
- Highest cover during summer, lowest during winter
- Dead herbaceous vegetation counted as bare soil as it is not quality forage for tortoises

Results

- Significant association between sampling quarter (season) and overall % vegetation coverage by $X^2(7, N=486) = 28.44$, $p = .0002$
- Not a significant association between plot type/burrow status (occupied, unoccupied, random) and overall % vegetation coverage by $X^2(2, N=486) = 3.92$, $p = .1408$
- Not a significant association between plot type/burrow status and season by $X^2(14, N=486) = 15.90$, $p = .3197$

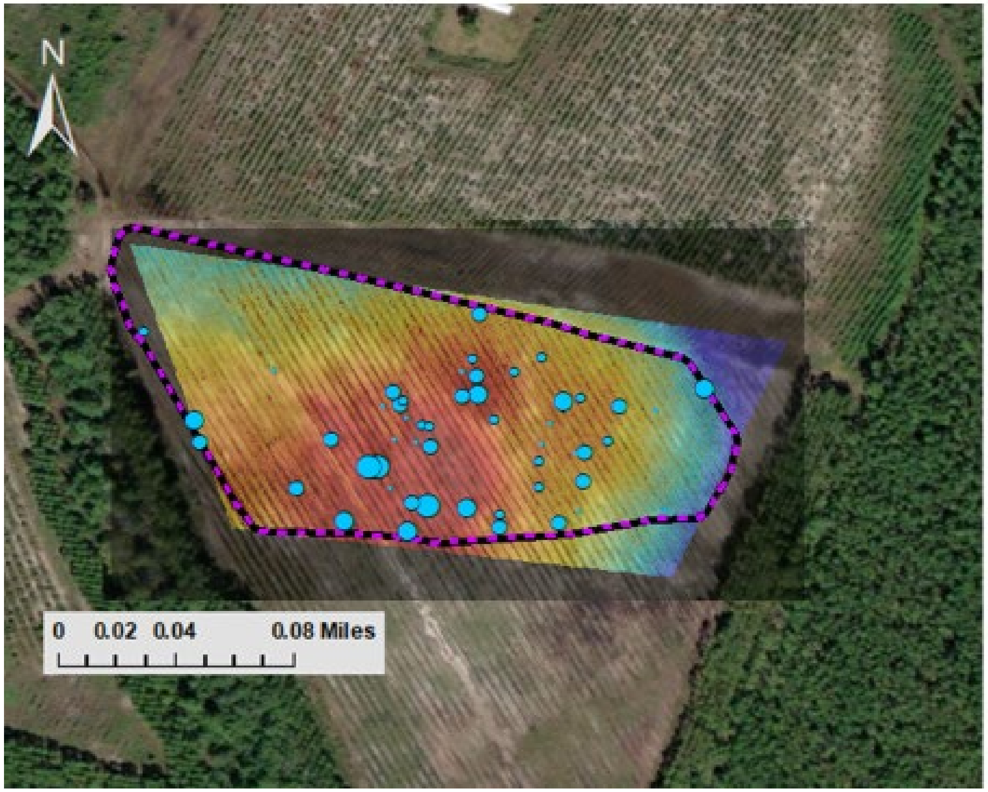
Measuring Reintroduction Success

- Field monitoring of post-released tortoises
- Tortoises contained using a silt fence pen over an area of ~4 ha (10 acres)
  - Allows them to overwinter and mitigates homing response
- Are they moving and behaving like healthy tortoises?
- Are they able to construct burrows?
- Interacting with other tortoises?
- Reproducing?
- Commensals being recruited?

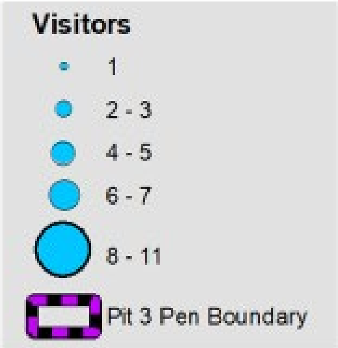
Methods—Spatial Research

- Equipped each tracked adult tortoise (n=16) with Perthold GPS loggers and ATS VHF transmitters using Waterweld epoxy
- Tracked to each tortoise on a weekly basis using VHF radio telemetry
- Game cameras set outside most burrows for further verification of location/activity and commensal species

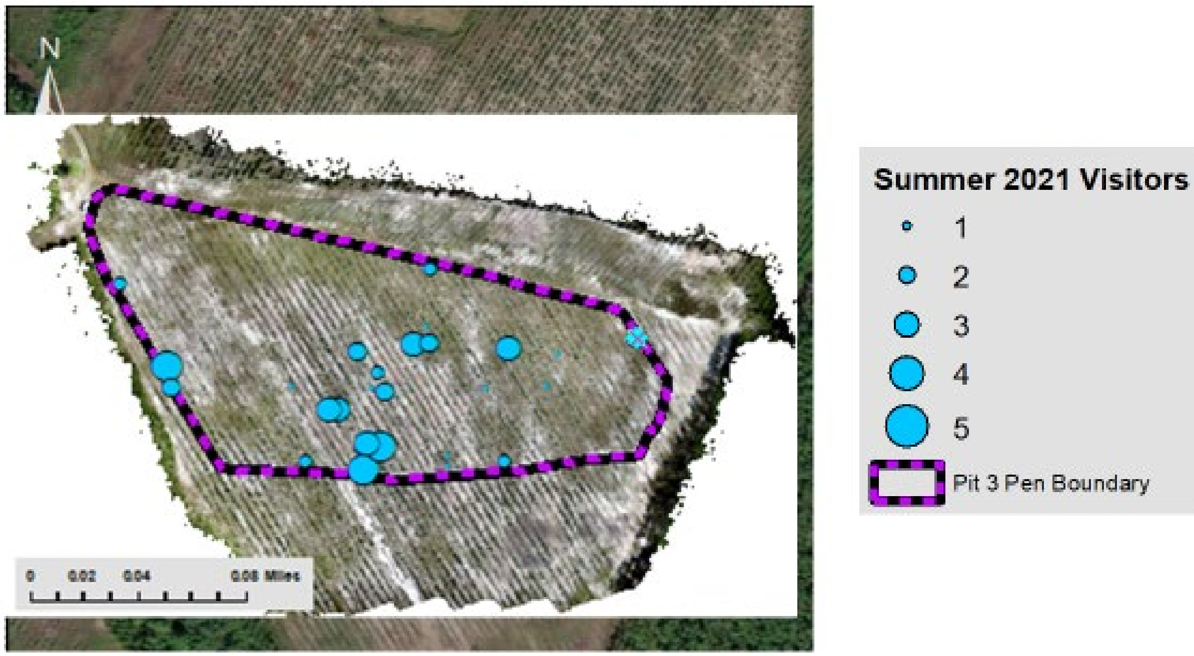
Tortoise Burrow Selection



- New points taken weekly
- Date range: June 23, 2021 – August 16, 2022
- Calculations based on # of different individual tortoises that were tracked to that burrow

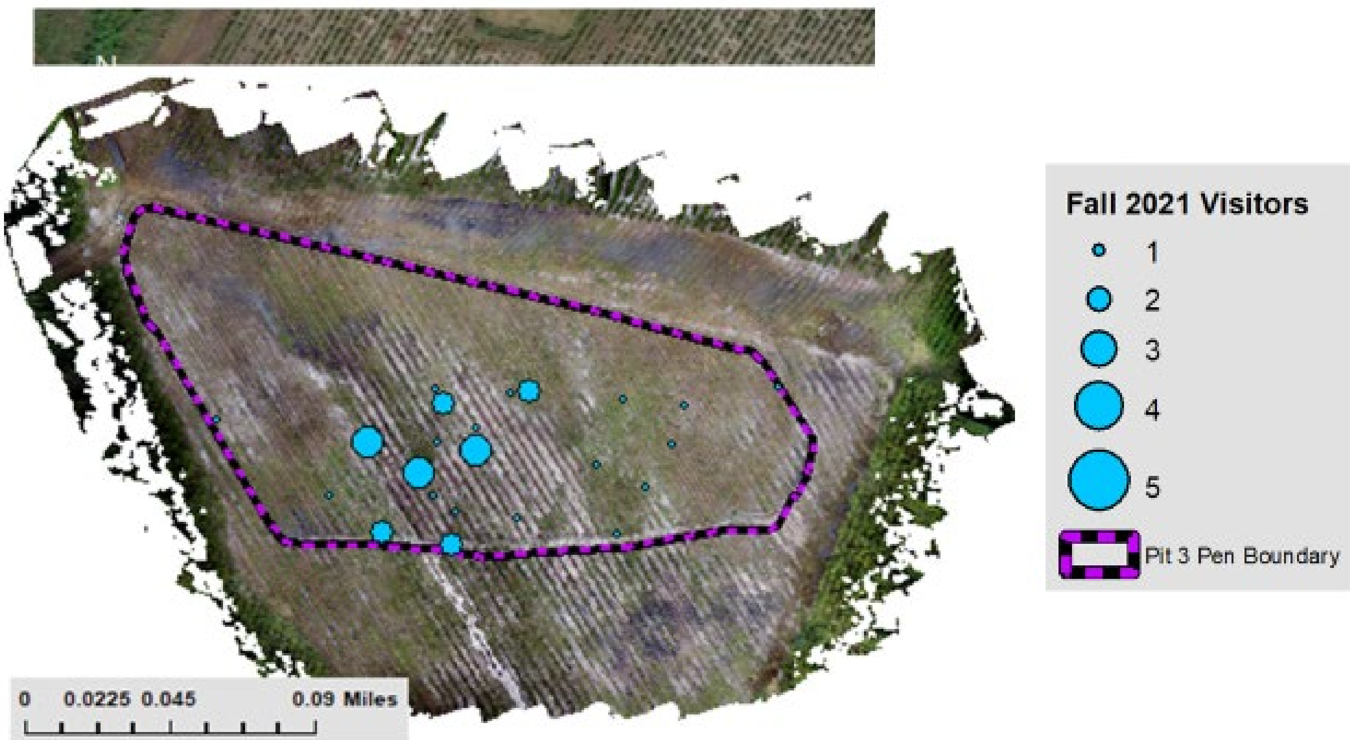


Summer 2021 Burrow Selection



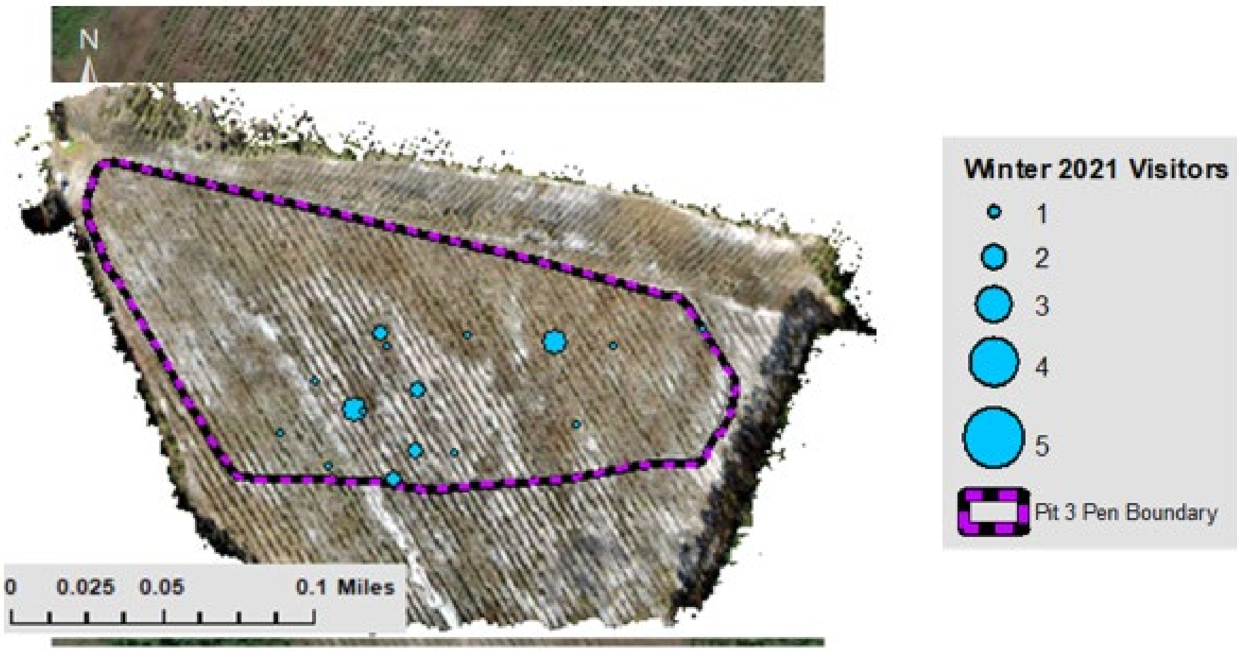
Summer quarter includes:
June
July
August

Fall 2021 Burrow Selection



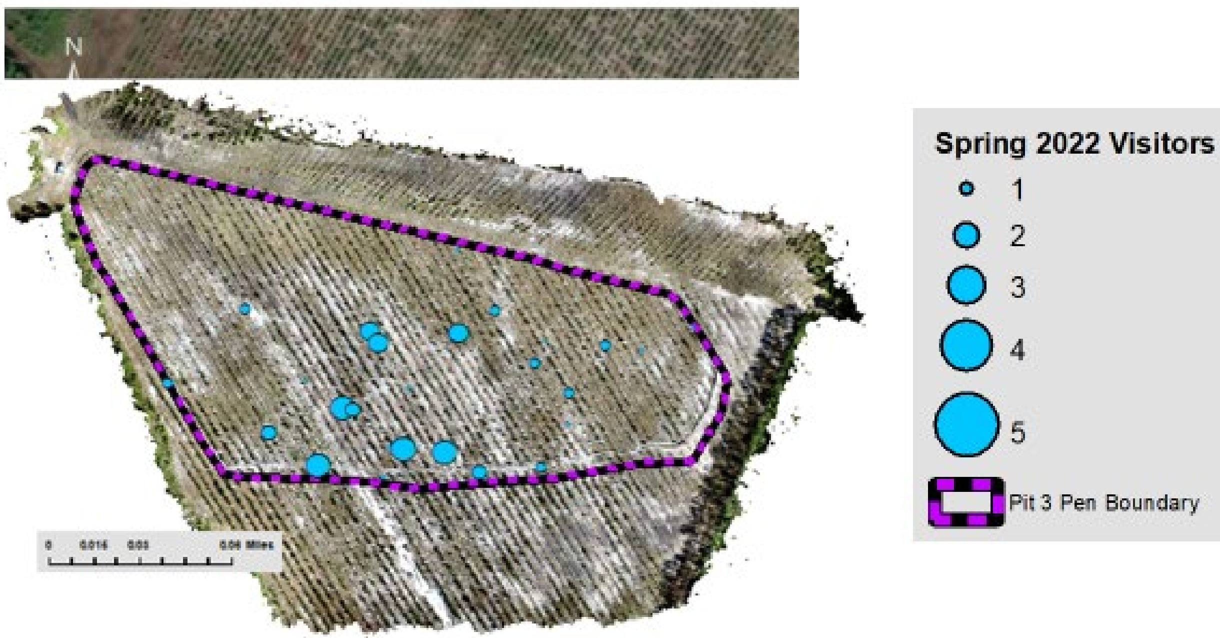
Fall quarter includes:
September
October
November

Winter 2021 Burrow Selection



Winter quarter includes:
December
January
February

Spring 2022 Burrow Selection



Spring quarter includes:
March
April
May

Summer 2022 Burrow Selection

Results

- Overall vegetation coverage did not have a statistically significant impact on tortoise burrow selection/dig locations
- Tortoises favor digging burrows in higher elevation
- Tortoises will avoid areas with more thinly distributed topsoil that resulted in minimal herbaceous vegetation growth
- Ongoing research

Implications

- Alternative to Department of Natural Resources (DNR) Wildlife Management Areas (WMAs) for gopher tortoise translocations
    - Shorter distance and eases demand for space on protected lands
- Sustainable mining practices
    - Environmental stewardship
- Keep historic gopher tortoise and commensal populations intact
- Reduce potential disease transfer
- Contributes to overall understanding of how gopher tortoises respond to translocation, and changes in soil and vegetation

Acknowledgements

- Funding was received from Chemours (previously Southern Ionics Minerals, LLC)
- Coastal Ecology Lab members and other staff at the UGA Marine Extension—Brunswick Station for support and patience with lots of tortoises around all the time
- Dr. Terry Norton, Jekyll Island Authority Georgia Sea Turtle Center, for veterinary support on wildlife health research

Chemours

Southern Ionics MINERALS

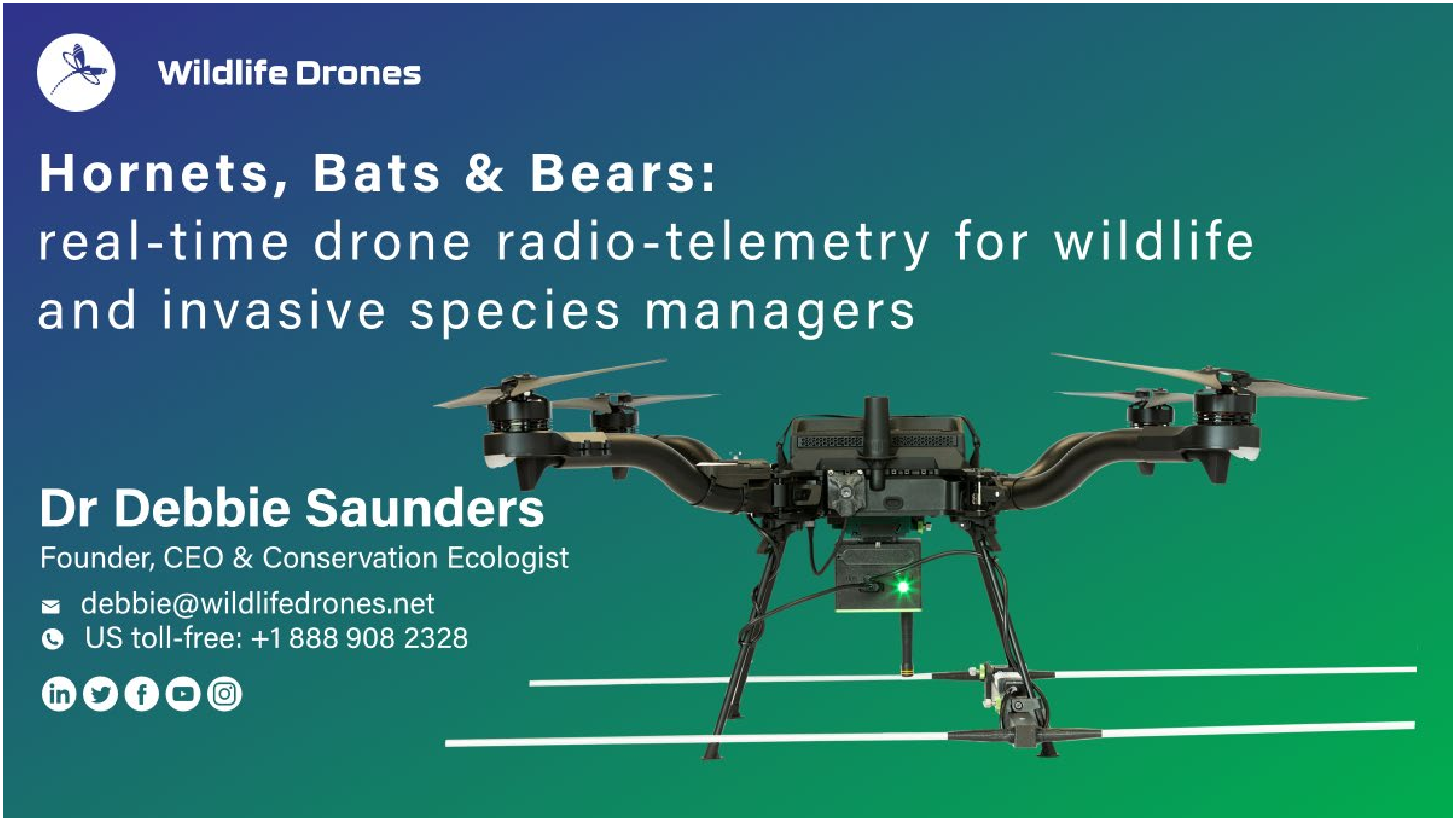
GEORGIA SEA TURTLE CENTER JEKYLL ISLAND


Questions?
For further questions, please contact me at
Bridgette.hancock@uga.edu

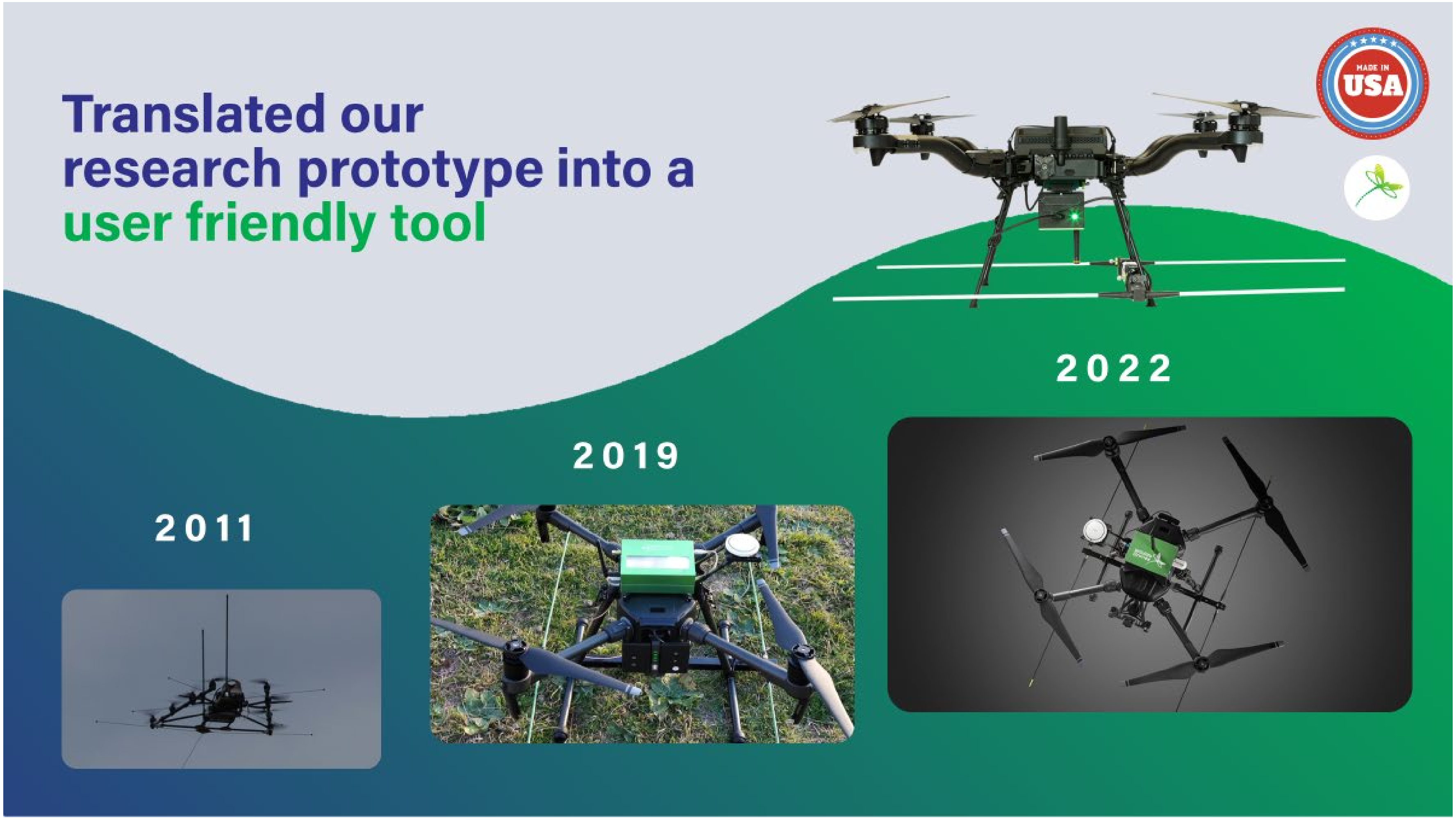
Hornets, Bats & Bears: Real-time Drone Radio-telemetry for Wildlife and Invasive Species Managers

Deb Saunders, Wildlife Drones, Canberra, Australia; debbie@wildlifedrones.net

Radio-telemetry is often the only way to shed light on movements of small animals and to gain critical insights for improving the effectiveness of management techniques. This includes threatened wildlife such as Indiana bats that are increasingly at risk from White Nose Syndrome, as well as invasive species such as giant Asian hornets that pose a threat to bee populations and other wildlife. However, the ability of these animals to move very fast across landscapes that are not as easily accessible on the ground, combined with the weak signals from their tiny radio tags, poses significant challenges for wildlife biologists tracking their movements. We provide examples of how innovative drone radio-telemetry technology has been used in both the United States and Australia to track such tiny species, overcoming many of the challenges faced when radio-tracking animals by hand from on the ground. We also explore future applications of this technology for tracking large game and wildlife, such as bears, mountain lions and wolves, for safely detecting and preventing conflicts between wildlife, people and livestock.

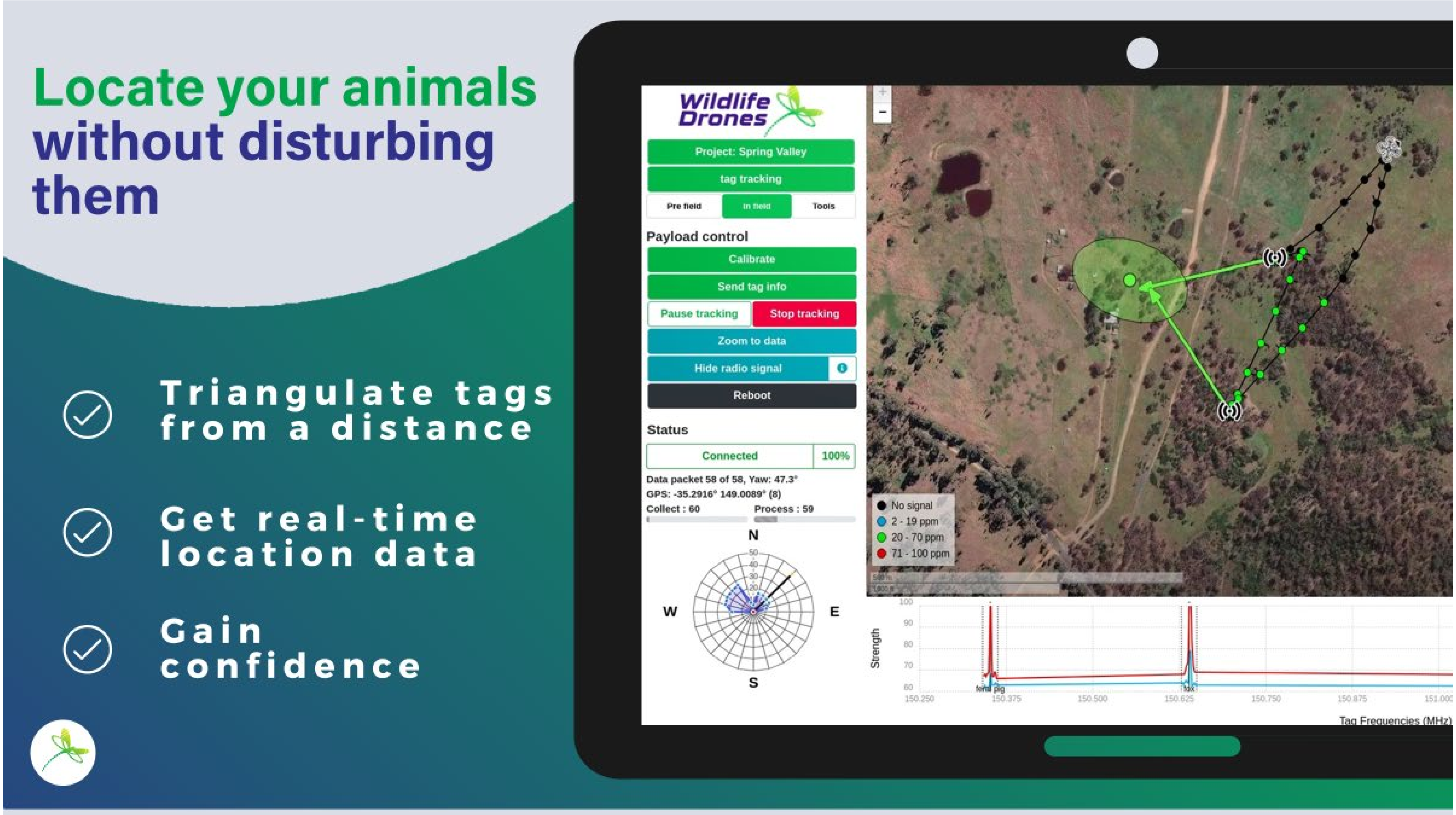

Wildlife Drones
Hornets, Bats & Bears:
real-time drone radio-telemetry for wildlife and invasive species managers
Dr Debbie Saunders
Founder, CEO & Conservation Ecologist
debbie@wildlifedrones.net
US toll-free: +1 888 908 2328


Have you ever done this?
We have too, and decided to change that!


Translated our
research prototype into a
user friendly tool
MADE IN
USA
2022
2019
2011


World's most advanced drone radio-tracking technology
Works straight out of the box
Attaches to off-the-shelf drone
Radio-receiver Payload
Base station

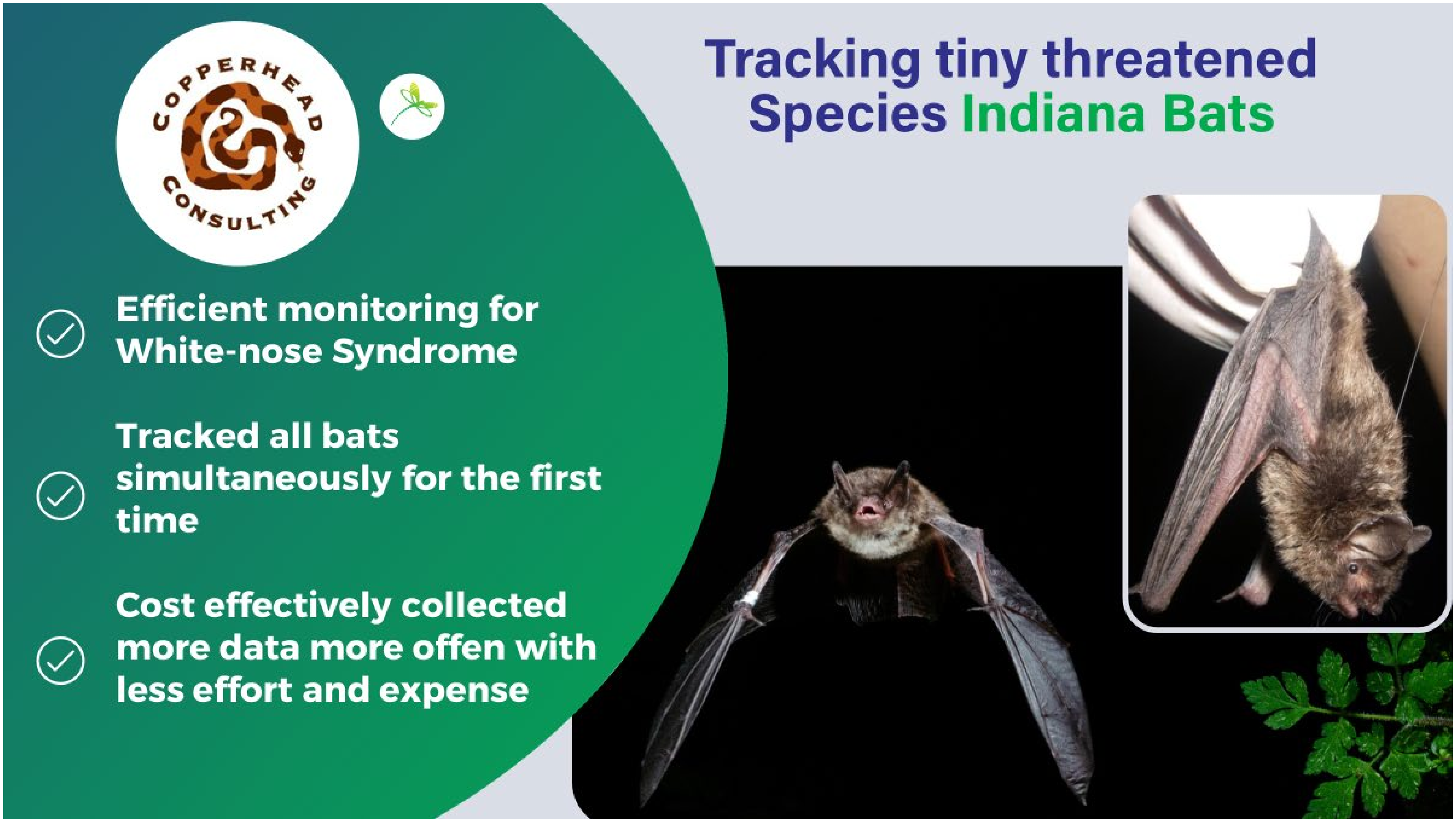

Sophisticated yet simple user interface
Rapid search mode
Mortality signal alerts in real time
Multiple tags simultaneously
Wildlife Drones
Project: Spring Valley
tag tracking
Pre field
In field
Tools
Payload control
Calibrate
Send tag info
Pause tracking
Stop tracking
Zoom to data
Hide radio signal
Reboot
Status
Connected
100%
Data packet 58 of 58, Yaw: 47.3°
GPS: -35.2916° 149.0089° (8)
Collect : 60
Process : 59
N
W
E
S
No signal
2 - 19 ppm
20 - 70 ppm
71 - 100 ppm
Path filters
Flight path
Signal pulses
PPM
Strength
Dot size
Tags
feral pig
fox
Strength
Tag Frequencies (MHz)

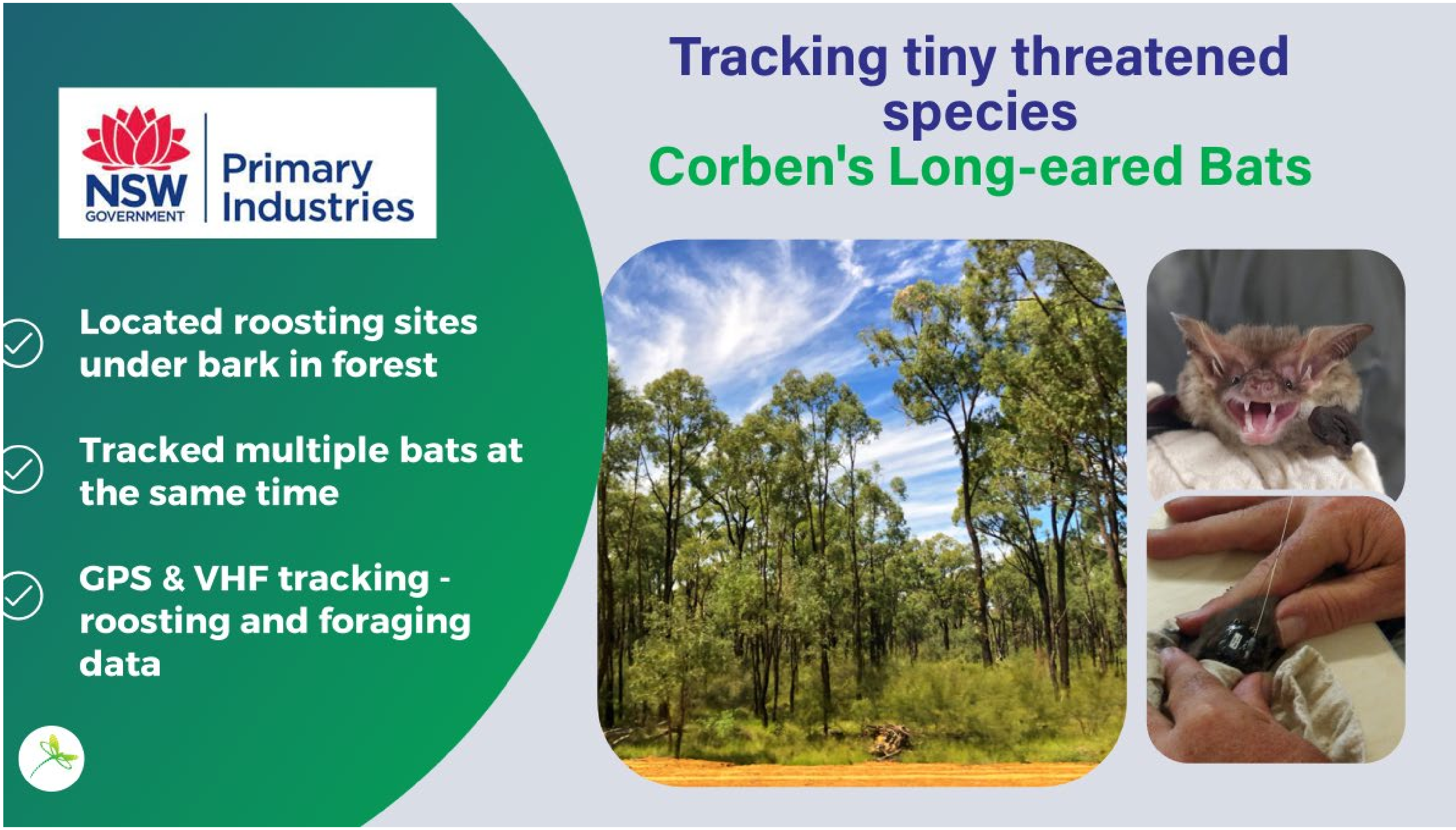

Locate your animals without disturbing them
Triangulate tags from a distance
Get real-time location data
Gain confidence
Wildlife Drones
Project: Spring Valley
tag tracking
Pre field
In field
Tools
Payload control
Calibrate
Send tag info
Pause tracking
Stop tracking
Zoom to data
Hide radio signal
Reboot
Status
Connected
100%
Data packet 58 of 58, Yaw: 47.3°
GPS: -35.2916° 149.0089° (8)
Collect : 60
Process : 59
N
W
E
S
No signal
2 - 19 ppm
20 - 70 ppm
71 - 100 ppm
Strength
Tag Frequencies (MHz)


Survey larger areas
with less effort
3.4x
Hand-held telemetry
12,615 acres
Wildlife Drones telemetry
42,584 acres
330ft


Tracking tiny invasive species
Giant Hornets
Washington State Dept Of Agriculture
WSDA
Track multiple hornets at the same time
Rapid tracking across any landscape (blackberries)
Safely locate nests for eradication


USDA
APHIS
Wildlife Services
Tracking large invasive species
Feral Swine
Tracked up to 15 animals simultaneously
Tracked both invasive and native species at the same time
Detected animals not detectable from on the ground
Mortality signal alerts in real time

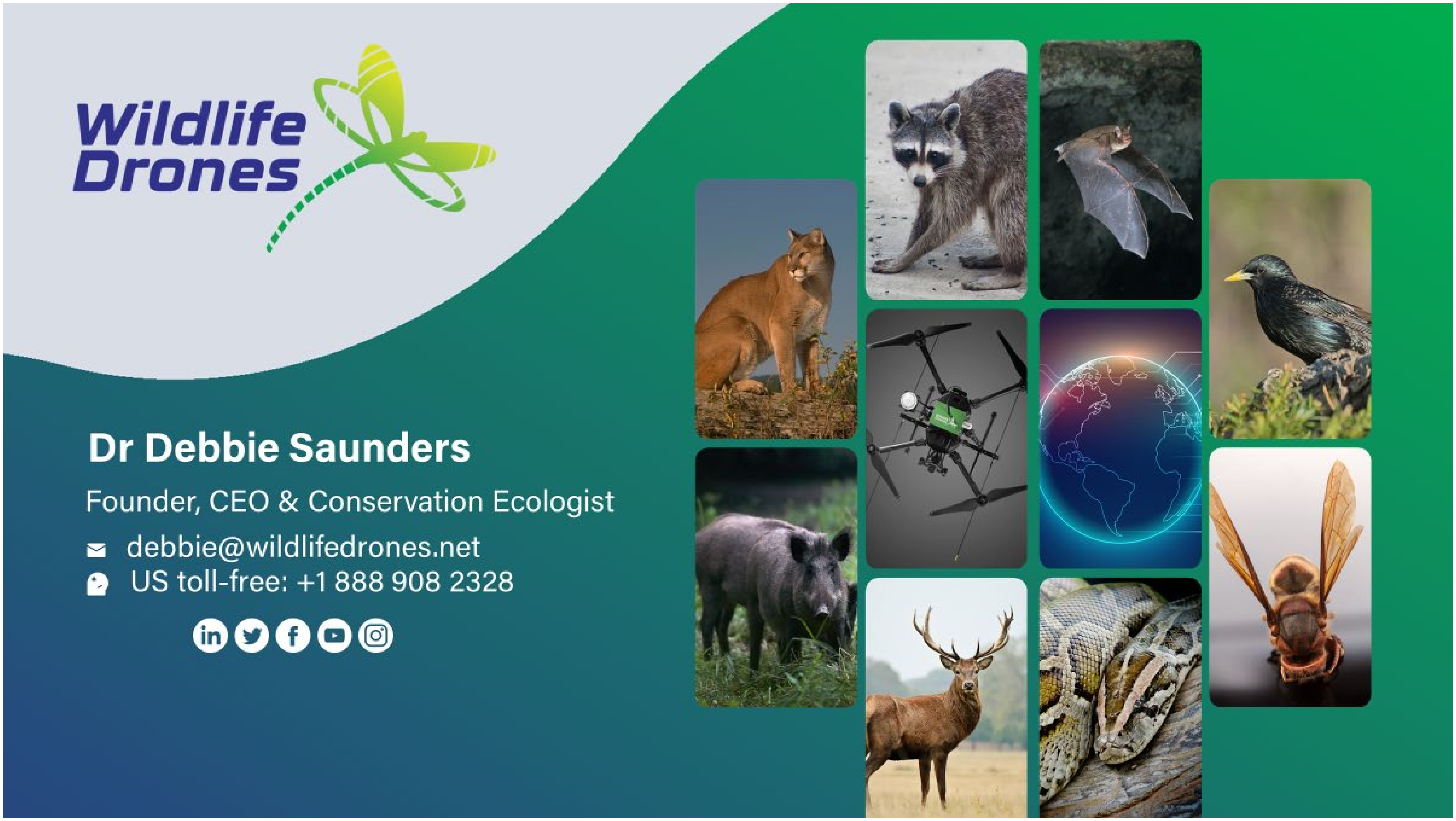

COPPERHEAD CONSULTING
Tracking tiny threatened Species Indiana Bats
Efficient monitoring for White-nose Syndrome
Tracked all bats simultaneously for the first time
Cost effectively collected more data more offen with less effort and expense


Tracking tiny threatened species
Corben's Long-eared Bats
NSW GOVERNMENT
Primary Industries
Located roosting sites under bark in forest
Tracked multiple bats at the same time
GPS & VHF tracking - roosting and foraging data


Helping with prevention of
human-wildlife conflict
Safely detect problematic wildlife from a distance in real-time
Track multiple animals at the same time
Enable immediate action on the ground to prevent conflicts


Helping with prevention of
human-wildlife conflict
Safely detect problematic wildlife in real-time and from a distance
Save lives and crops with early detection
Track multiple animals and species at the same time


Worldwide
tracking projects


Wildlife Drones
Dr Debbie Saunders
Founder, CEO & Conservation Ecologist
debbie@wildlifedrones.net
US toll-free: +1 888 908 2328

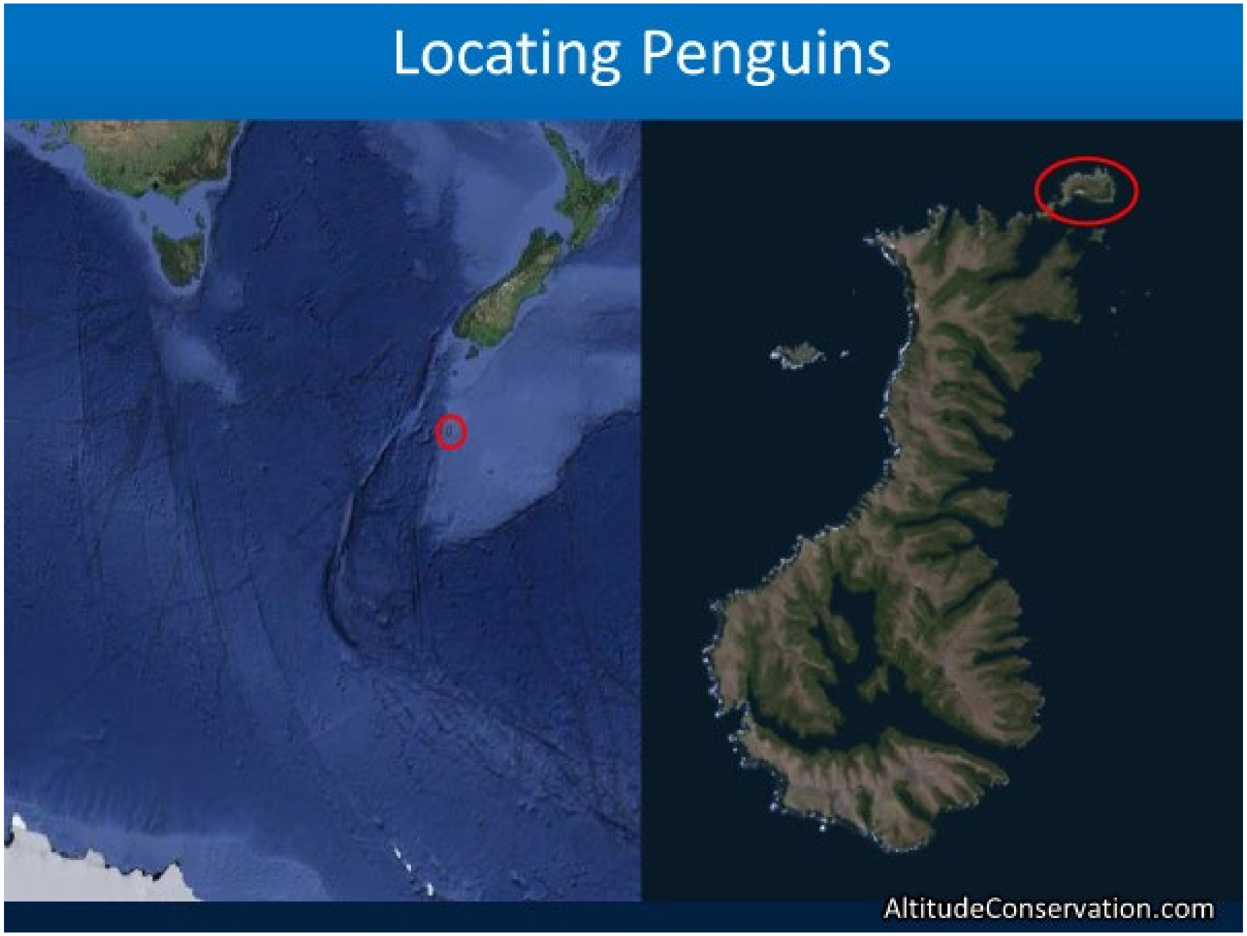
Re-Inventing VHF Tracking – How to Avoid the Pitfalls of Aerial Wildlife Monitoring

Chris Muller, Wildlife and Ecology Group, School of Agriculture and Environment, Massey University, New Zealand; cmuller@technologist.com

Very high frequency (VHF)-radio tracking is widely-used for locating and monitoring wildlife, but the equipment has changed little since the 1980s. Multi-frequency receiver technology can revolutionize conservation research, especially when paired with new aerial-tracking technology. Tracking from the air offers many advantages over traditional ground-based survey and research techniques. As well as making fieldwork faster, safer, and more efficient, searches can follow an automated flight plan for repeatability. Unoccupied aerial vehicles (UAVs, or drones) are cheaper and more portable than aircraft, making them more accessible to biologists. However, there are a number of technical considerations to get best results from this emerging tool. Endangered yellow-eyed penguins (*Megadyptes antipodes*) breed on Enderby Island in the New Zealand subantarctic, nesting individually underneath thick coastal scrub up to 1 km (0.6 miles) from the sea. Nests must be monitored but are difficult and time-consuming to find by ground searching, and field conditions can be hazardous. For this research we developed a multi-frequency VHF receiver offering many advantages over traditional single-frequency receivers, especially for aerial tracking, including simultaneous monitoring of 500 frequencies (instead of sequential scanning). Unlike standard receivers, this system also stores position data for easy spatial analysis, and comparisons over time. Here we discuss the evolution of this technology and the successes and failures of various methods of using drones, including the performance of different sensors such as thermal imagery and multi-frequency VHF for applied conservation. In this case-study we present results comparing the efficiency of different tracking methods for locating cryptic penguin nests.


Re-Inventing VHF Tracking – How To Avoid The Pitfalls Of Aerial Wildlife Monitoring
Chris Muller
Massey University, New Zealand
• Wildbase, School of Veterinary Science, Massey University,
• Wildlife and Ecology Group, School of Agriculture and Environment, Massey University
AltitudeConservation.com


Locating Wildlife
Population focus
• Population surveys
• Habitat use
• Home ranges
Individual focus
• Monitoring breeders
• Focal animals
• Recovering electronics
AltitudeConservation.com


Locating Penguins
AltitudeConservation.com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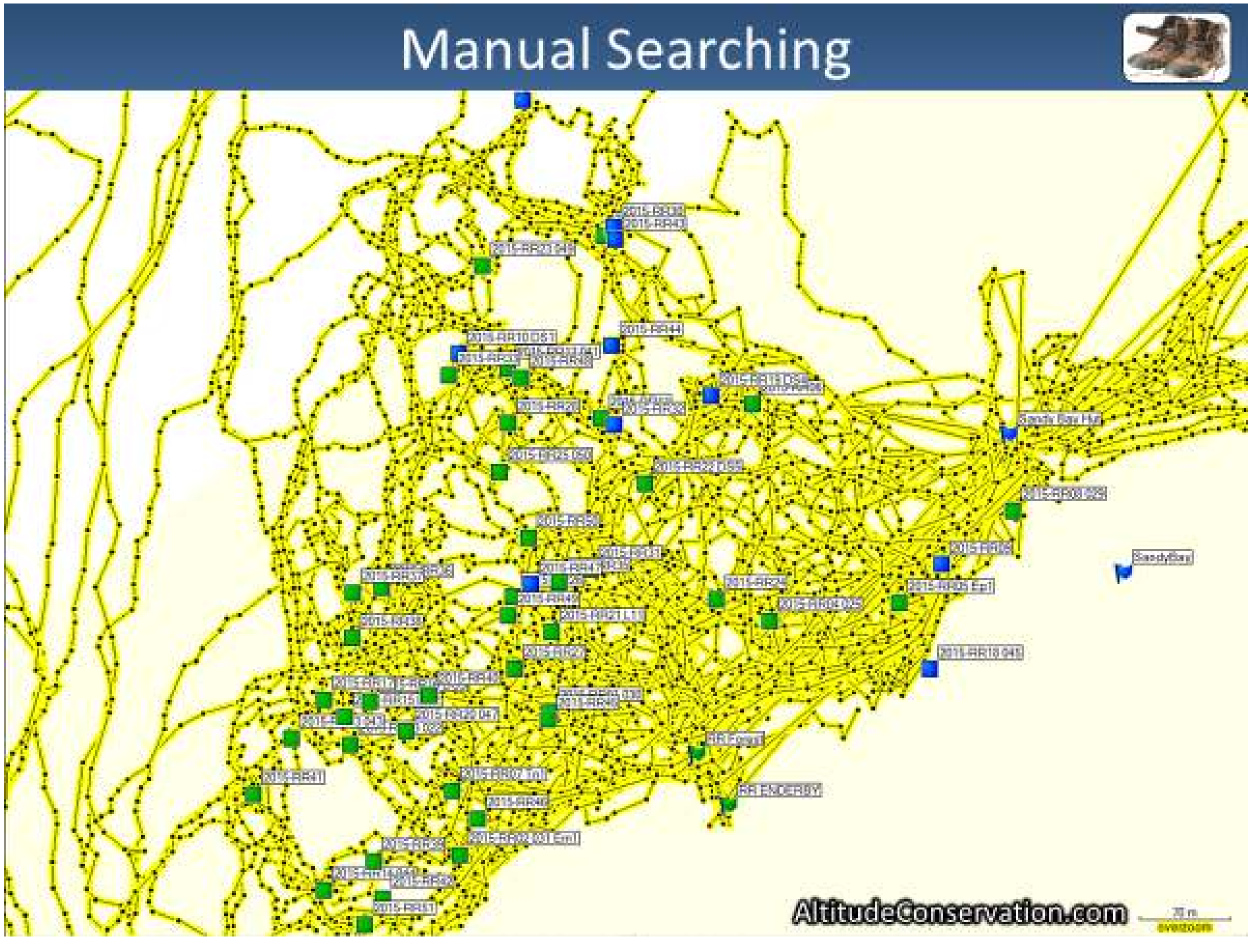
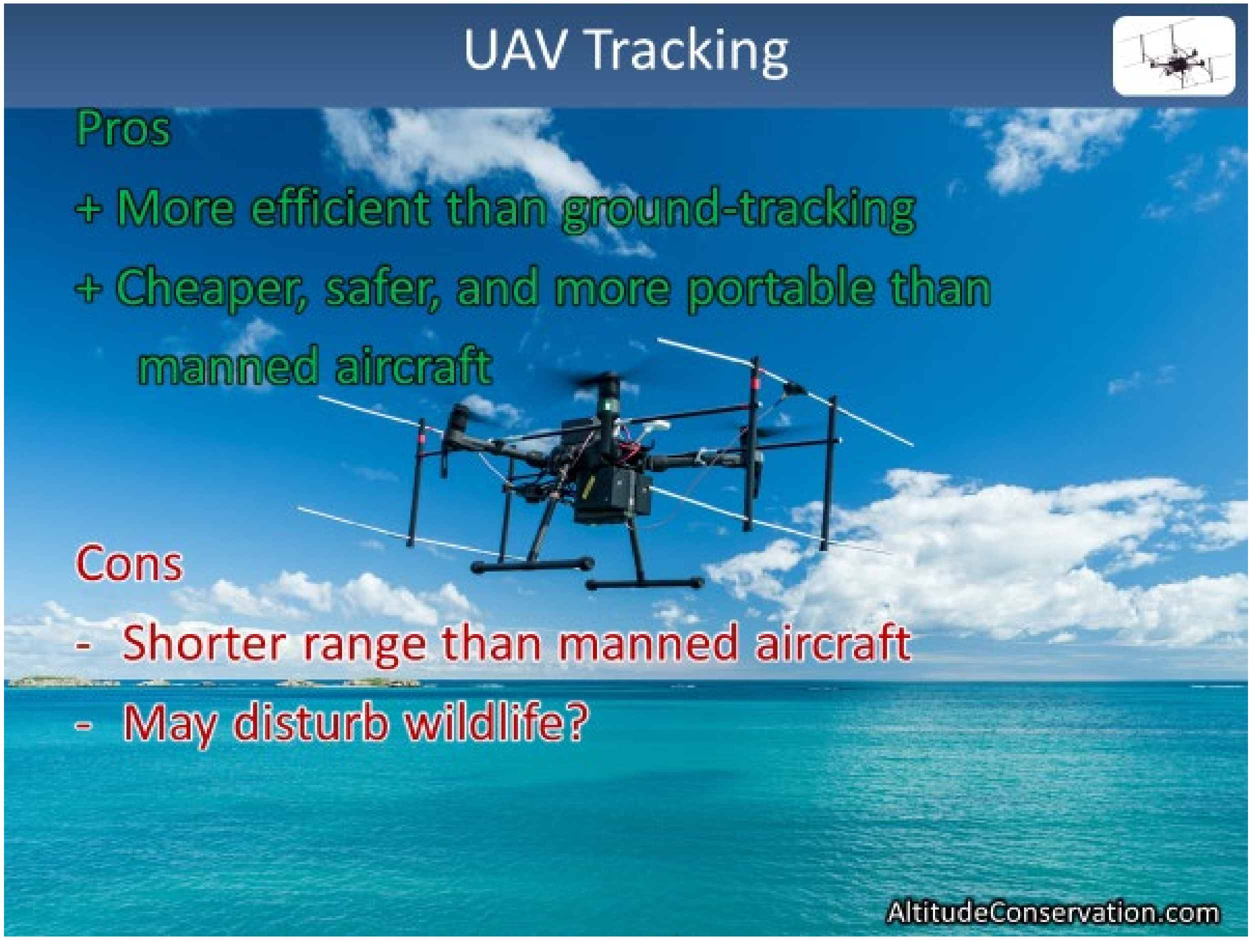
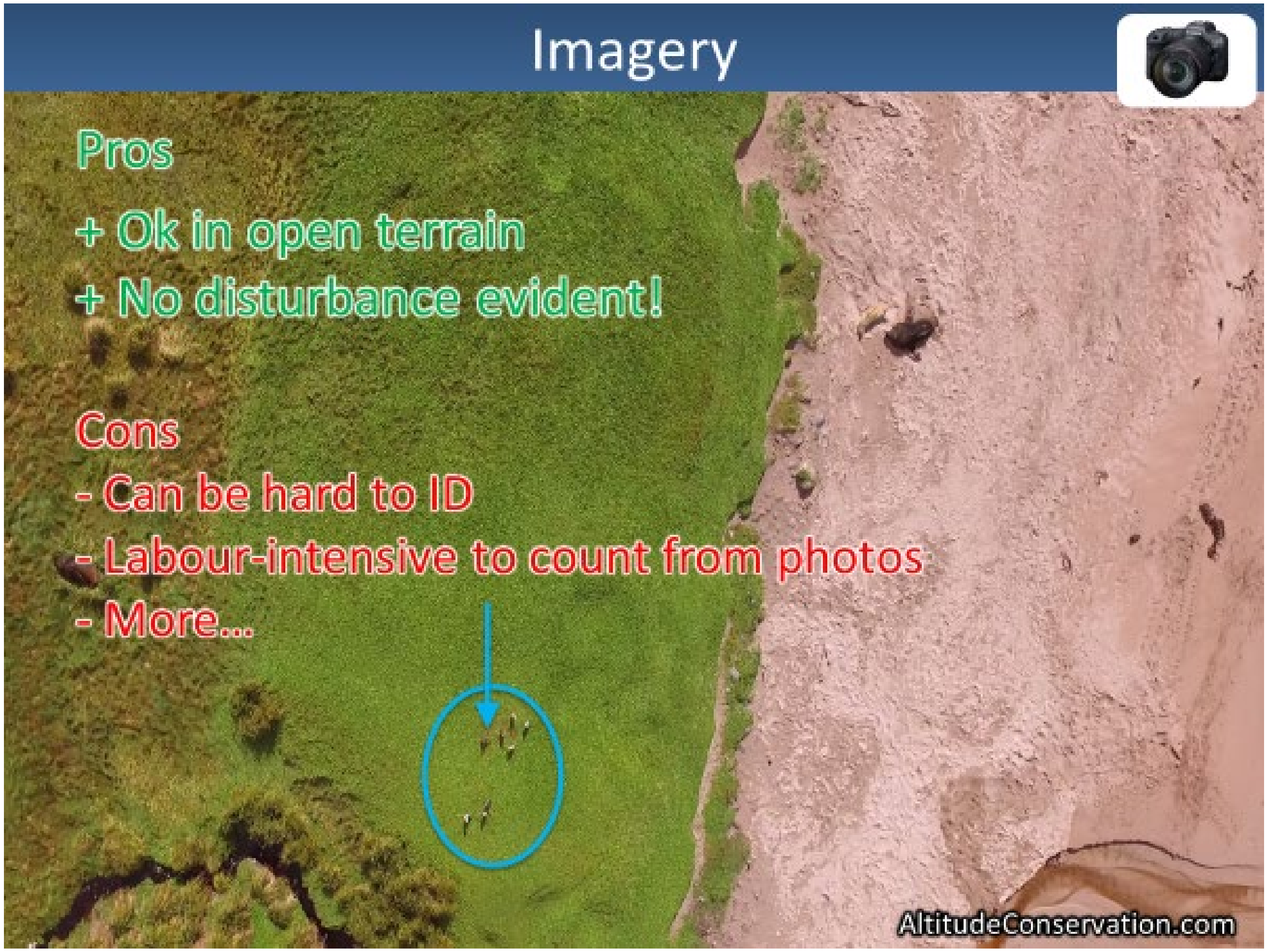
The Problem
AltitudeConservation.com

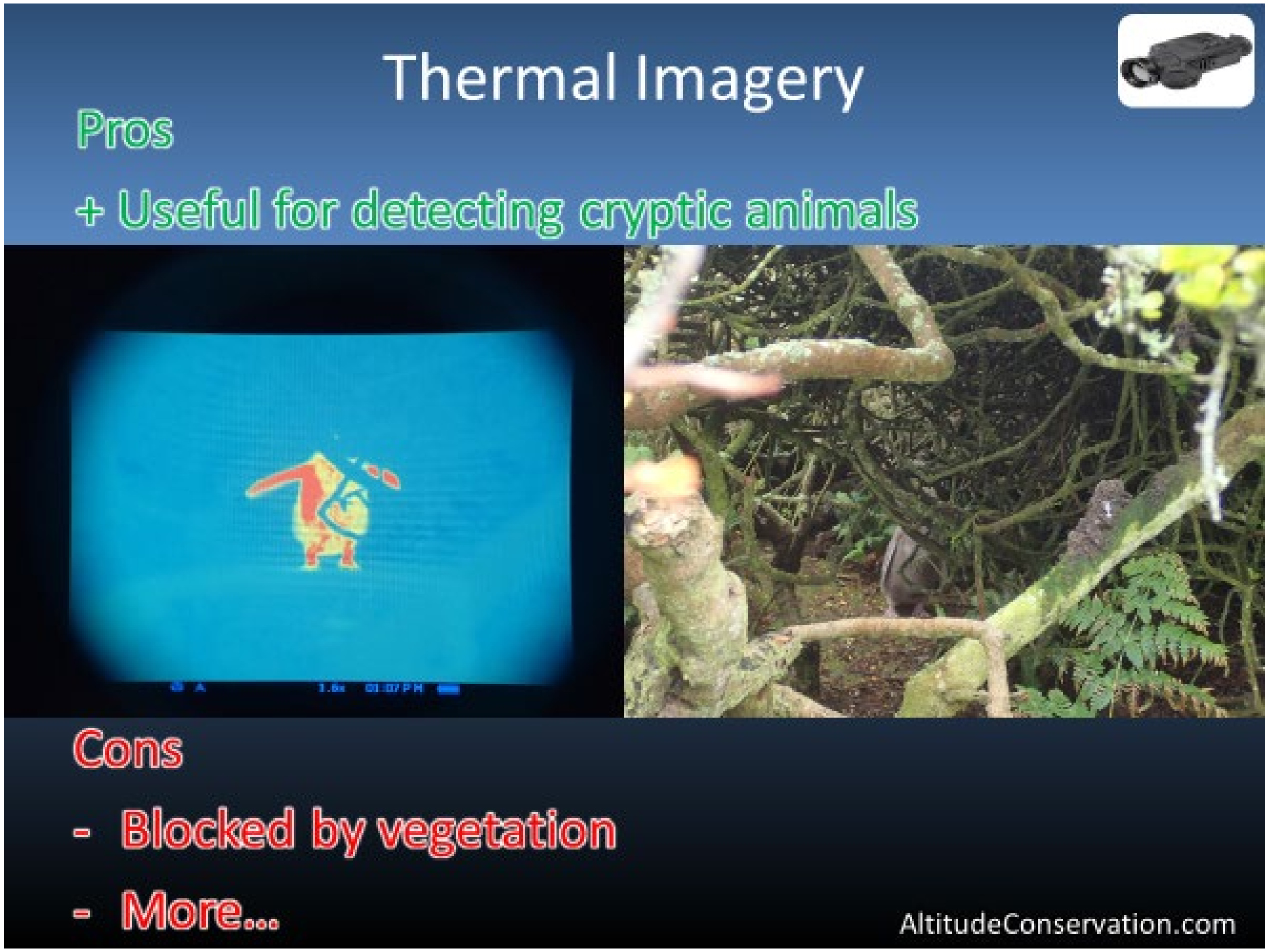

Manual Searching
AltitudeConservation.com

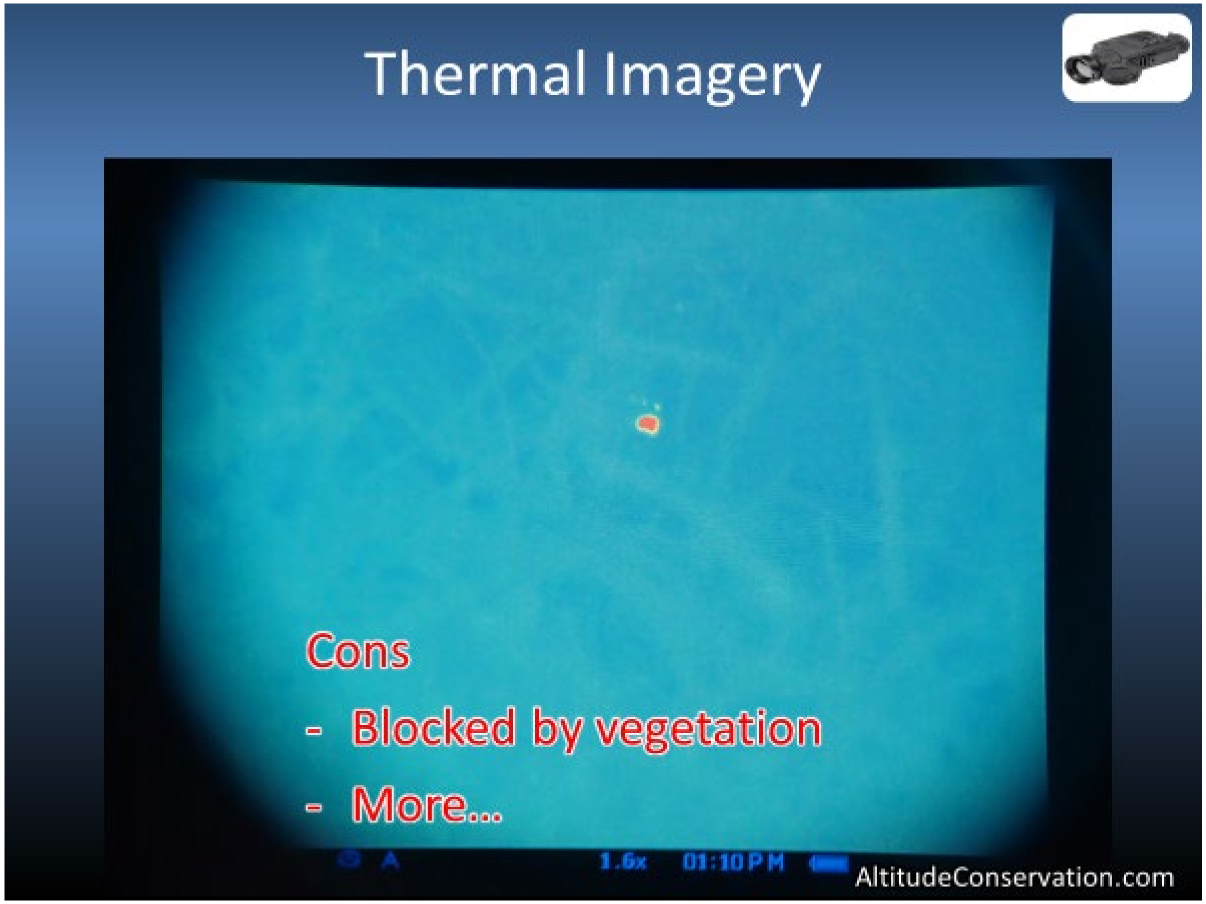

Aircraft Tracking
Pros
+ Search large areas quickly
+ Safer in hazardous terrain
Cons
- Expensive
- Also hazardous
- Requires landing area nearby
AltitudeConservation.com

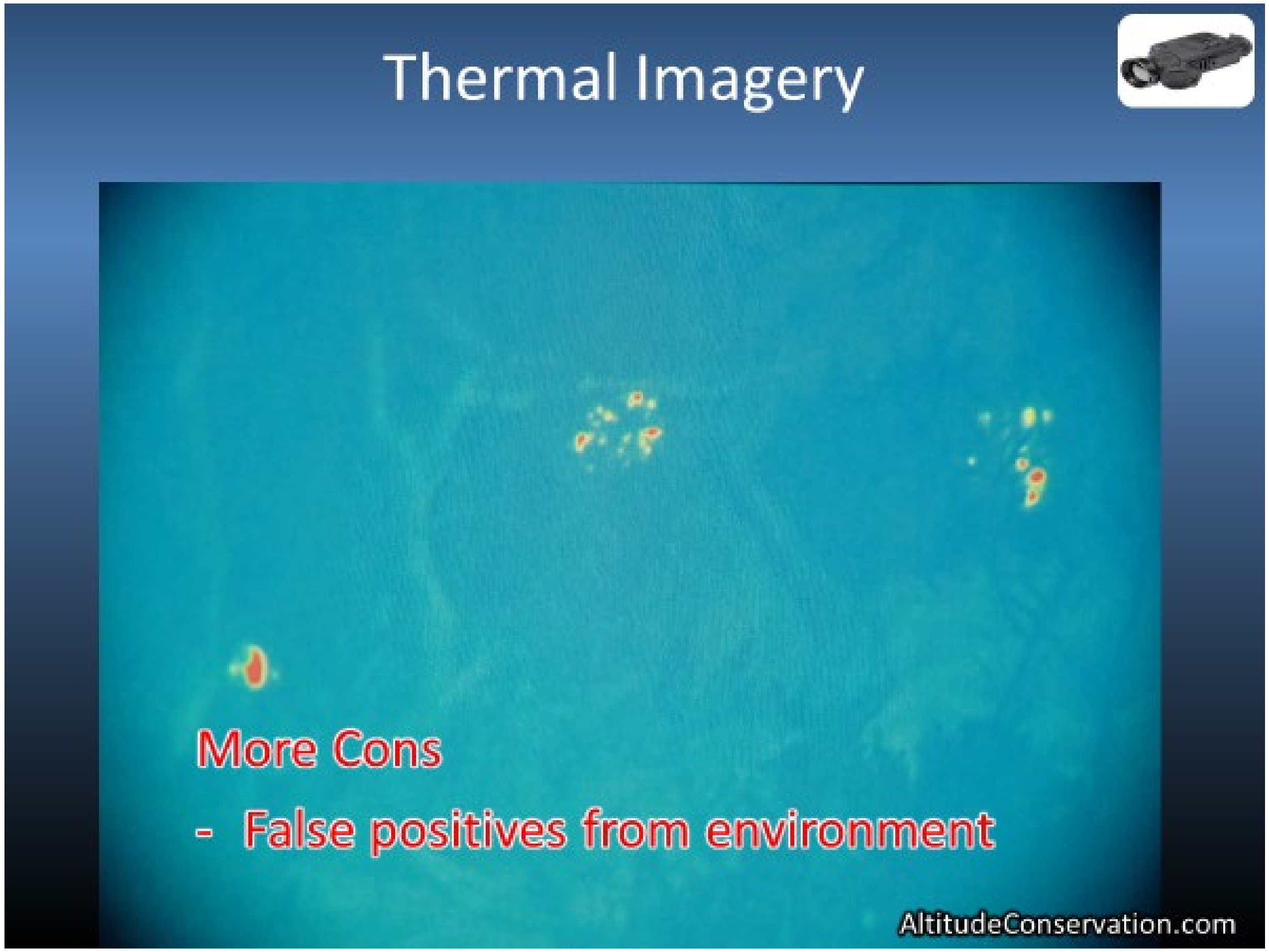

UAV Tracking
Pros
+ More efficient than ground-tracking
+ Cheaper, safer, and more portable than manned aircraft
Cons
- Shorter range than manned aircraft
- May disturb wildlife?
AltitudeConservation.com

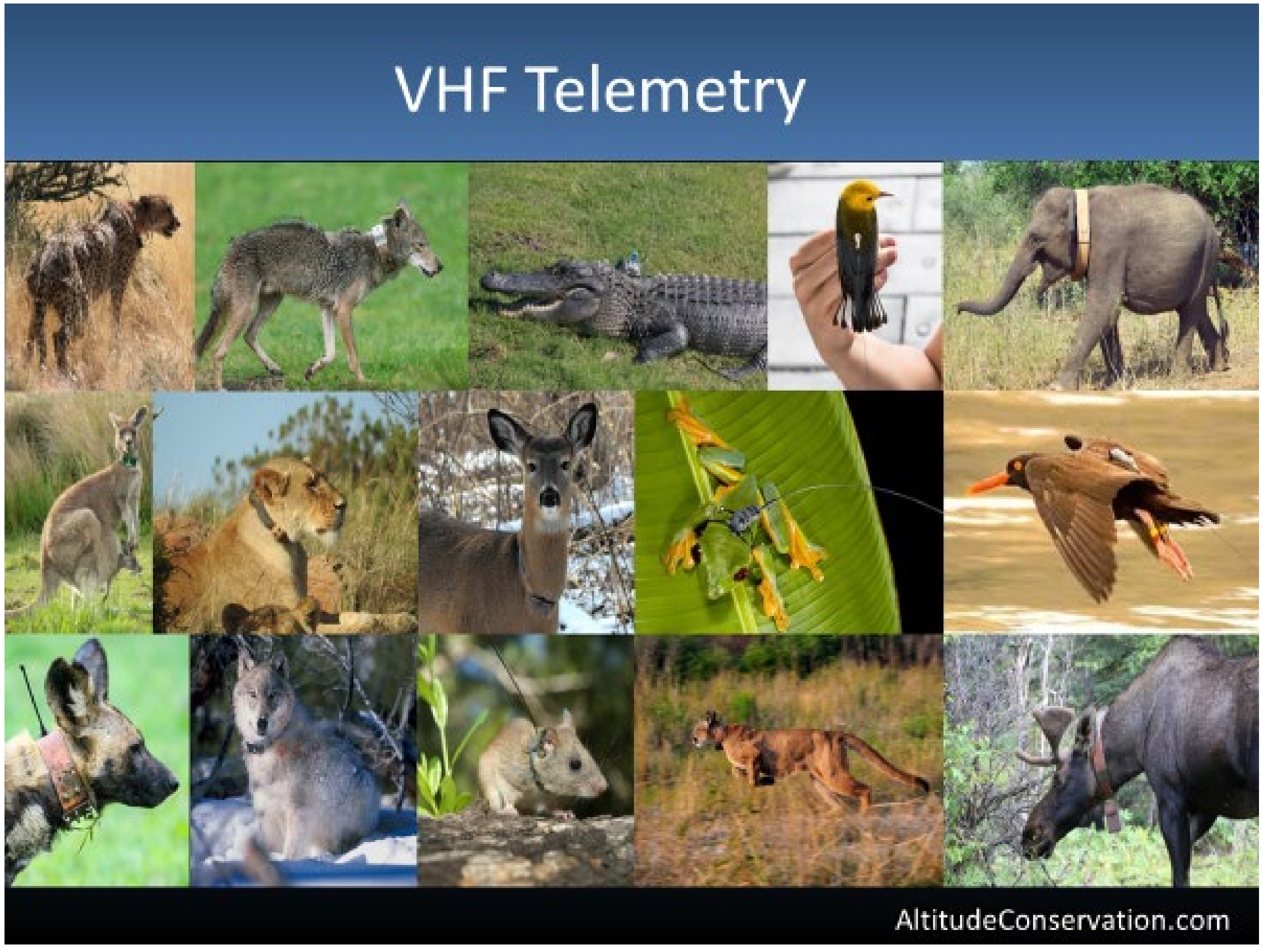

Imagery
Pros
+ Ok in open terrain
+ No disturbance evident!
Cons
- Can be hard to ID
- Labour-intensive to count from photos
- More...
AltitudeConservation.com

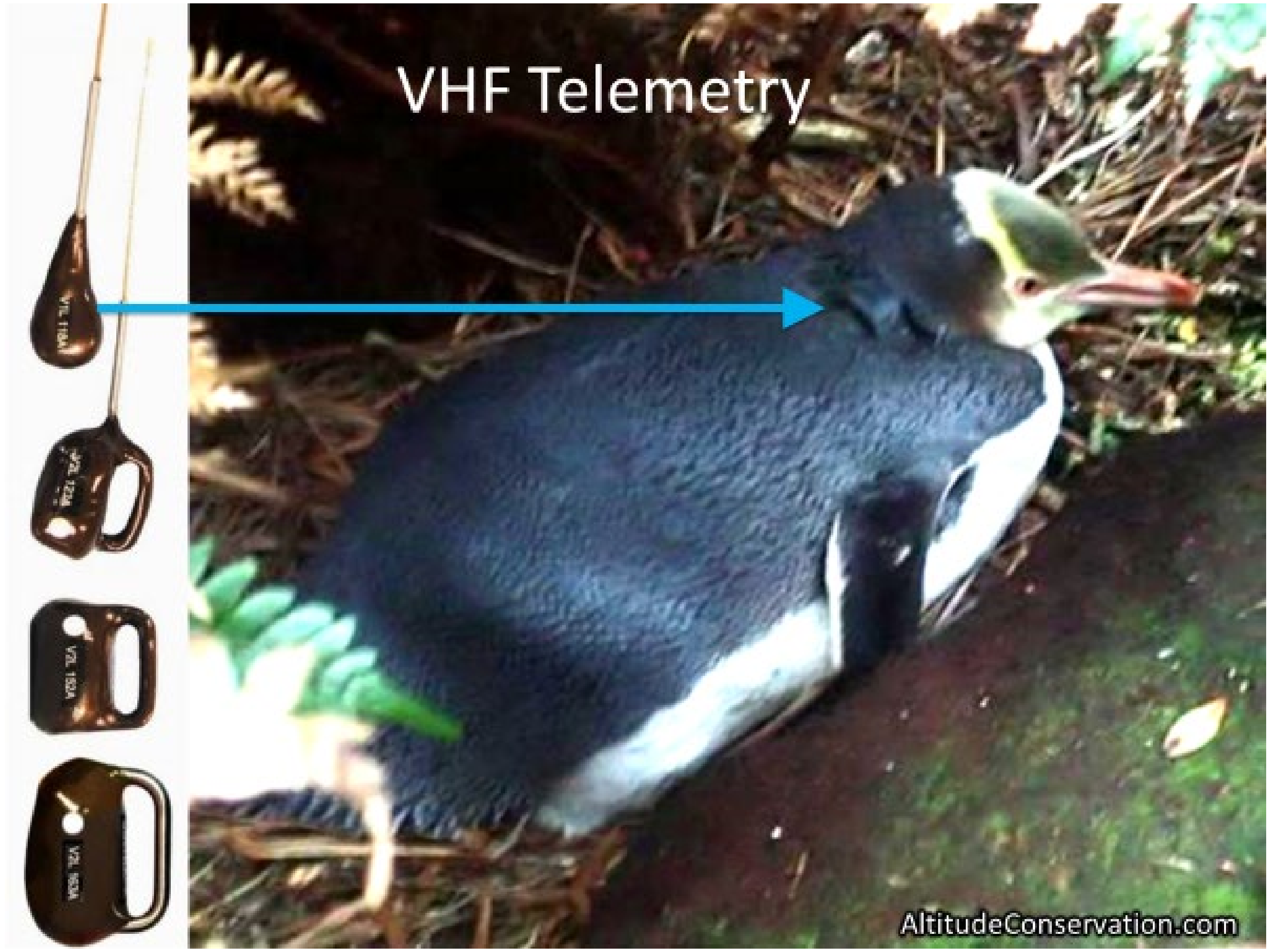

Imagery
AltitudeConservation.com


Thermal Imagery
Pros
+ Useful for detecting cryptic animals
Cons
- Blocked by vegetation
- More...
AltitudeConservation.com


Thermal Imagery
Cons
- Blocked by vegetation
- More...
1.6x 01:10PM
AltitudeConservation.com

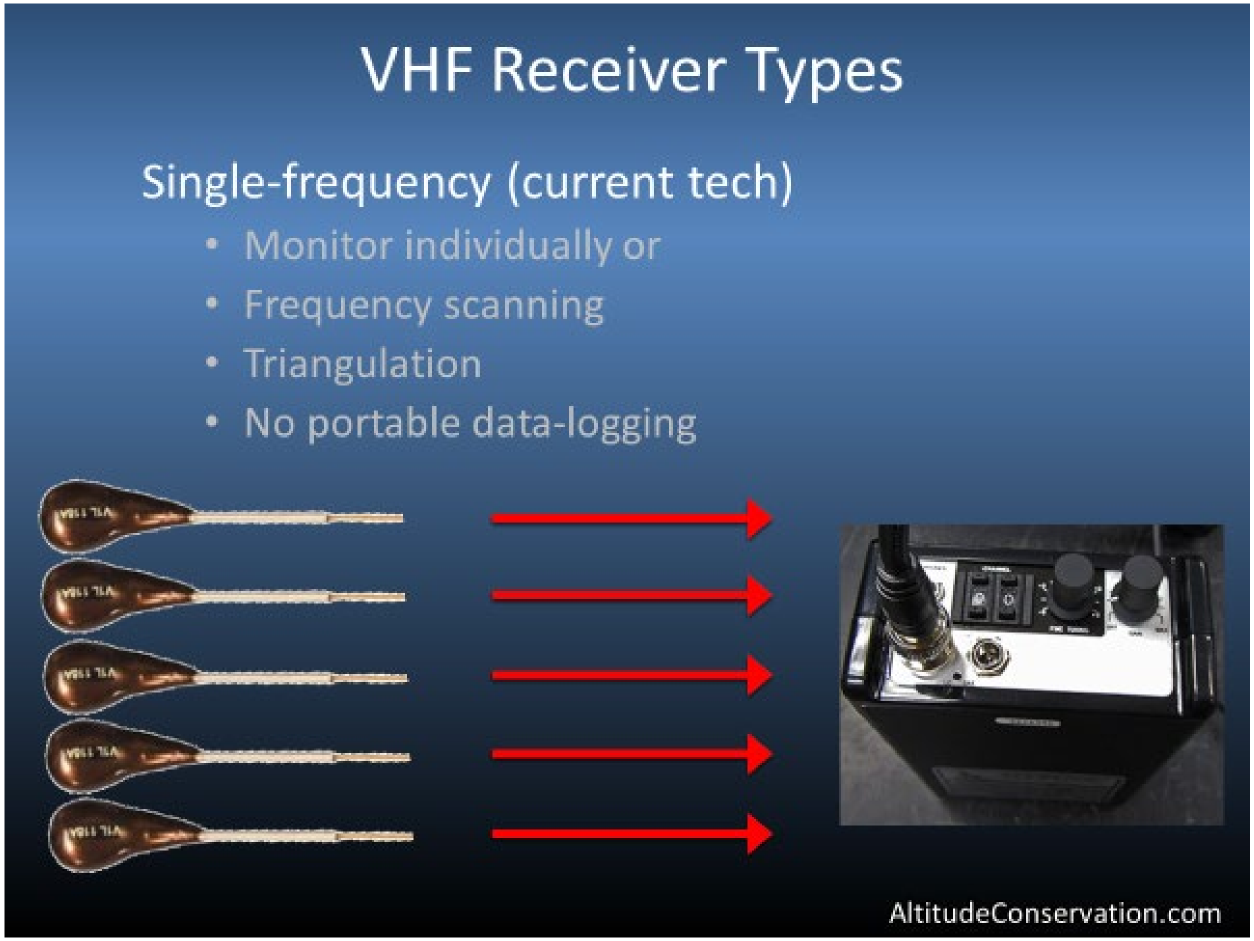

Thermal Imagery
More Cons
- False positives from environment
AltitudeConservation.com

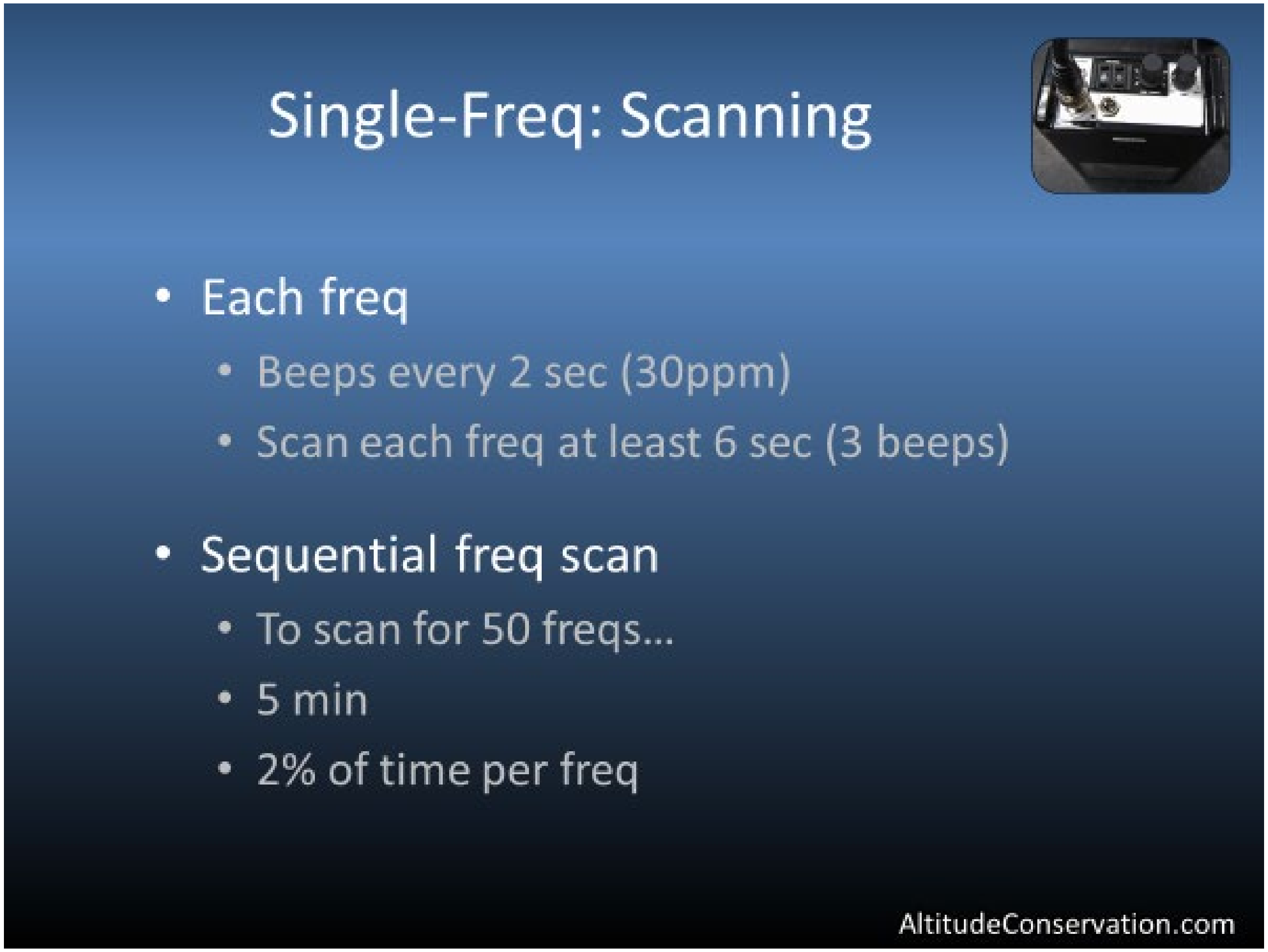

VHF Telemetry
AltitudeConservation.com

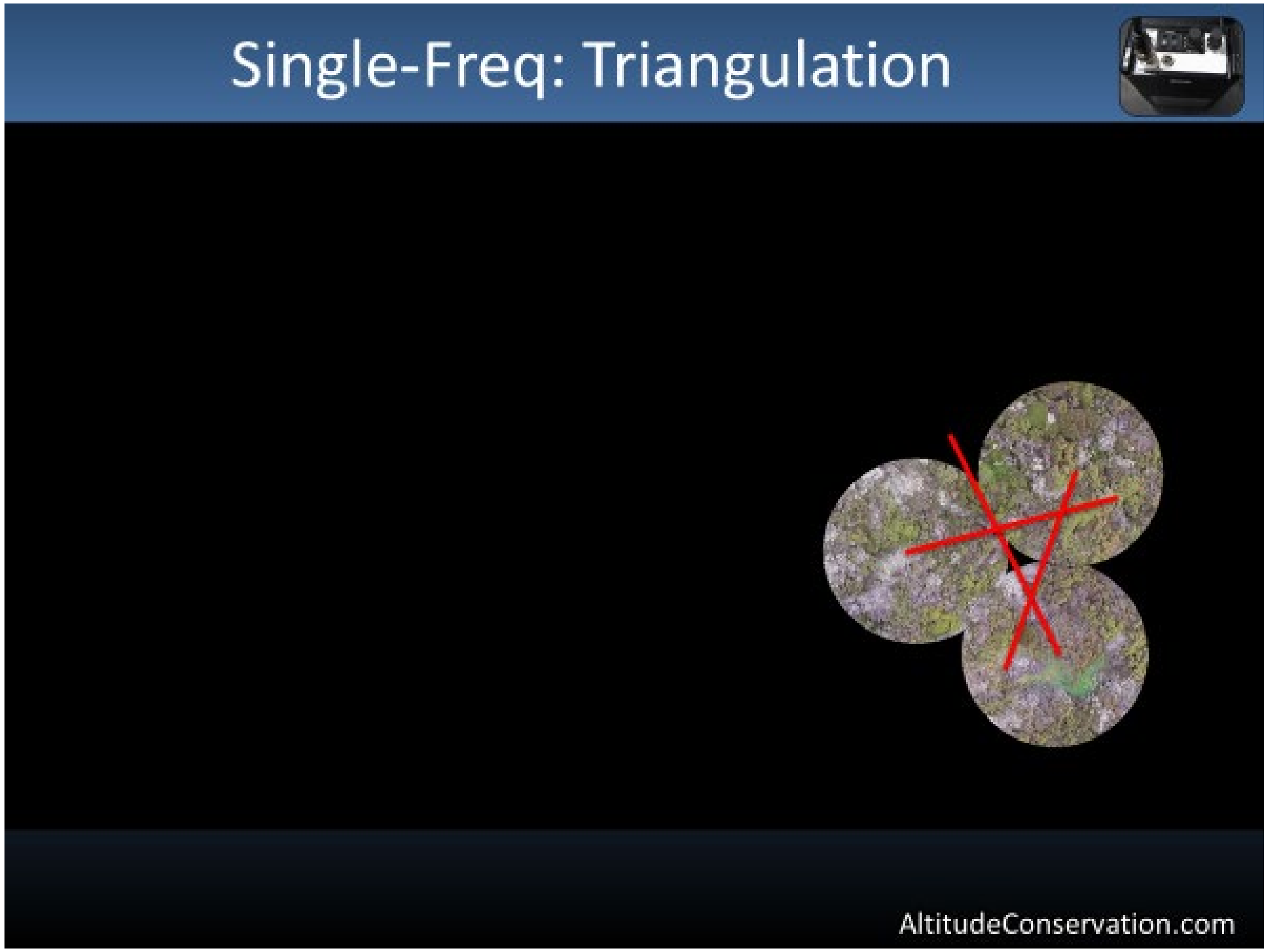

VHF Telemetry
AltitudeConservation.com

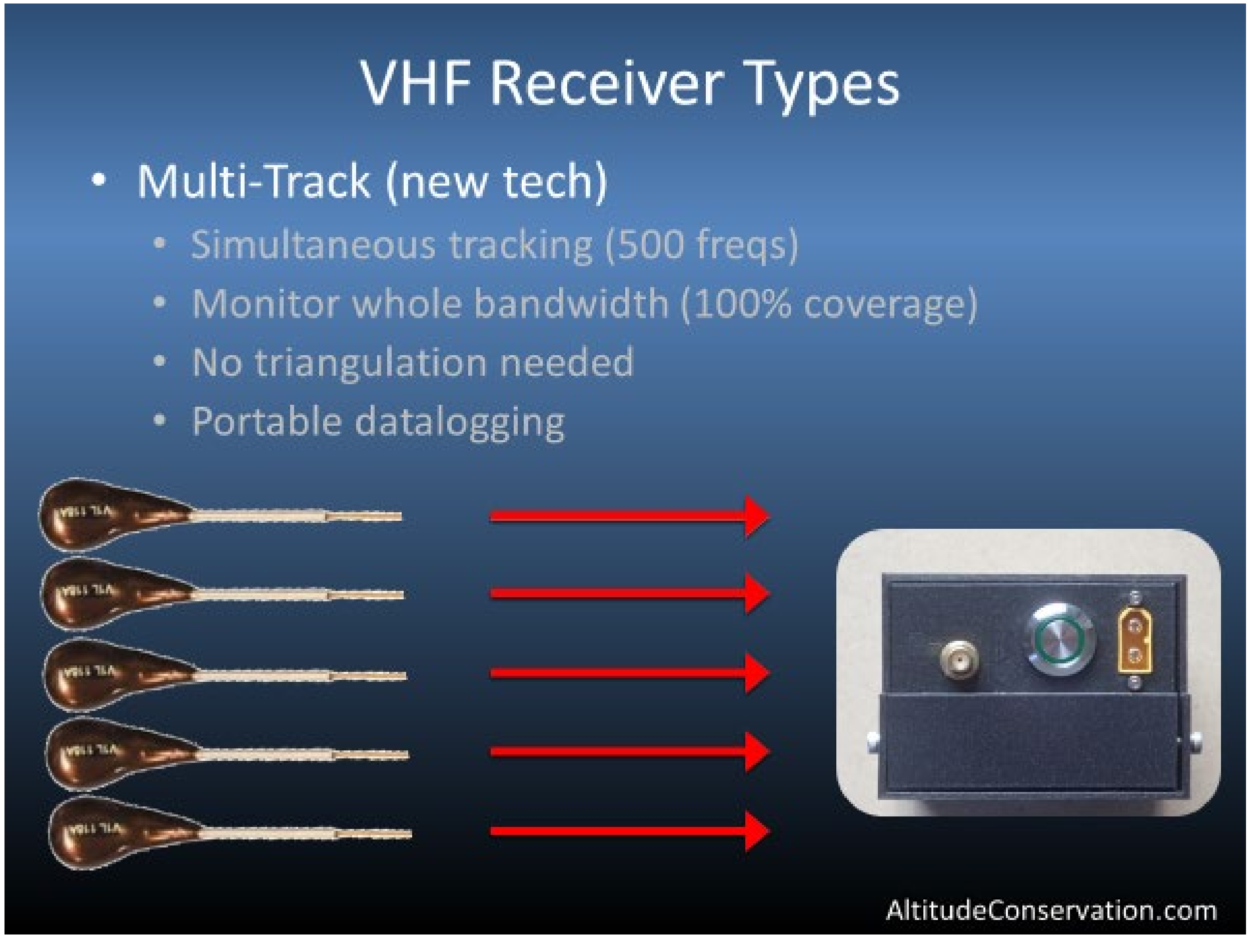

Ground VHF Tracking
AltitudeConservation.com

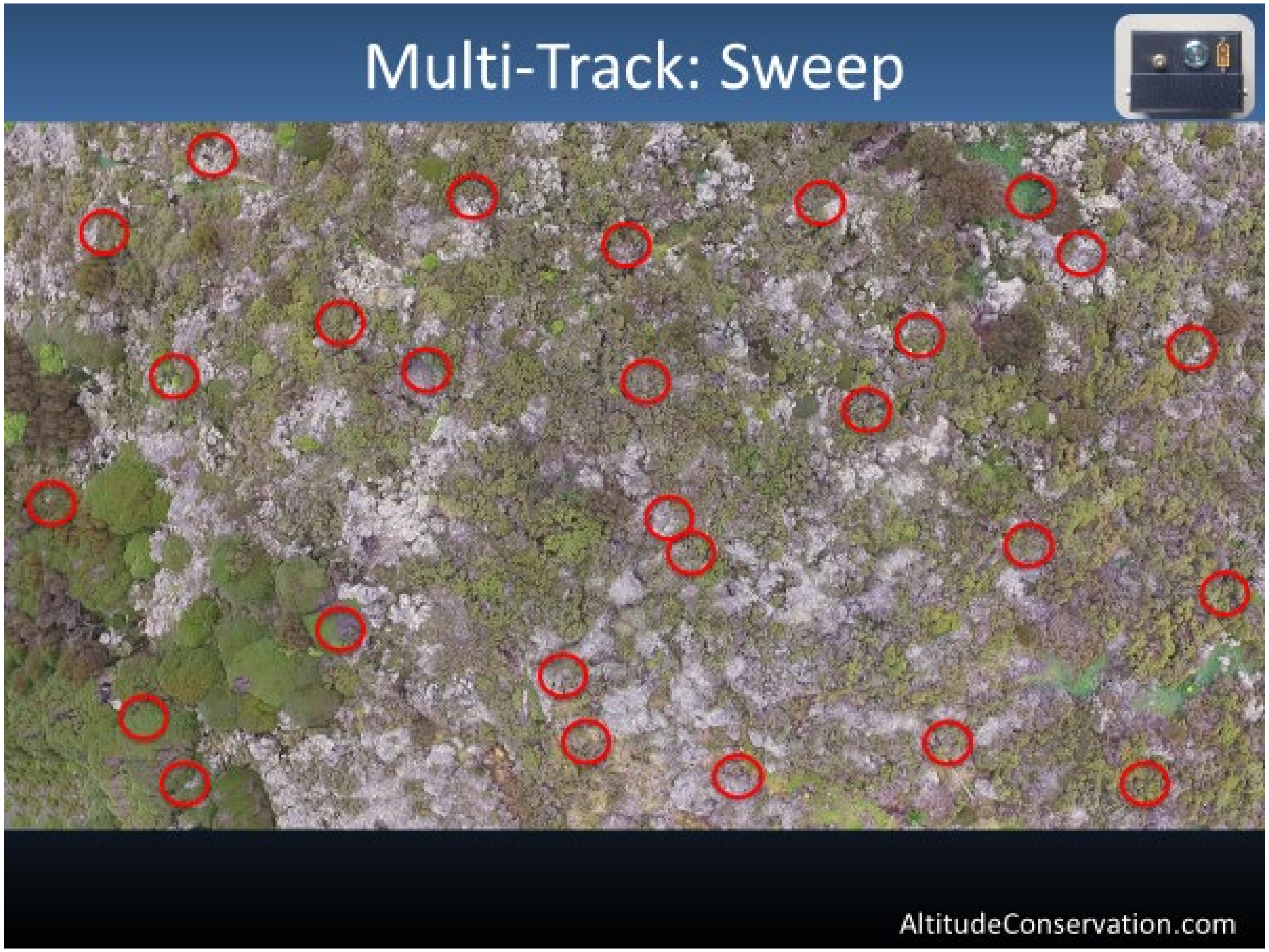

Aerial VHF Tracking
AltitudeConservation.com

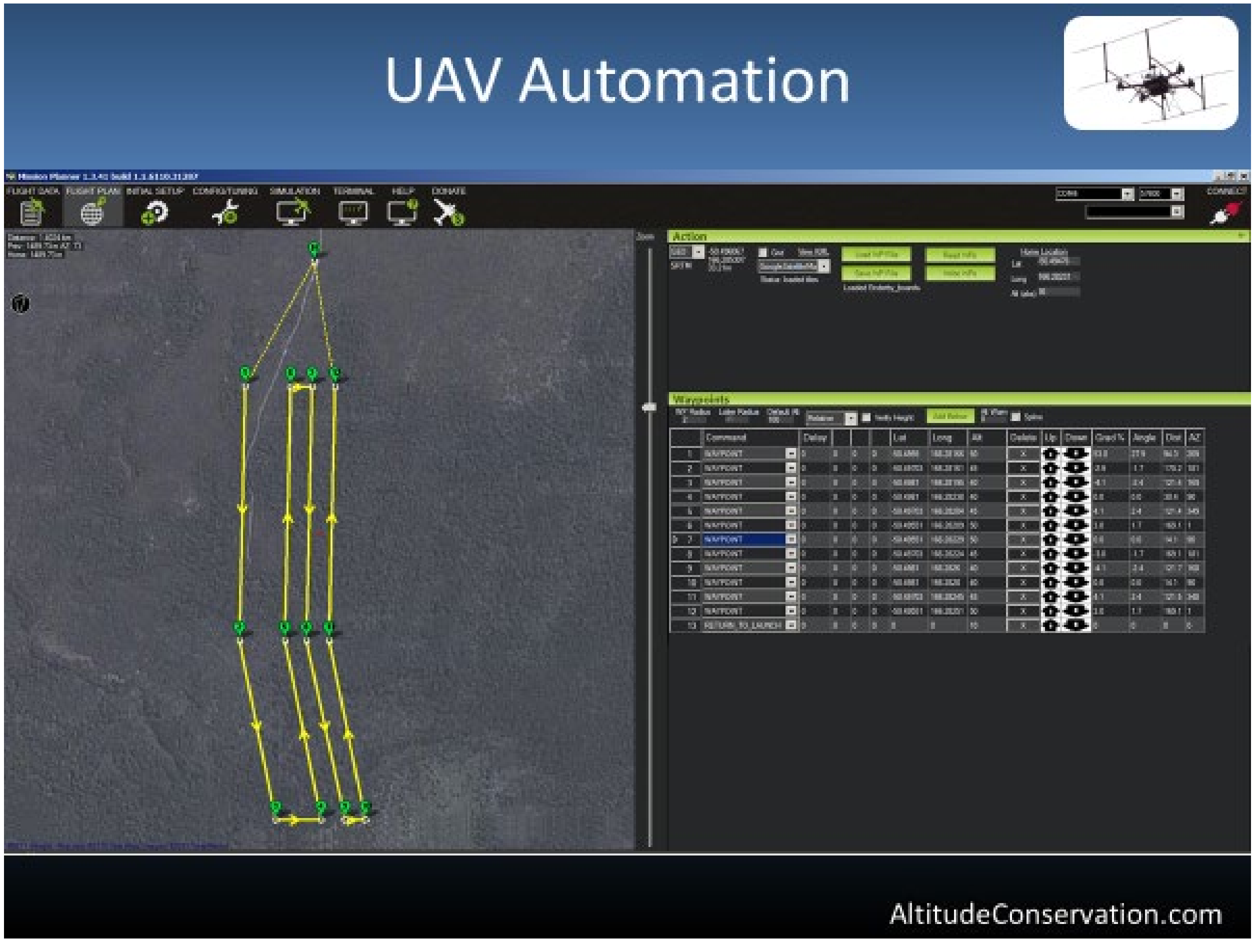

VHF Receiver Types
Single-frequency (current tech)
• Monitor individually or
• Frequency scanning
• Triangulation
• No portable data-logging
AltitudeConservation.com

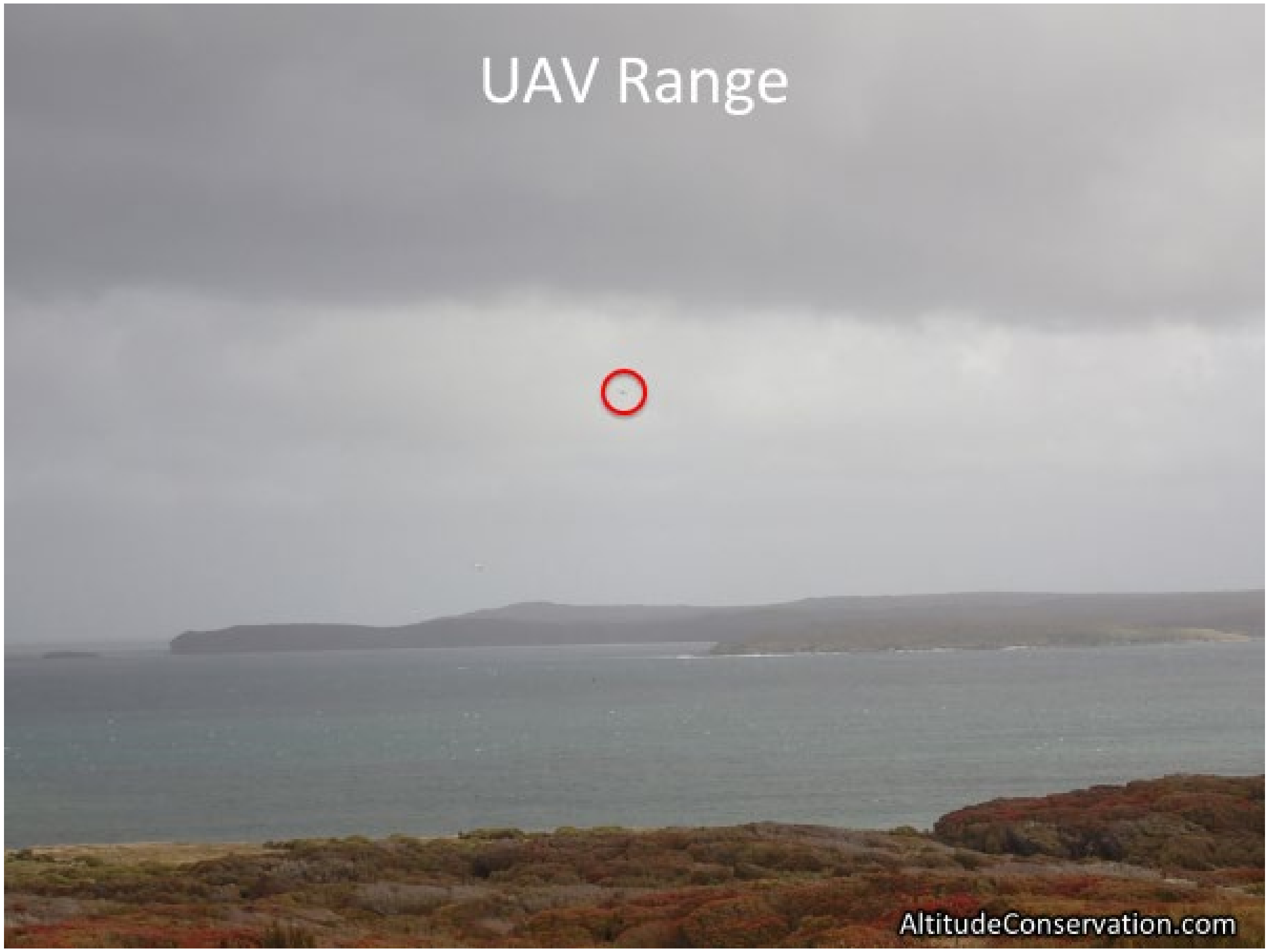

Single-Freq: Scanning
• Each freq
• Beeps every 2 sec (30ppm)
• Scan each freq at least 6 sec (3 beeps)
• Sequential freq scan
• To scan for 50 freqs…
• 5 min
• 2% of time per freq
AltitudeConservation.com

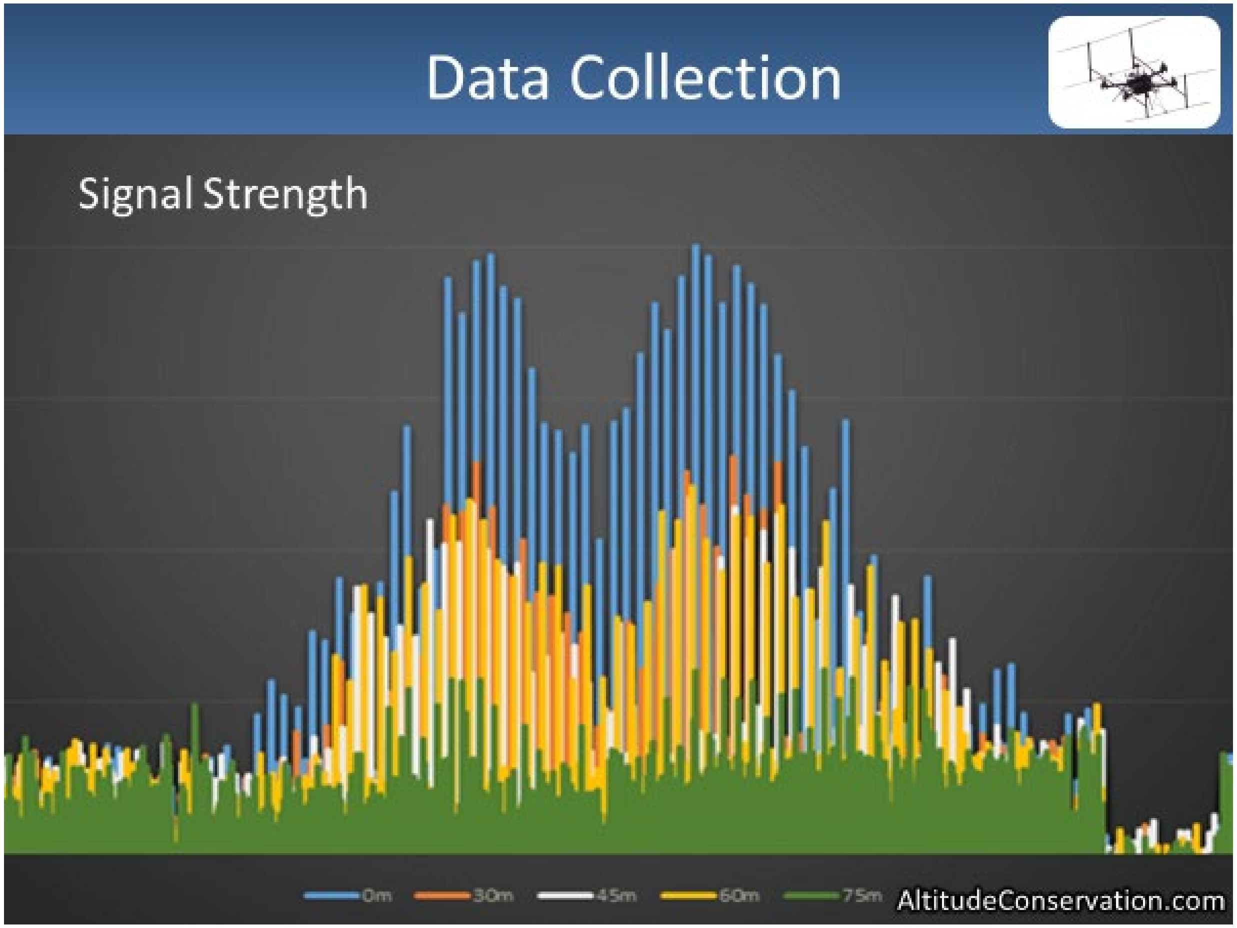

Single-Freq: Triangulation
AltitudeConservation.com


VHF Receiver Types
• Multi-Track (new tech)
• Simultaneous tracking (500 freqs)
• Monitor whole bandwidth (100% coverage)
• No triangulation needed
• Portable datalogging
AltitudeConservation.com

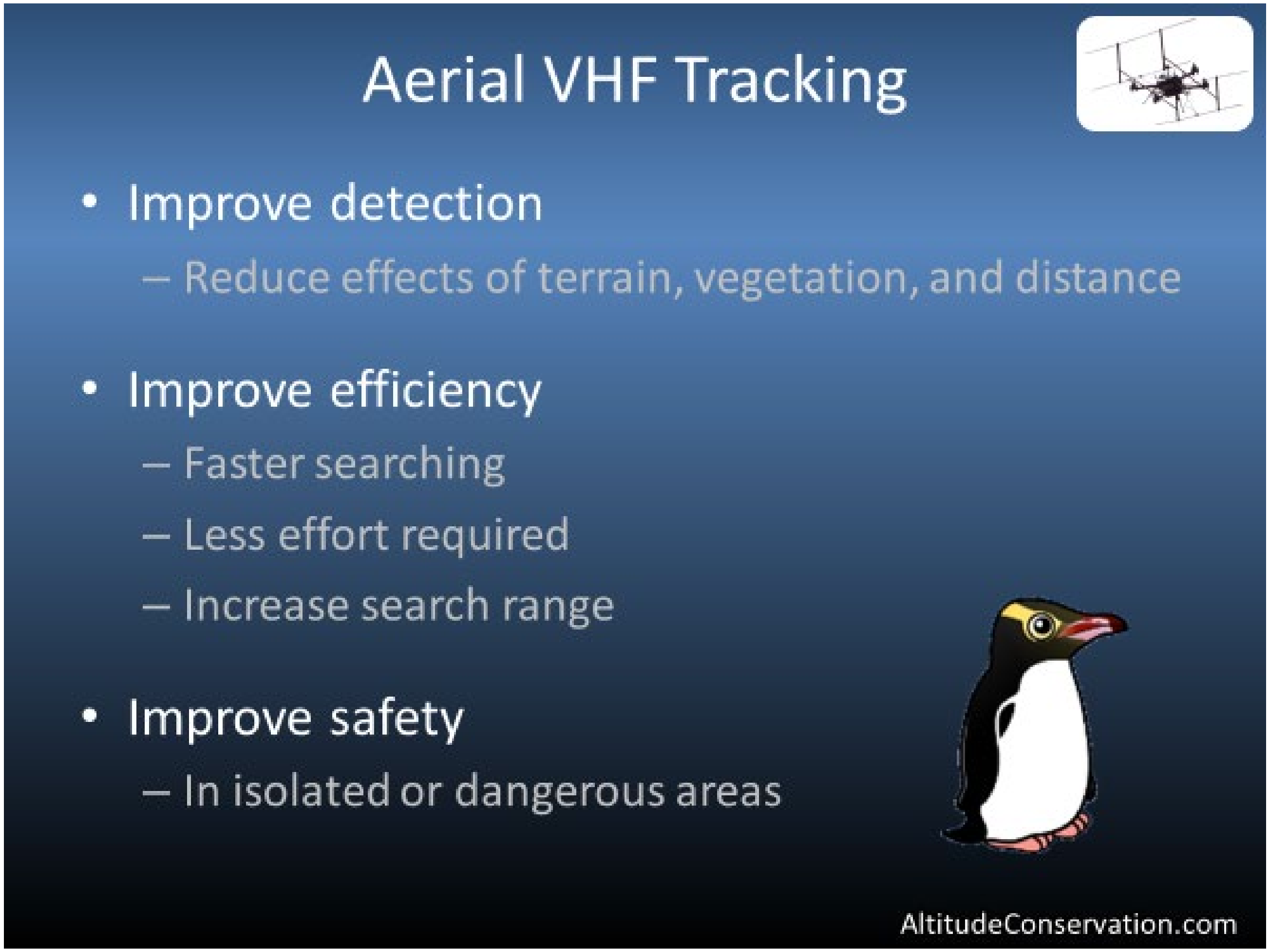

Multi-Track: Sweep
AltitudeConservation.com

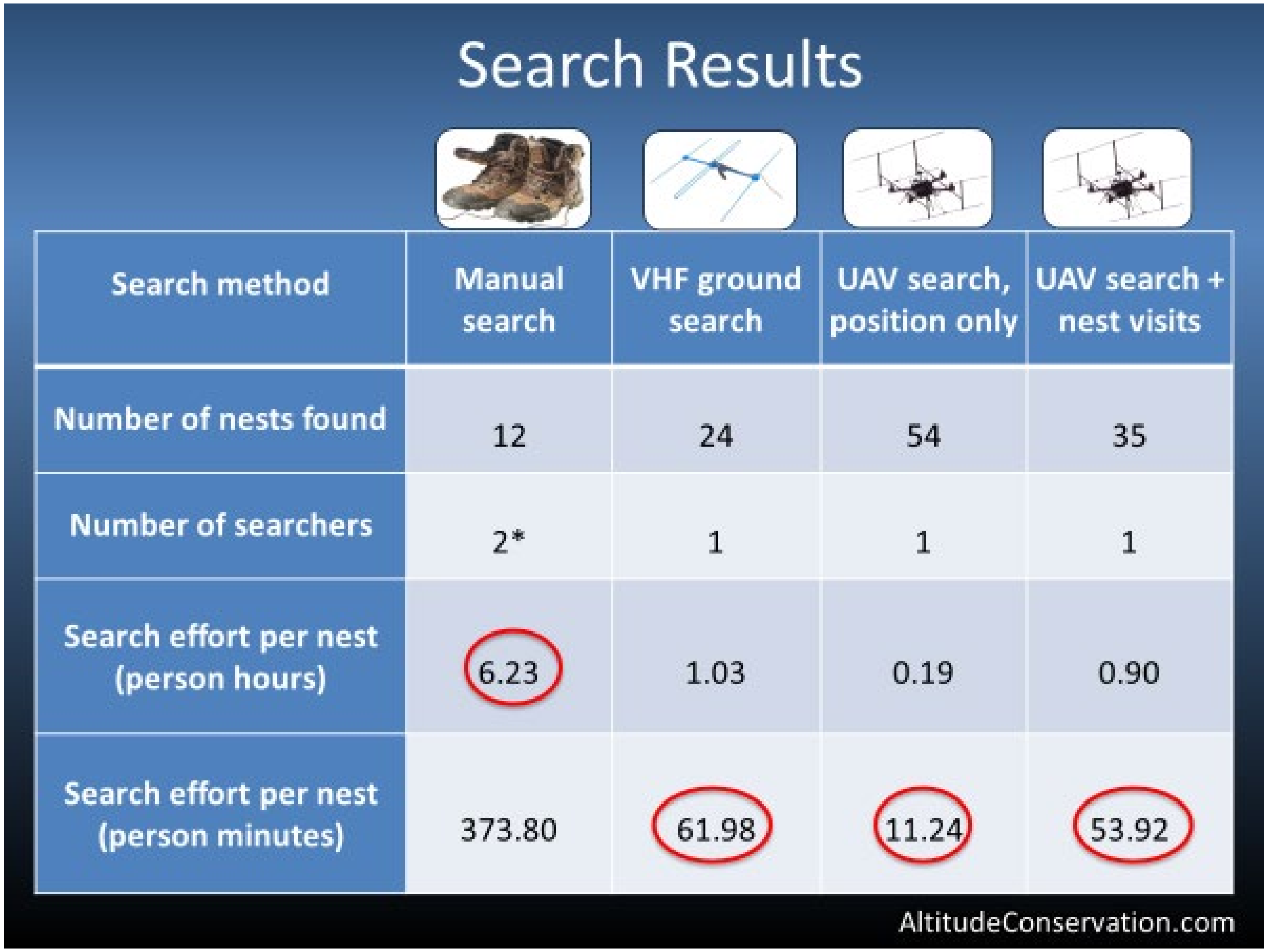

UAV Automation
AltitudeConservation.com


UAV Range
AltitudeConservation.com


Data Collection
Signal Strength
0m
30m
45m
60m
75m
AltitudeConservation.com


Data Collection
Map
AltitudeConservation.com


Aerial VHF Tracking
• Improve detection
– Reduce effects of terrain, vegetation, and distance
• Improve efficiency
– Faster searching
– Less effort required
– Increase search range
• Improve safety
– In isolated or dangerous areas
AltitudeConservation.com



Search Results

Search method	Manual search	VHF ground search	UAV search, position only	UAV search + nest visits
Number of nests found	12	24	54	35
Number of searchers	2*	1	1	1
Search effort per nest (person hours)	6.23	1.03	0.19	0.90
Search effort per nest (person minutes)	373.80	61.98	11.24	53.92

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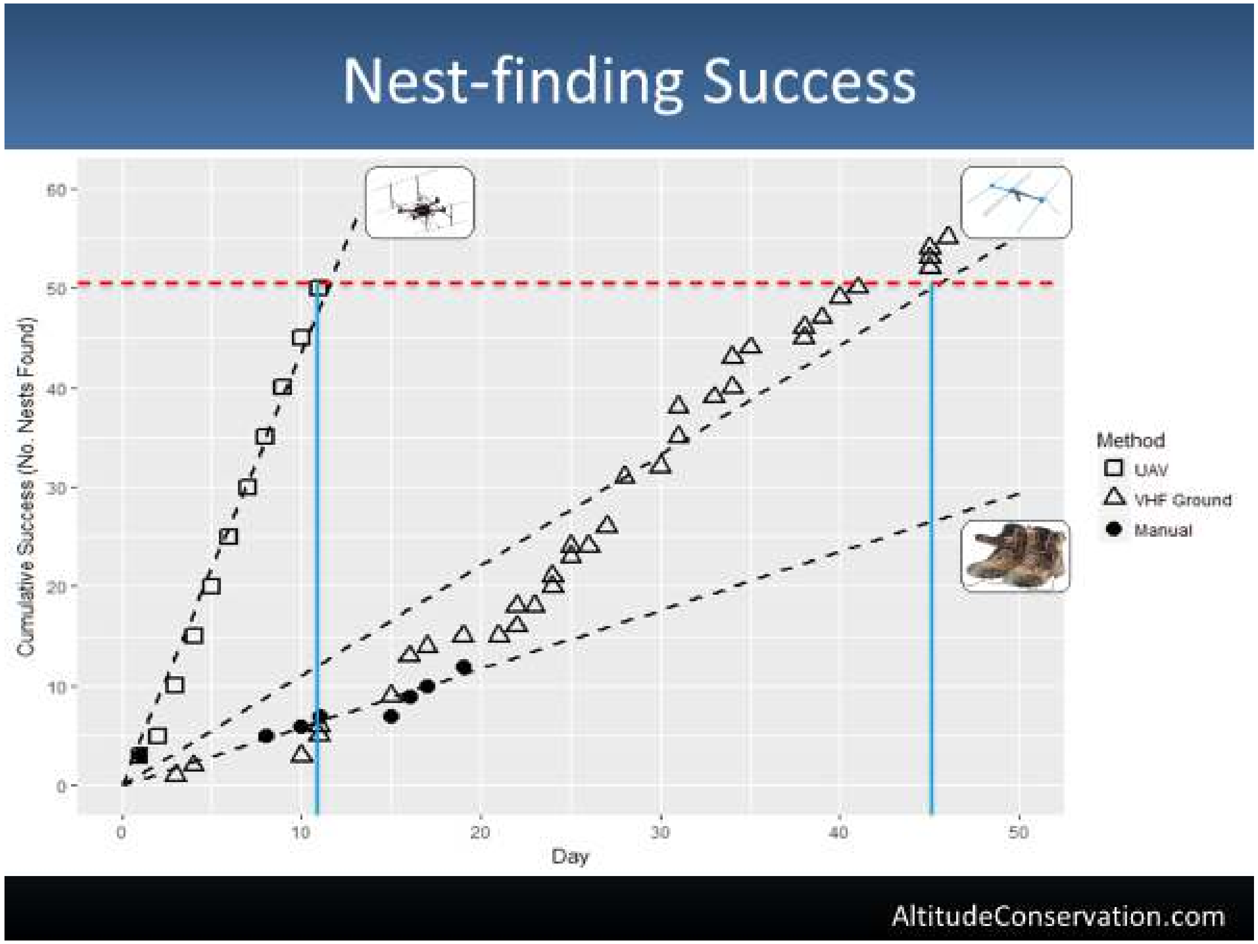
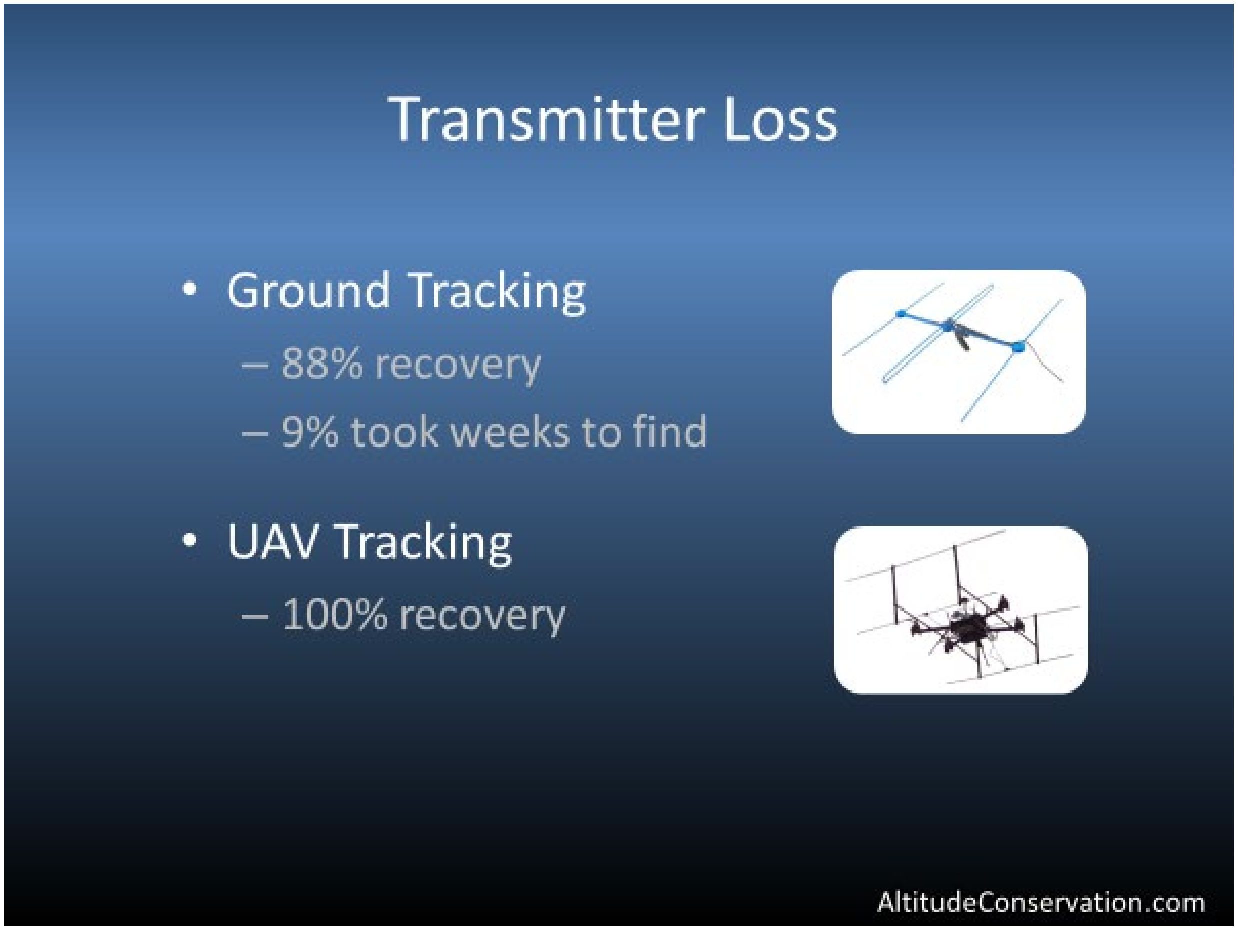

Nest-finding Success
Cumulative Success (No. Nests Found)
Day
Method
UAV
VHF Ground
Manual
AltitudeConservation.com


Transmitter Loss
• Ground Tracking
– 88% recovery
– 9% took weeks to find
• UAV Tracking
– 100% recovery
AltitudeConservation.com

Search Type Comparison

Single-frequency receiver	Multi-Track receiver
Monitor 1 freq at a time	Monitor 500 freqs at a time
Requires freq scanning	Single sweep of area sufficient
2% monitoring (n=50 freqs)	100% monitoring (n=500 freqs)
Triangulation dictates flight path	No deviation from flight path needed
Requires telemetry link + manual flight	Full autonomous flight
BVLOS difficult	BVLOS capable
Locations slow, inefficient (hovering + rotating)	Fast locations at cruising speed

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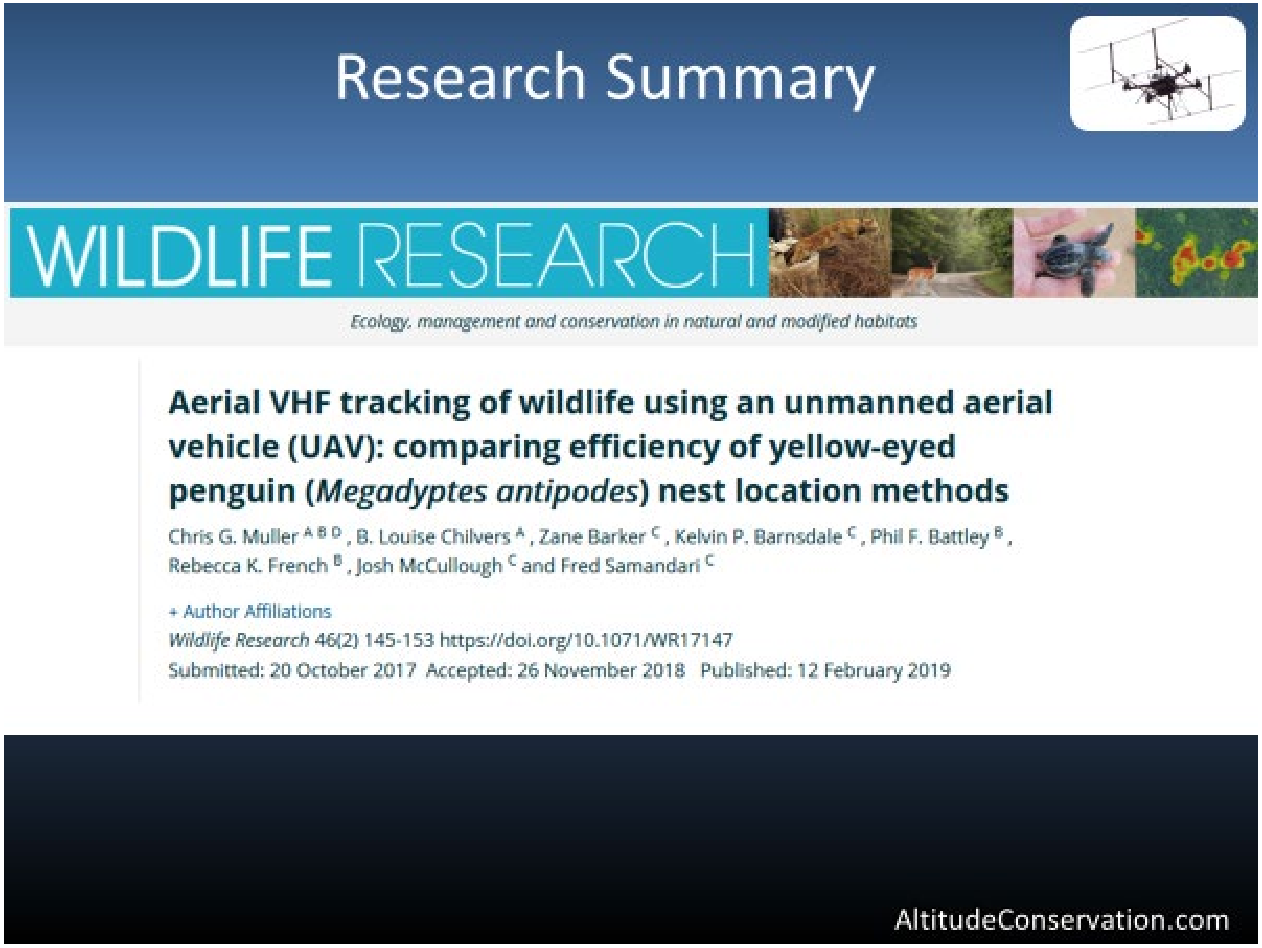
Research Summary
WILDLIFE RESEARCH
Ecology, management and conservation in natural and modified habitats
Aerial VHF tracking of wildlife using an unmanned aerial vehicle (UAV): comparing efficiency of yellow-eyed penguin (*Megadyptes antipodes*) nest location methods
Chris G. Muller [A B D], B. Louise Chilvers [A], Zane Barker [C], Kelvin P. Barnsdale [C], Phil F. Battley [B], Rebecca K. French [B], Josh McCullough [C] and Fred Samandari [C]
+ Author Affiliations
Wildlife Research 46(2) 145-153 https://doi.org/10.1071/WR17147
Submitted: 20 October 2017 Accepted: 26 November 2018 Published: 12 February 2019
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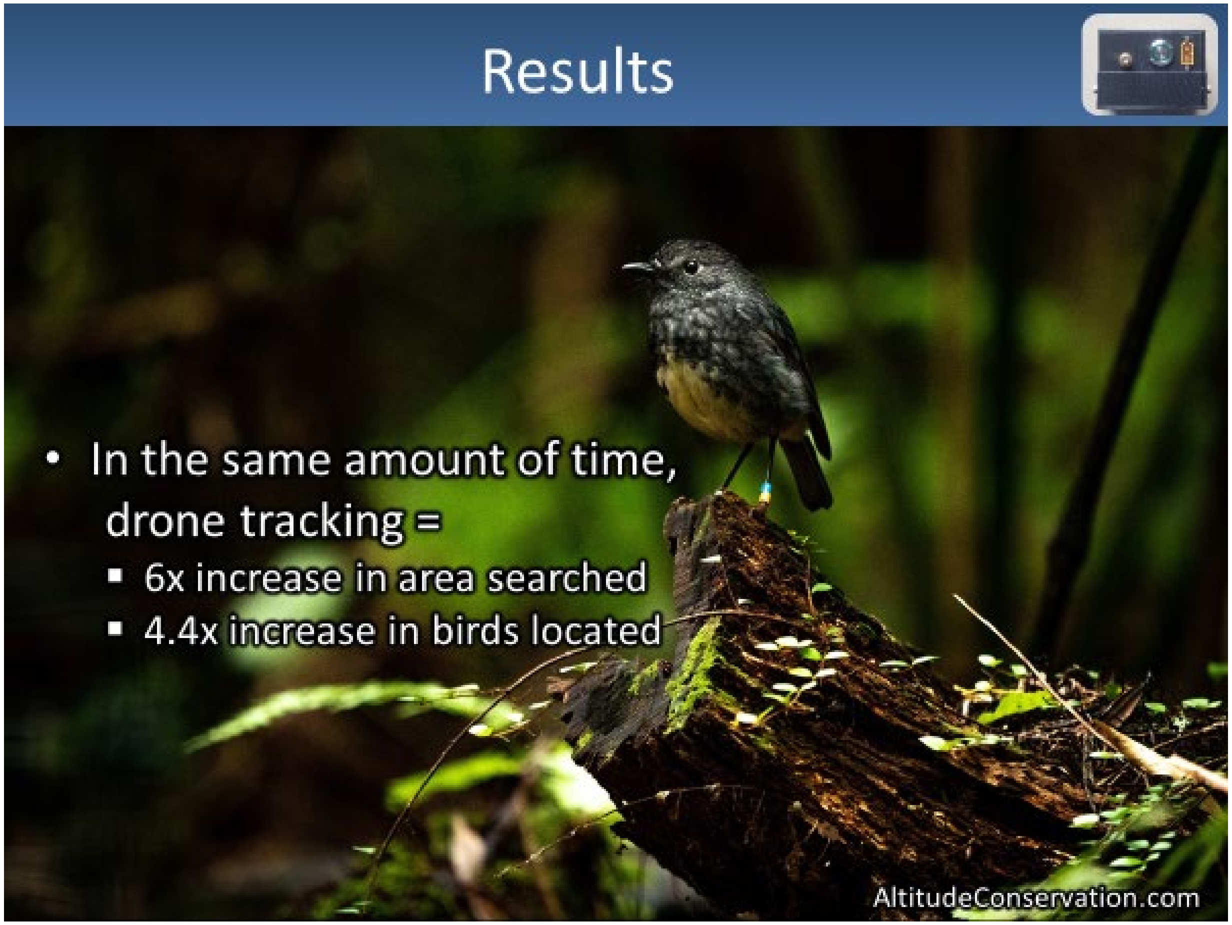
Forest Birds
• North Island robin
• Monitoring post-translocation
• Zoe Stone, Kevin Parker, Doug Armstrong
AltitudeConservation.com


Results
• In the same amount of time, drone tracking =
▪ 6x increase in area searched
▪ 4.4x increase in birds located
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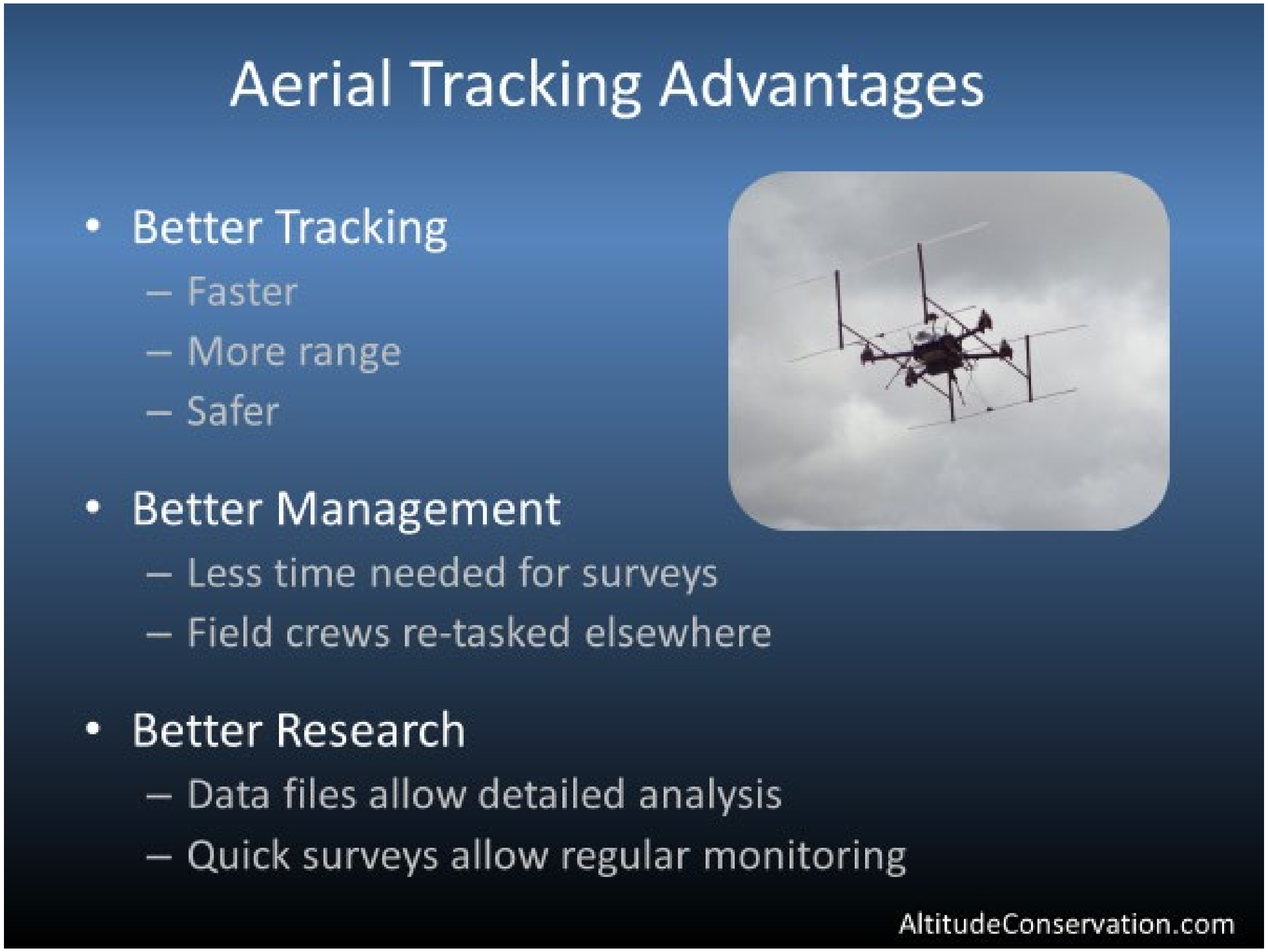
Aerial Tracking Advantages
• Better Tracking
– Faster
– More range
– Safer
• Better Management
– Less time needed for surveys
– Field crews re-tasked elsewhere
• Better Research
– Data files allow detailed analysis
– Quick surveys allow regular monitoring
AltitudeConservation.com

Multi-Track Advantages

- VHF can track where cameras can't
- More efficient aerial tracking
  - Monitor up to 500 frequencies simultaneously
  - No more channel surfing = No missed signals!
  - Search at cruising speed
- Systematic searches provide accuracy and repeatability for data collection

AltitudeConservation.com


Multi-Track Advantages
Revolutionize VHF Radio Tracking...
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Sponsors
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UNIVERSITY OF NEW ZEALAND
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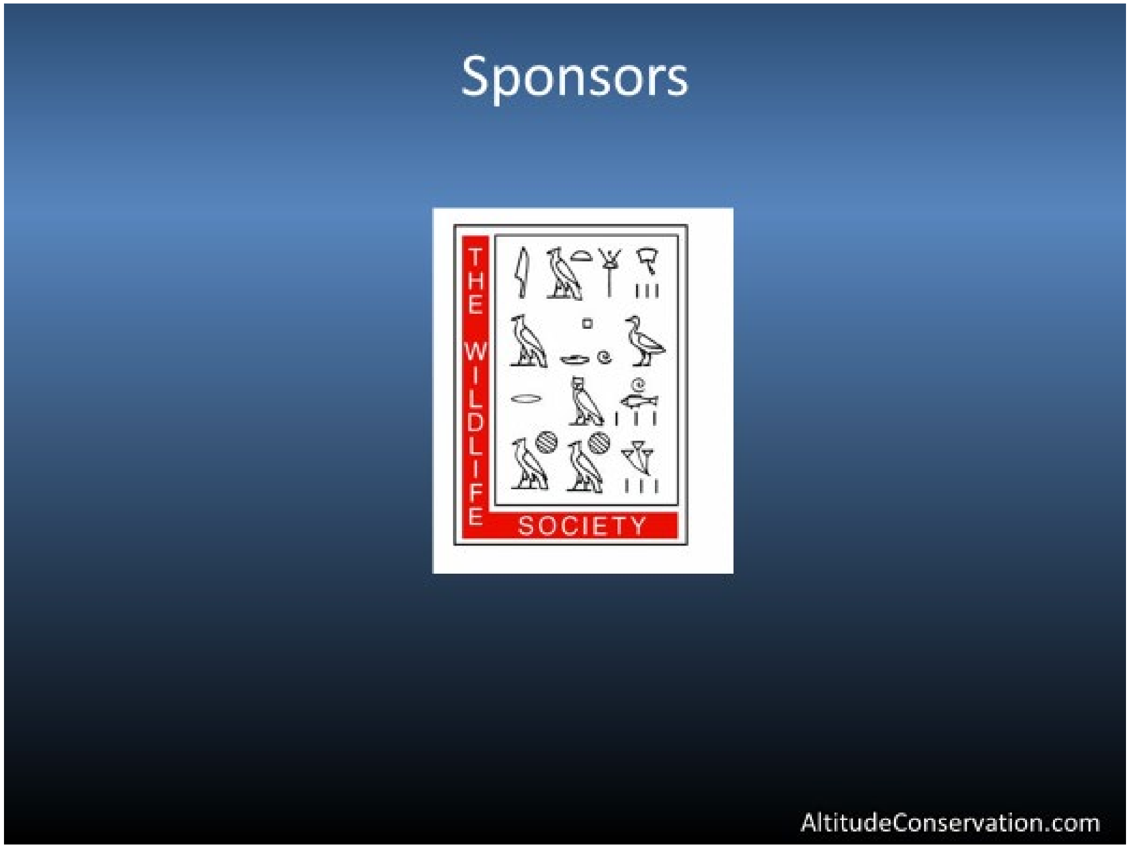
phillipisland
nature parks australia
Department of Conservation
SIRTRACK
YELLOW-EYED PENGUIN TRUST
Birds New Zealand
BLUE PLANET MARINE
The Freemasons Charity
a tradition of caring
AltitudeConservation.com


Sponsors
THE WILDLIFE SOCIETY
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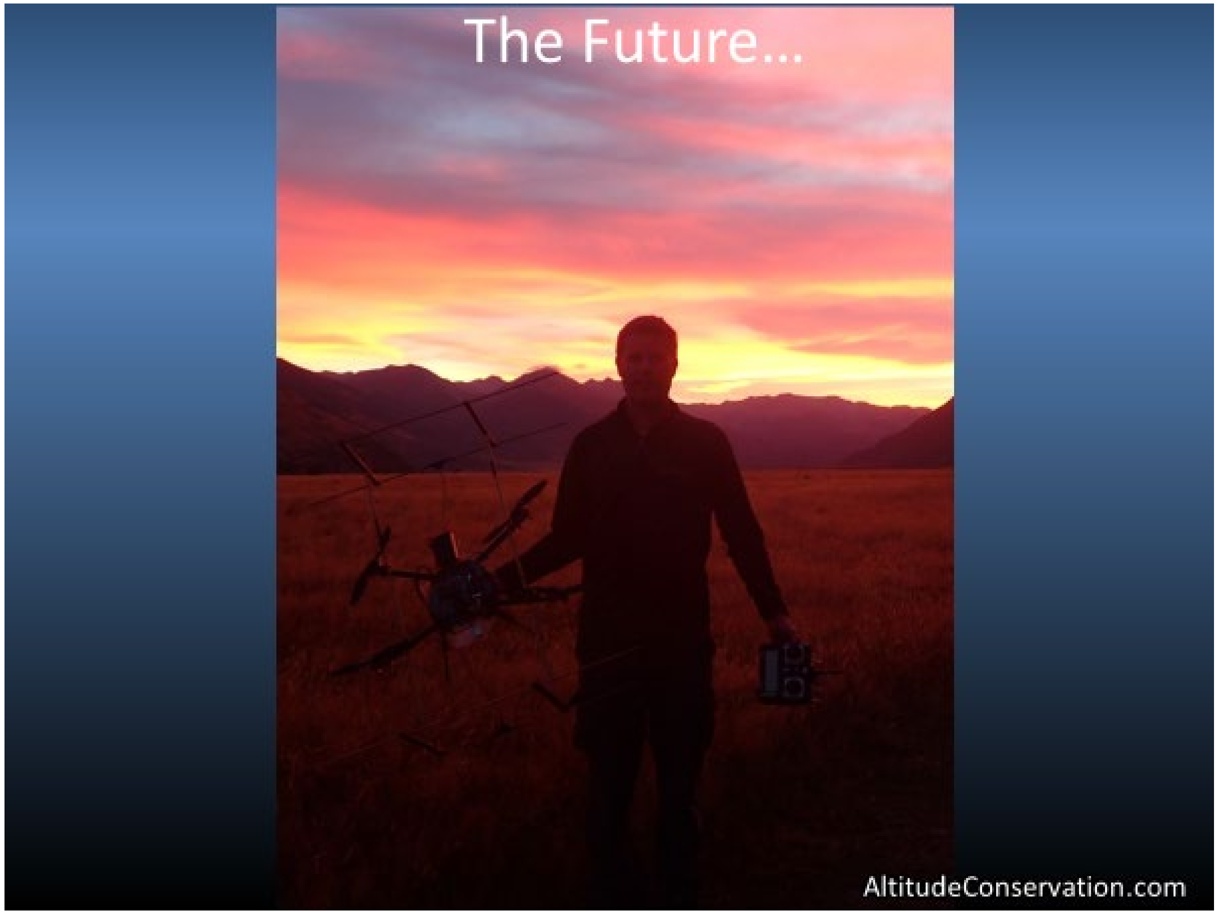
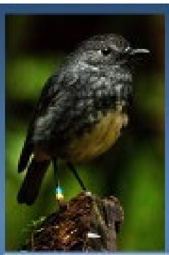

The Future…
AltitudeConservation.com



Search Results

Search Method	Ground	UAV
Search Hours	300	10
Search Area (ha)	2000	600
No. Detections	284	40
Area (ha) / hr	6.67	60
Detections / hr	0.95	4

AltitudeConservation.com

Use of Drones to Advance and Scale Invasive Species Eradications on Islands

Timo Sullivan[1], David Will[1], Paula Castano[1], Stefan Knapp[2], Cameron Baker[2], Debbie Saunders[3], Tim Haynie[4], Satish Samiappan[5], and Daniel McCraine[5]

[1]Island Conservation, timo.sullivan@islandconservation.org

[2]Envico Technologies Ltd., Tauranga, New Zealand; https://www.envicotech.co.nz/

[3]Wildlife Drones, Canberra, Australia; https://wildlifedrones.net/

[4]Spectrabotics, LLC, Colorado Springs, CO; https://www.spectrabotics.com/

[5]Mississippi State University, MS

Non-native, damaging invasive species harm island and marine ecosystems and are the leading cause of extinctions on islands. Removing invasive species is a proven intervention action that halts extinctions and catalyzes the restoration of natural systems. Drone technology will significantly expand global capacities for these types of island restoration actions by overcoming the challenges associated with helicopter-based operations and ground-based monitoring for animals at low densities. Further, the use of drones for island restoration projects will dramatically reduce project costs for these management actions, empowering both conservation partners and local island communities to implement more—and better—restoration actions. We will provide an update on the development and demonstration of technologies for island restoration catalyzed in partnership with technology companies. Specifically, heavy-lift drone technology for aerial broadcast applications with Envico Technologies, remote wildlife VHF tracking with Wildlife Drones, and hyperspectral-based animal detection with Spectrabotics.


Use of drones to advance and scale invasive species eradications on islands
Timo Sullivan[1], David Will[1], Paula Castano[1], Stefan Knapp[2], Cameron Baker[2], Debbie Saunders[3], Tim Haynie[4] Satish Samiappan[5], and Daniel McCraine[5]
[1]Island Conservation, [2]Envico Technologies, [3]Wildlife Drones, [4]Spectrabotics, [5]Mississippi State University
2019 ISLA SEYMOUR NORTE, GALAPAGOS ARCHIPELAGO
WORLD'S FIRST DRONE-POWERED INVASIVE RAT ERADICATION
ISLAND CONSERVATION
Preventing Extinctions


ISLAND CONSERVATION
Preventing Extinctions
41% of the world's threatened species are found on islands.

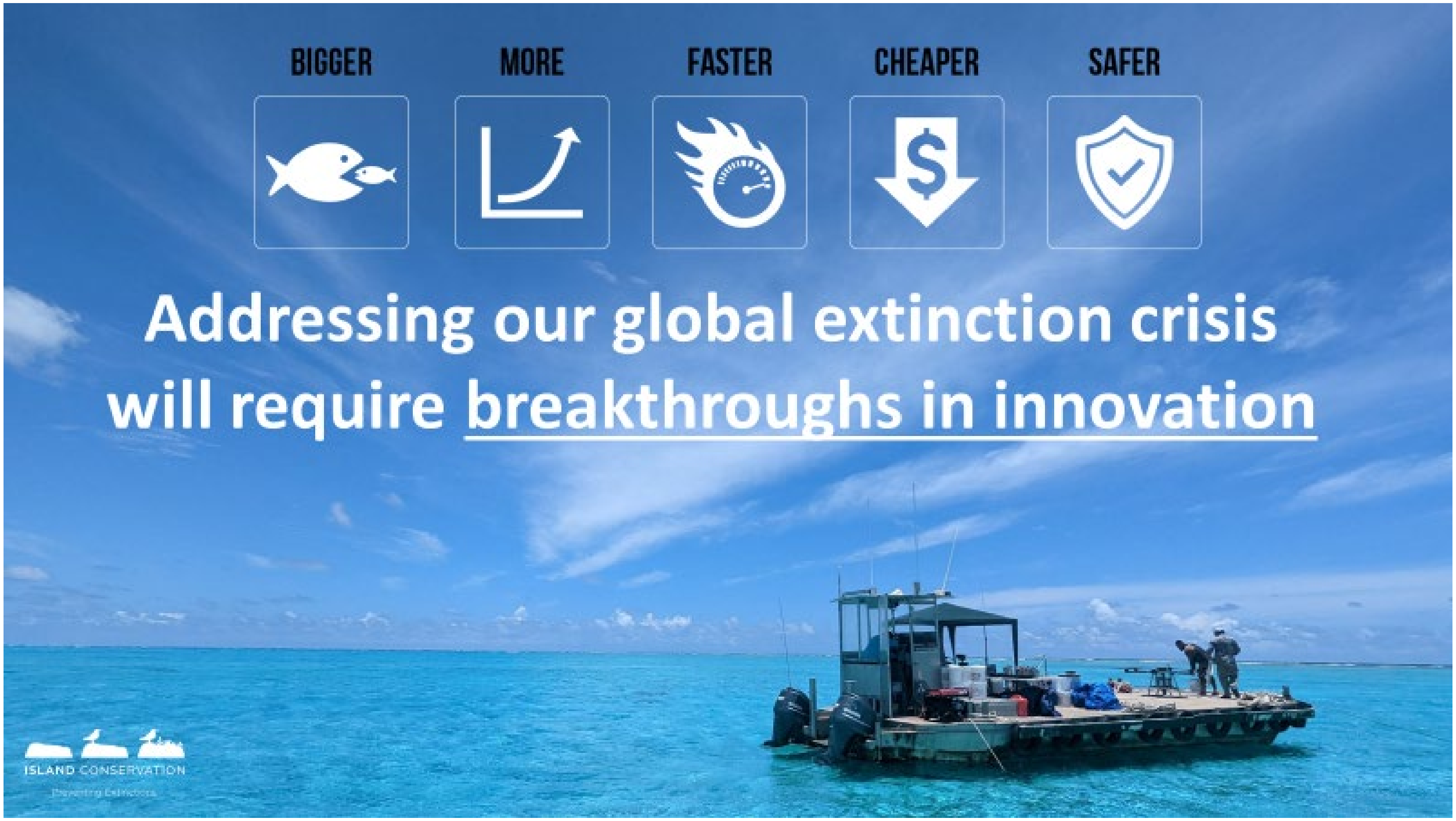

86%
ISLAND CONSERVATION
Preventing Extinctions


Eradicating invasive species is a proven intervention that prevents extinction
ISLAND CONSERVATION


New snail species:
Rábida Island, Galápagos
"Extinct" gecko:
Rabida Island, Galápagos
First Shearwater sighting:
Desecheo Island
50% more fish biomass:
Chagos Archipelago
ISLAND CONSERVATION

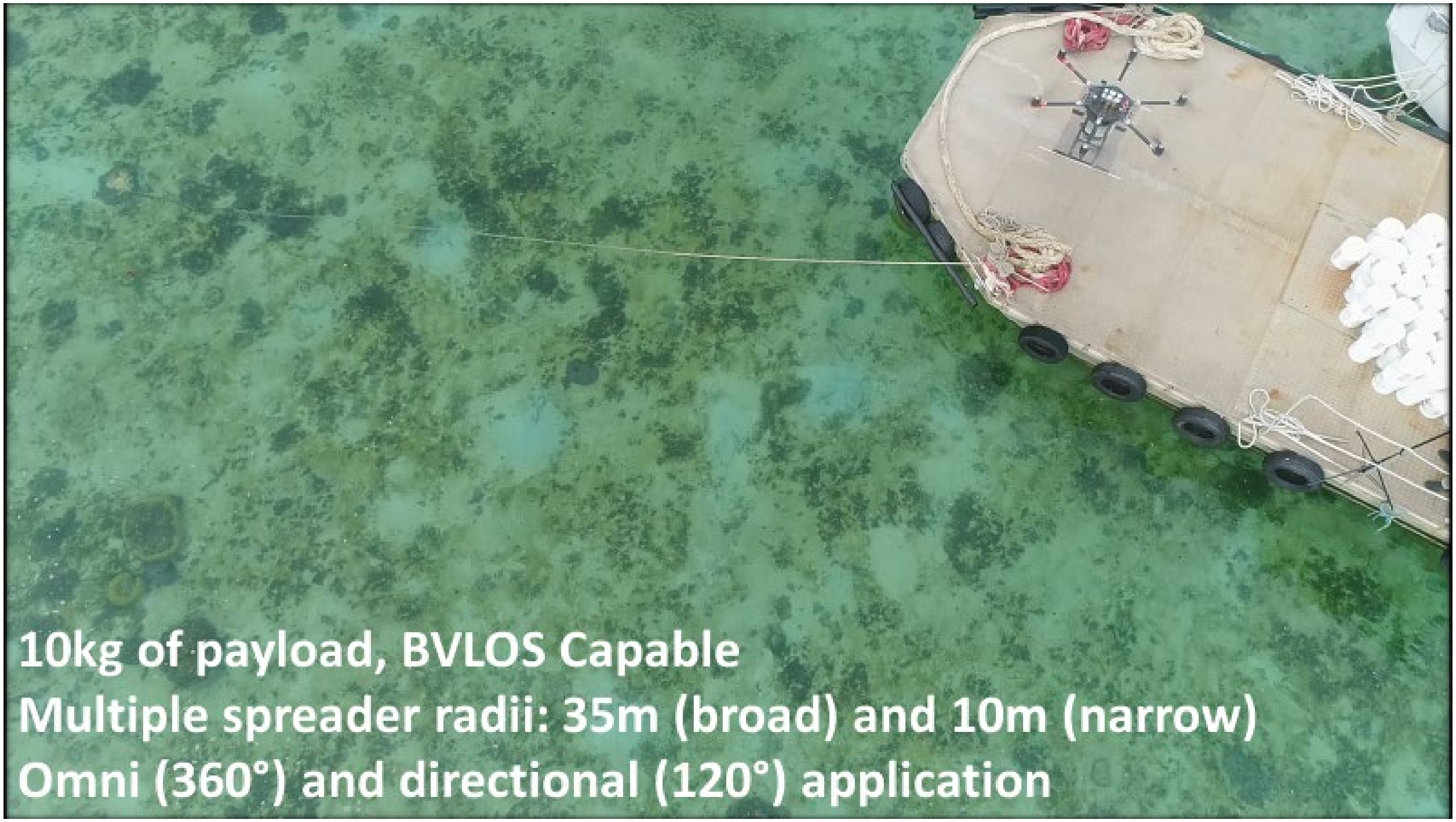

Removal of invasive rabbits
Choros Island, Chile.
BEFORE
AFTER
ISLAND CONSERVATION


PALMYRA ATOLL
ISLAND CONSERVATION
Preventing Extinctions
2011
2012
2014


BIGGER
MORE
FASTER
CHEAPER
SAFER
Addressing our global extinction crisis will require breakthroughs in innovation
ISLAND CONSERVATION

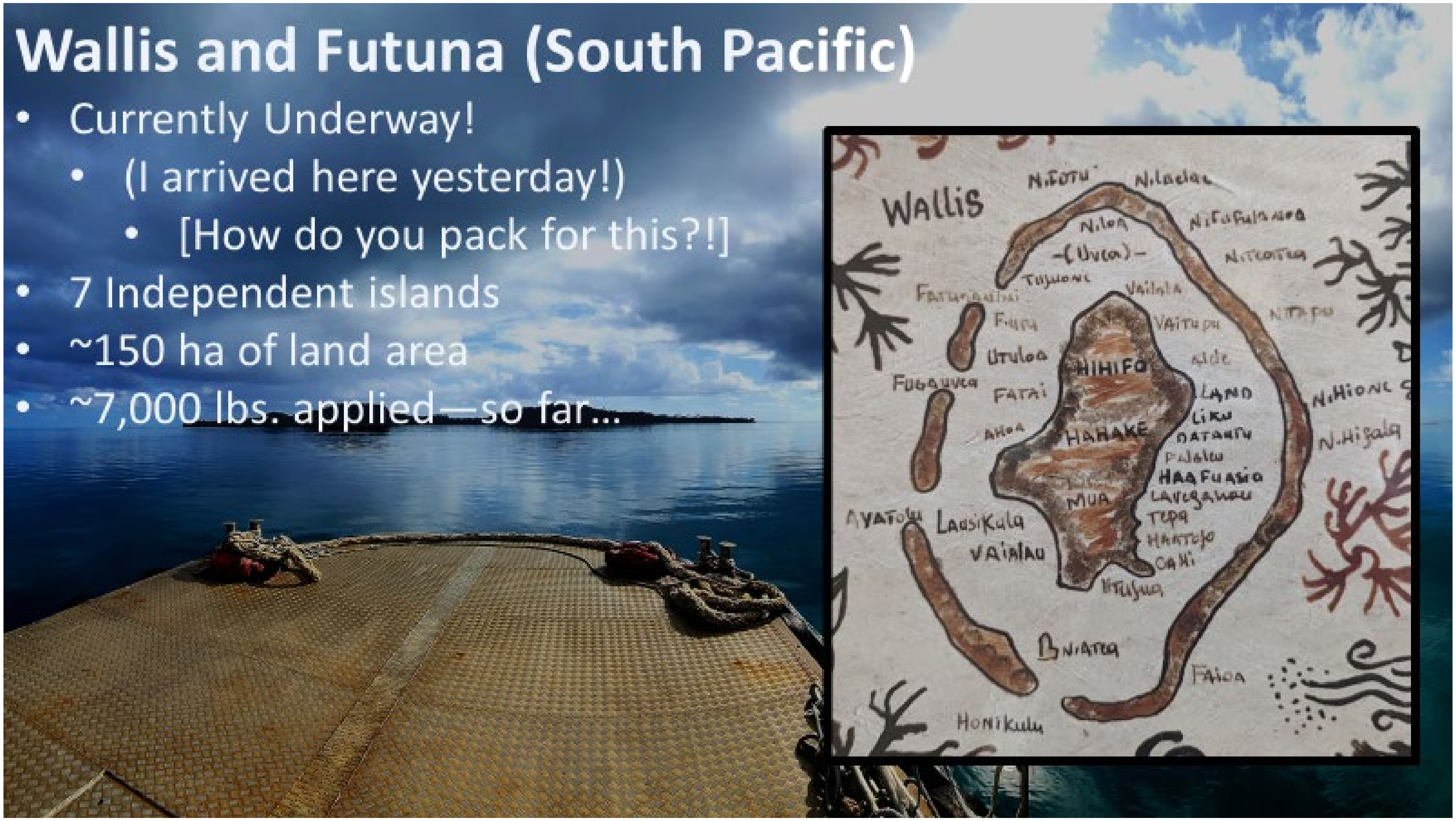

Helicopter-based aerial broadcast is a major expense, high risk, or impossibility for remote island projects
ISLAND CONSERVATION
Hawadax Island, Alaska Maritime National Wildlife Refuge


Envico Technologies' ENV10
ISLAND CONSERVATION

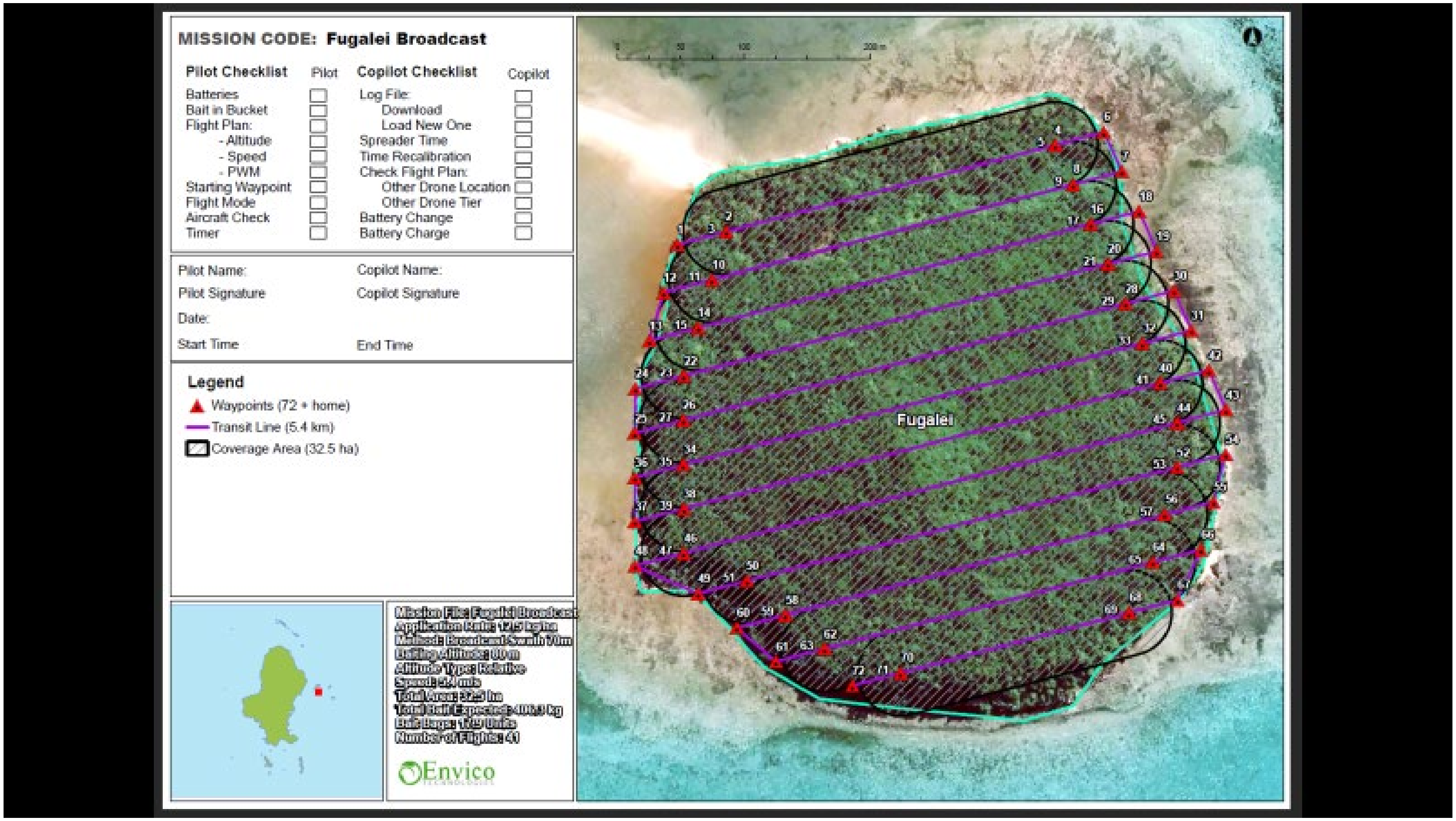

10kg of payload, BVLOS Capable
Multiple spreader radii: 35m (broad) and 10m (narrow)
Omni (360°) and directional (120°) application

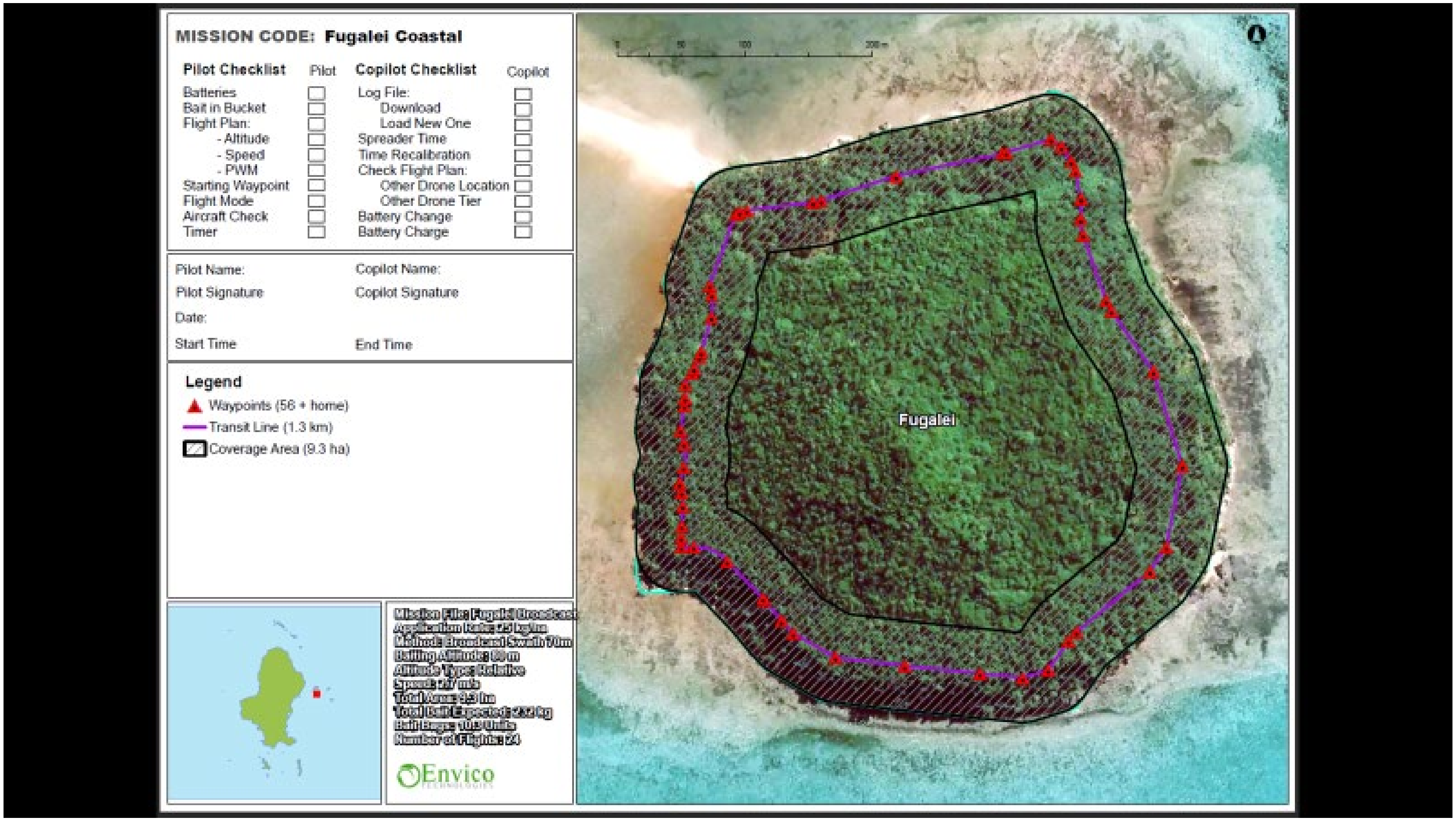

>22,000 lbs. of rodenticide applied since 2019
Galapagos, Palau, French Polynesia, and Wallis and Futuna

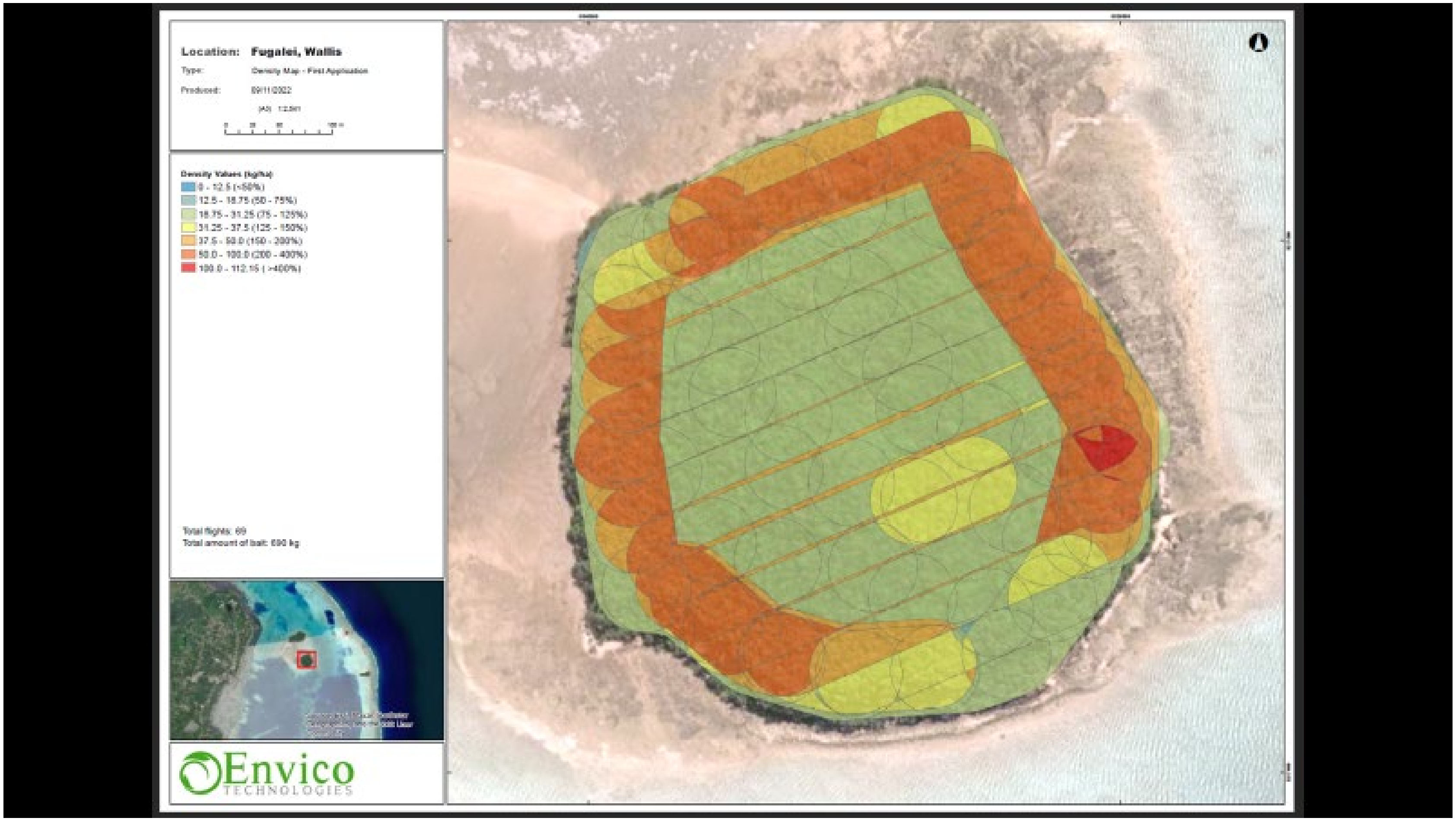

10968 WF

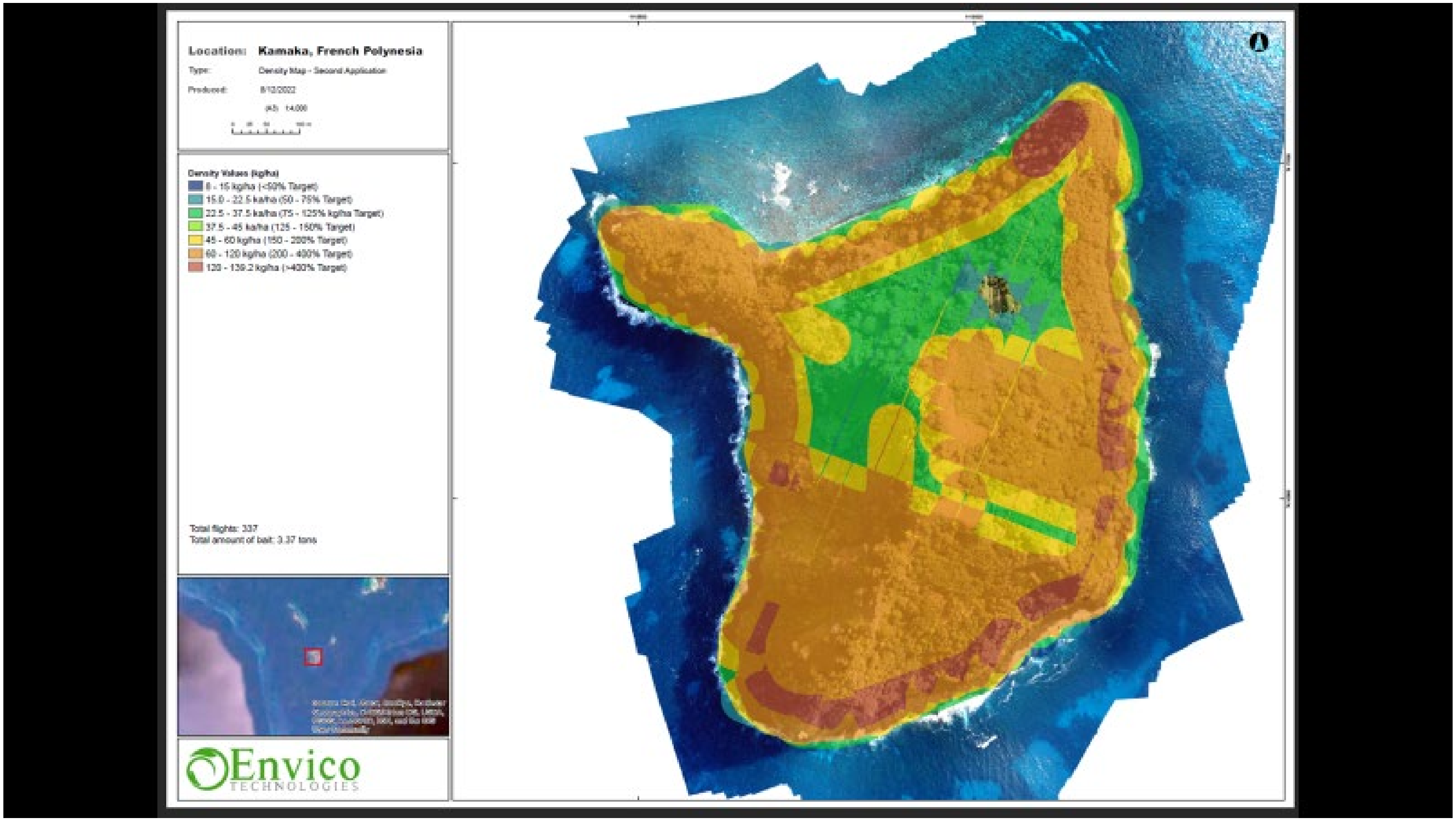

Wallis and Futuna (South Pacific)
• Currently Underway!
• (I arrived here yesterday!)
• [How do you pack for this?!]
• 7 Independent islands
• ~150 ha of land area
• ~7,000 lbs. applied—so far…
Wallis
HIHIFO
HAHAKE
MUA


The drone and the barge,
A logistical love story


MISSION CODE: Fugalei Broadcast
Pilot Checklist
Pilot
Batteries
Bait in Bucket
Flight Plan:
- Altitude
- Speed
- PWM
Starting Waypoint
Flight Mode
Aircraft Check
Timer
Copilot Checklist
Copilot
Log File:
Download
Load New One
Spreader Time
Time Recalibration
Check Flight Plan:
Other Drone Location
Other Drone Tier
Battery Change
Battery Charge
Pilot Name:
Pilot Signature
Date:
Start Time
Copilot Name:
Copilot Signature
End Time
Legend
Waypoints (72 + home)
Transit Line (5.4 km)
Coverage Area (32.5 ha)
Envico
Fugalei


MISSION CODE: Fugalei Coastal
Pilot Checklist
Pilot
Batteries
Bait in Bucket
Flight Plan:
- Altitude
- Speed
- PWM
Starting Waypoint
Flight Mode
Aircraft Check
Timer
Copilot Checklist
Copilot
Log File:
Download
Load New One
Spreader Time
Time Recalibration
Check Flight Plan:
Other Drone Location
Other Drone Tier
Battery Change
Battery Charge
Pilot Name:
Copilot Name:
Pilot Signature
Copilot Signature
Date:
Start Time
End Time
Legend
Waypoints (56 + home)
Transit Line (1.3 km)
Coverage Area (9.3 ha)
Mission File: Fugalei Broadcast
Application Rate: 25 kg/ha
Method: Broadcast Swath 70m
Altitude Type: Relative
Total Area: 9.3 ha
Total Bait Expected: 232 kg
Number of Flights: 24
Envico
Fugalei


Location: Fugalei, Wallis
Type: Density Map - First Application
Density Values (kg/ha)
0 - 12.5 (<50%)
12.5 - 18.75 (50 - 75%)
18.75 - 31.25 (75 - 125%)
31.25 - 37.5 (125 - 150%)
37.5 - 50.0 (150 - 200%)
50.0 - 100.0 (200 - 400%)
100.0 - 112.15 (>400%)
Envico
TECHNOLOGIES


Location: Kamaka, French Polynesia
Type: Density Map - Second Application
Produced: 8/12/2022
(A3) 1:4,000
Density Values (kg/ha)
8 - 15 kg/ha (<50% Target)
15.0 - 22.5 ka/ha (50 - 75% Target)
22.5 - 37.5 ka/ha (75 - 125% kg/ha Target)
37.5 - 45 ka/ha (125 - 150% Target)
45 - 60 kg/ha (150 - 200% Target)
60 - 120 kg/ha (200 - 400% Target)
120 - 139.2 kg/ha (>400% Target)
Total flights: 337
Total amount of bait: 3.37 tons
Envico
TECHNOLOGIES

Growing Pains

- 10kg payload feels small
  - 3,000 kg = 300 flights!
  - <12 flights per hour
- Large, on-site generator required
- Importing can be a problem
- Batteries must be ocean freighted
  - Always delayed


Envico's next generation drone the ENV50

- 50 kg payload
- Requires 6 batteries per flight
- Tested (with significant issues) early this year in Palau
- IC funded development for mid-2023


Envico's next generation drone the ENV50
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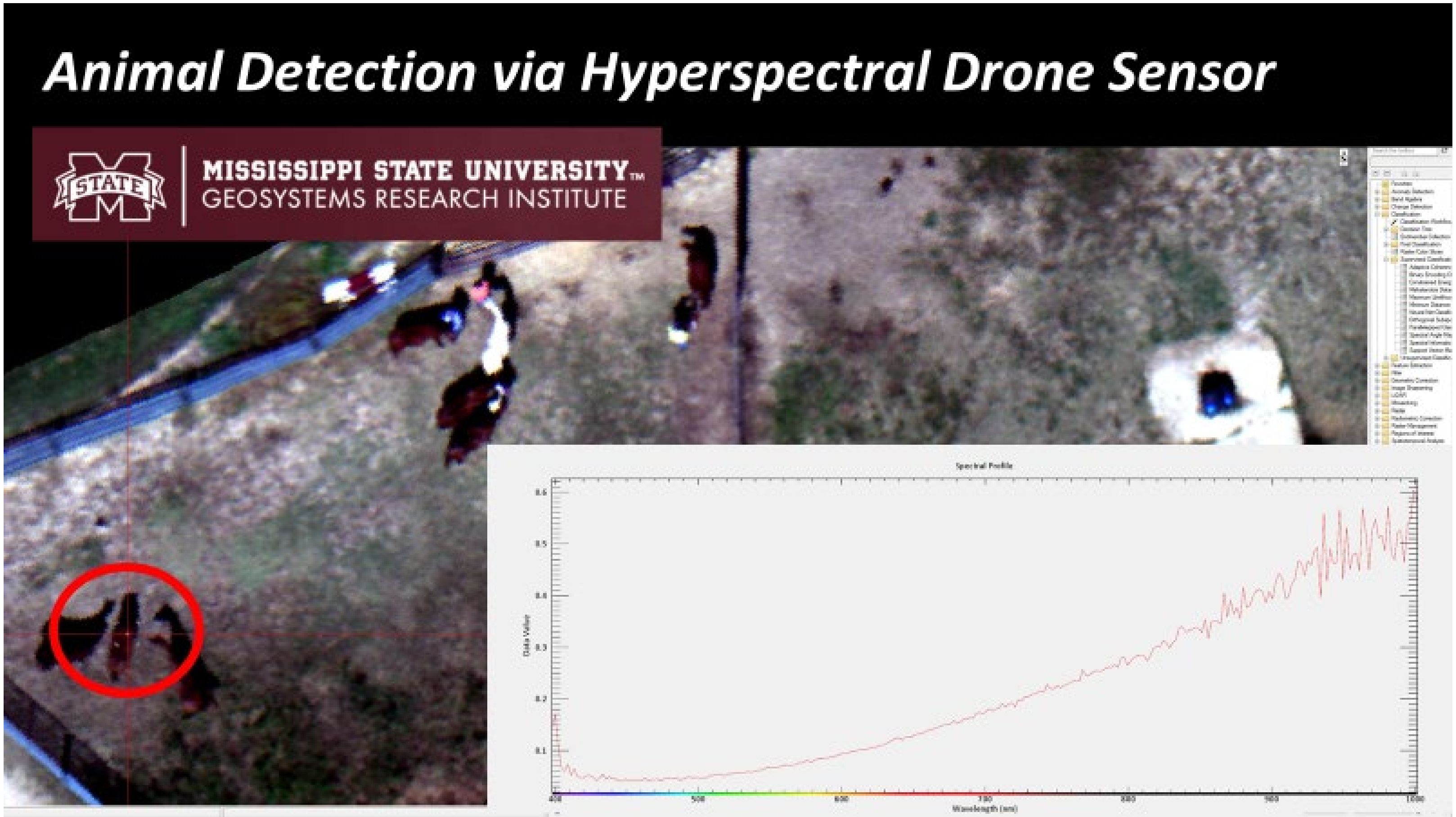
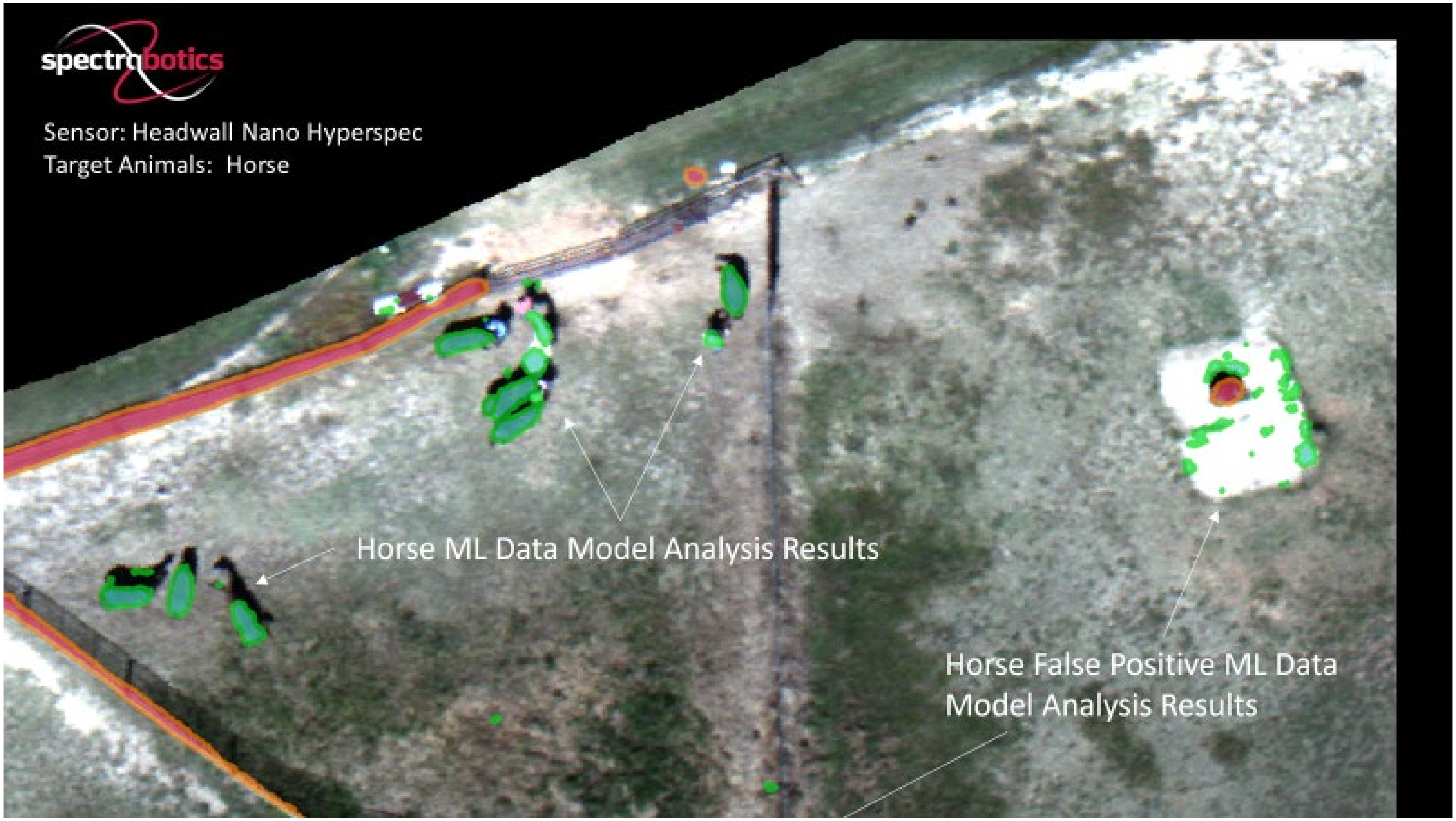
Parallel Flight Technologies' Firefly
• 50 kg payload
• Hybrid Power
• PFT + USDA + IC partnership for Wake Island Federal demonstration
• Planned for mid-2024


Animal Detection via Hyperspectral Drone Sensor
MISSISSIPPI STATE UNIVERSITY™
GEOSYSTEMS RESEARCH INSTITUTE
STATE
Spectral Profile
Data Value
Wavelength (nm)


spectrobotics
Sensor: Headwall Nano Hyperspec
Target Animals: Horse
Horse ML Data Model Analysis Results
Horse False Positive ML Data
Model Analysis Results

21 JUN 2022 ISLAND CONSERVATION 0 CONSERVATION NEWS, ISLAND NEWS, NEWS, PRESS RELEASES & EVENTS

Press Release: New Conservation partnership will see revolutionary drone technology used to save endangered species.


ISLAND CONSERVATION
Preventing Extinctions