THE WILDLIFE SOCIETY
VIRTUAL CONFERENCE

DRONE SYMPOSIUM (NOVEMBER 2021)

DRONE APPLICATIONS FOR
WILDLIFE RESEARCH, MANAGEMENT, AND CONSERVATION

Sponsored by:
TWS Drone Working Group

Abstracts for the 2021 TWS Drone Symposium: DRONE APPLICATIONS FOR WILDLIFE RESEARCH, MANAGEMENT, AND CONSERVATION

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

Use of Data Mule UAS to Remotely Download Camera Trap Data on Military Lands

David Delaney[1], Jean Pan[2], Zane Mountcastle[3], Martin Slosarik[3], Aaron Alvidrez[4], and Martin Ruane[5]

[1]U.S. Army Construction Engineering Research Laboratory; David.Delaney@usace.army.mil
[2]Naval Facilities Engineering Command and Expeditionary Warfare Center, Port Hueneme, CA
[3]Mission Mule, LLC.
[4]56th Range Management Office, Luke AFB, AZ
[5]NAS Point Mugu, Naval Base Ventura County, CA

Ground sensors are often placed in remote areas to collect important natural resource data which informs management decisions on military installations and other land management agencies. Data are often collected manually (i.e., by vehicle, on foot) which is time consuming, costly, and can risk personnel safety in rugged terrain. Moreover, access to field equipment can be restricted due to military training, inhospitable weather, or to reduce disturbance during sensitive periods (i.e., wildlife breeding season). This can delay data acquisition and lead to missed opportunities to make informed management decisions. There is a need for technology that can improve access to ground-based sensor data. We demonstrated the use of a Data Mule unoccupied aircraft system (UAS) to remotely collect camera trap data at artificial water provisioning sites on U.S. Air Force land in 2019 and to monitor sensitive bird species on U.S. Navy land in 2020. The Data Mule UAS autonomously flew to and circled over each ground station (includes communication hub, camera trap, and a solar panel) and wirelessly uploaded data from the ground station to the UAS payload. The UAS then returned home loaded with sensor data, which was offloaded by the flight crew upon landing. We successfully conducted flights, some of which were upwards of 12 km, to multiple field sites and conducted missions where multiple ground sensors were visited and data downloaded in a single flight. The results of this project are widely applicable across all military facilities, federal, state, or any lands of interest where there is a need for alternative cost-effective methods for collecting data from camera traps and other remote ground-based sensors.

Federal Regulations Governing the Operation of Drones in Natural Resource Studies

Stephen D. Earsom, USFWS; Stephen_Earsom@fws.gov

Unmanned aircraft systems (UAS, drones) are rapidly gaining traction as useful tools in conservation. A review will be provided of certain federal statutes and regulations, and how drones can and cannot currently be employed for research and management of natural resources. The focus will be on U.S. Fish and Wildlife Service statutes and regulations including the Airborne Hunting Act, Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act, Endangered Species Act, National Wildlife Refuge System Improvement Act, and other regulatory authorities within Title 50 of the Code of Federal Regulations. Regulatory changes finalized during the Trump administration, and proposed changes by the Biden administration, will be discussed.

How Drones Are Being Used to Help Wildlife Today

David M. Bird[1], Paul Pace[2], and Kyle Elliott[1]

[1]McGill University, Montreal, Quebec, Canada; david.bird@mcgill.ca
[2]Retired

Unoccupied Vehicle Systems (UVS; aka drones) are gaining more and more acceptance as a bonafide technological tool for wildlife biologists and managers all over the world. Compared to using manned light airplanes or helicopters, flying drones can be cheaper, greener, less obtrusive, and much safer (the number one source of mortality for wildlife biologists is dying in a plane or helicopter crash!). In the last 13 years or so, the use of drones by biologists has come a long way. Whether one is flying a drone to census nest contents of raptorial birds and tree-nesting water birds, to count ground-nesting birds or sea turtles, to map habitat for an endangered wildlife species, to detect animals with infrared cameras or acoustic recording sensors, to track movements of various wildlife species, or to disperse nuisance wildlife, new applications are being tested every year. There is also a growing interest in studying the disturbance impact upon wildlife. The latest efforts by McGill University researchers include modifying an off-the-shelf drone to peer into the nesting holes of birds and to collect insect biota above the forest canopy and evaluating insect resources as food for insectivorous birds. This presentation provides insights into the very latest wildlife research and management using drones, including successes and failures.

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

David Will[1], Cameron Baker[2], Jose Luis Cabello[1], Richard Griffiths[1], Chad Hanson[1], Thomas Hall[1], Baudouin des Monstiers[1], and Samuel Vye[2]

[1]Island Conservation, Santa Cruz, CA; dwill@islandconservation.org
[2]Envico Technologies Ltd., Tauranga, New Zealand

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 that halts extinctions and catalyzes the restoration of natural systems. Drone technology can disrupt the field of island restoration by overcoming challenges associated with helicopter-based aerial broadcast dispersing conservation bait and ground-based monitoring detecting invasive animals at low densities. The wide-spread use of drones for island restoration projects will dramatically reduce project costs, break through current feasibility and technology barriers limiting restoration of larger islands and empower island communities with tools to implement community driven restorations. We completed the world's first drone-based aerial broadcast eradication proof-of-concept in 2019 and are working with partners to scale 1) heavy-lift and ultra-heavy-lift drone technology to complete high-volume precision bait application on islands up to 50,000 acres, 2) machine learning-enabled drone monitoring systems that detect island species, and 3) drone data mule technology reducing labor intensive field collection efforts. We report on lessons learned from demonstration projects and the future advances necessary to significantly reduce project costs and break the 'glass ceiling' limiting restoration of larger islands where benefits to biodiversity, ecosystems, and human communities are the greatest.

Investigating Nocturnal UAS flights in an Applied Context to Prevent Gulls from Nesting on Rooftops

Morgan B. Pfeiffer[1], Craig K. Pullins[2], Scott F. Beckerman[3], Joshua L. Hoblet[1], and Bradley F. Blackwell[1]

[1]USDA, Wildlife Services, National Wildlife Research Center, Sandusky, OH; Morgan.Drabik-Hamshare@usda.gov
[2]USDA, APHIS, Wildlife Services, O'Hare International Airport, Chicago, IL
[3]USDA, APHIS, Wildlife Services, Springfield, IL

Ring-billed (*Larus delawarensis*) and herring gulls (*L. argentatus*) hereafter referred to collectively as gulls, are numerous and widespread in North America. These gulls pose substantial risk of colliding with aircraft based on their body size, abundance, flocking behavior, and ubiquitous presence in urban environments, including rooftop nesting behavior. The presence of gull nesting colonies in the vicinity of airports likely increases the risk of bird-aircraft collisions by frequently exposing more birds to aircraft in flight. Bird collisions with aircraft result in the death of the bird and threatens human safety. In an applied context involving two rooftops in two states, we assessed the responses of gulls to an unoccupied aircraft system (UAS, aka drone) at night with the objective of dispersing them prior to egg-laying. Camera trap images from the 2020 breeding season revealed that most of the gulls were present on the roof during the evening. We hypothesized that nocturnal UAS operation, like nocturnal predator disturbance, might induce nesting colony desertion. Two weeks prior to egg-laying in spring 2021, we conducted nocturnal UAS operations over target roofs at least once every hour from 1900h until 0200h, weather permitting for 15 minutes. The UAS flew directly above (~ 4 m) loafing gulls and then descended (~ 15 kph). No gulls interacted with the UAS and most flushed within 2 minutes. Generally, the first UAS flight of a night dispersed all the gulls (range: 1-130 individuals) and gulls did not return to the target roof until daylight. Our operations were affected by the logistics and safety considerations of UAS flights, sample size, variability in gull rooftop use, and weather. We discuss our observations, given the constraints on our operations and in light of efficacy with regard to labor, shifting birds to other nearby sites, and safety.

Using Thermal Imaging Drones to Survey Cryptic Burrow-Nesting Seabirds

Lindsay Young[1], Dena Spatz[1], Eric VanderWerf[1] and Matthew McKown[2]

[1]Pacific Rim Conservation, Honolulu, HI, USA (lindsay@pacificrimconservation.org)
[2]Conservation Metrics, Santa Cruz, CA

Burrow-nesting petrels and shearwaters include some of the seabird species most vulnerable to extinction and species with some of the largest knowledge gaps. Much of this is due to their cryptic, nocturnal habits and their tendency to nest in underground burrows that are often in inaccessible locations. Locating nests, or in some cases even entire colonies, can be difficult. The use of unoccupied aerial vehicles (drones) in conservation biology has accelerated in recent years, but few studies have examined the potential to combine traditional visible spectrum photography with infrared thermal imaging to survey wildlife. We tested the use of thermal imaging cameras mounted alongside traditional RGB cameras to detect the heat signatures of cryptic burrow-nesting seabirds. We conducted flights of a quad copter drone with a dual sensor RGB/infrared camera over survey plots in a Wedge-tailed Shearwater colony prior to sunrise at Kaena Point, Oahu, Hawaii. Within one hour of the flights, we then manually counted the burrows in each plot and confirmed their contents to verify the drone results. The thermal images taken by the drone were able to detect the presence of birds in burrows by the signature of heat venting from the burrow entrance. Burrows were detectable at an altitude of up to 10m in this colony, despite a small difference between the ambient temperature and the birds. This technique can be expected to perform better in cooler climates with larger thermal gradients. Enhanced monitoring tools are needed to provide more information about seabirds and guide conservation efforts, and the results from this study can be broadly applied to other cryptic birds, mammals, and habitats.

Monitoring Raptor Nests with Drones: The Case of the Endangered Chaco Eagle in Argentina

Diego Gallego[1,2] and José Hernán Sarasola[1,2]

[1]Centro para el Estudio y Conservación de las Aves Rapaces en Argentina (CECARA), Facultad de Ciencias Exactas y Naturales, Universidad Nacional de La Pampa, La Pampa, Argentina. (diego.gallego@cecara.com.ar)
[2]Instituto de las Ciencias de la Tierra y Ambientales de La Pampa (INCITAP), Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), La Pampa, Argentina.

Unoccupied Aerial Vehicles (commonly known as drones) are novel tools that allow researchers to monitor bird nests in a faster and safer way. However, few studies have measured the influence of these vehicles on birds' behavior and reproductive success. We present a case study with the endangered Chaco Eagle (*Buteogallus coronatus*) in semiarid landscapes of central Argentina. We followed a strict protocol,

consisting of three different stages (approach, flight and withdraw), to monitor Chaco Eagle nests with drones. We performed 76 drone flights at 41 Chaco Eagle nests registering flight duration, tree height, nest relative height and pilot proximity to nest. Of those, 38 flights were done over active nests, where we recorded adult behavior, classifying it into six categories of increasing disturbance: indifference, vigilance, observation, vocalizations, flight and attack. Before drone took off (approach), most adult eagles remained vigilant in the nests or observing in the surroundings (<100 meters away), particularly during the incubation period and in tall trees. During drone flights, only one adult flew as a response to drone flights, and no attack was registered. The rest of them remained vigilant or emitted alarm calls while incubating or perched on the nest platform. During withdrawal, some adults returned to the nest, the rest of them remaining in the vicinity. The use of drones to monitor Chaco Eagle's nests significantly reduced levels of disturbance when compared with traditional methods, where all adults flew away during climbing. Additionally, this method was almost three times faster in comparison to traditional climbing (performed at the end of the reproductive season) and had no negative effects on reproductive success of Chaco Eagles. Although responses to drones could be species-specific, our results encourage researchers to test the use of drones as a less disturbing and rapid method to monitor breeding raptor populations.

Drone-based Infrared Thermography to Study the Health of Large Whales

Gina Lonati[1], Daniel Zitterbart[2], Sebastian Richter[2], Natasha Hynes[1], Carolyn Miller[2], Peter Corkeron[3], Michael Moore[2], and Kimberley Davies[1]

[1]University of New Brunswick Saint John, Canada (gina.lonati@unb.ca)
[2]Woods Hole Oceanographic Institution, Woods Hole, MA
[3]Anderson Cabot Center for Ocean Life at the New England Aquarium, Boston, MA

Monitoring the health of large whales is challenging because live-capture is unsafe or impractical, individuals cannot be examined in managed care, and species range over vast distances. Traditional methods to assess health involve vessels or occupied aircraft. The former is limited to oblique-angle photographs and biological samples that require close vessel approaches, while the latter is expensive, poses a risk to researchers, and generally precludes close-up photography or sampling of whales. The recent advancement of unoccupied aerial vehicles (UAV) and their payloads has facilitated the collection of new quantitative data and biological samples from whales with minimal invasiveness. For example, UAVs equipped with RGB cameras and laser altimeters can obtain higher-resolution photographs of whales compared to planes, allowing researchers to detect subtler changes in body condition relative to prey dynamics, reproduction, or human impacts. Our research team is exploring the use of another UAV-based payload – thermal infrared (IRT) cameras – to evaluate the health of large whales. Using data collected from North Atlantic right whales (*Eubalaena glacialis*, NARWs) in Cape Cod Bay, Massachusetts, USA between 2017-2018 and from humpback whales (*Megaptera novaeangliae*) in the Bay of Fundy, Canada in 2020, we have demonstrated that UAV-based IRT can be used to: (a) study natural or pathological heat loss patterns from whales' heads and backs; (b) more efficiently follow subsurface, traveling whales via their cold-water "footprints"; and (c) measure the temperature of open blowholes as a proxy for internal body temperature. The third use requires multiple in-field calibration protocols that will be further refined in the Gulf of St. Lawrence, Canada over NARWs in 2021. Combined with other information that can be collected from whales with UAVs, UAV-based IRT will provide a fuller understanding of large whale health and improve population monitoring efforts for species at risk, such as NARWs.

Systematic Map Effort of Using Small Unoccupied Aircraft Systems (sUAS) to Monitor Animals

Jared Elmore[1], Kristine Evans[1], Sathishkumar Samiappan[2], Meilun Zhou[2], Morgan Pfeiffer[3], Bradley Blackwell[3], and Raymond Iglay[1]

[1]Department of Wildlife, Fisheries & Aquaculture, Mississippi State University, MS; jae8908@gmail.com
[2]Geosystems Research Institute, Mississippi State University, MS
[3]USDA, APHIS, Wildlife Services, National Wildlife Research Center, Sandusky, OH

Small unoccupied aircraft systems (sUAS) are replacing or supplementing manned aircraft and ground-based surveys in animal monitoring with finer spatial and temporal resolutions, while improving access, safety, sampling efficiency, and logistics, as well as reducing costs, observer bias, and environmental impacts. Various sUAS models and sensors are available and usefulness depends on survey goals and design features such as target species, geographic scopes, flight conditions, and flight considerations. However, justification for selection of sUAS models and sensors are often unreported in published literature. Moreover, most existing sUAS reviews provide limited information regarding survey goals and design considerations, performance of sUAS model and sensor technology considerations among taxonomic groups, spatial distributions of sUAS applications, or reported technology pitfalls. Therefore, we conducted a systematic map to collect and consolidate evidence pertaining to sUAS monitoring of animals and investigate the current state of knowledge using an accurate, comprehensive, and repeatable methodology. We used standardized search terms to identify peer-reviewed and grey literature, dissertations, and theses using online databases, supplemented by literature provided by collaborators or found in Google Scholar and other public websites. We used a tiered approach to exclusion with eligible studies being those that monitor (i.e., identify, count, estimate) animals. We recorded and queried data pertaining to sUAS, sensors, animals, and methodology to produce tables, figures, and geographic maps. Our systematic map provides a useful synthesis of current applications of sUAS-animal related studies and identifies knowledge clusters and gaps that may influence future research directions and sUAS applications.

Advances in Drone Radio-Tracking Technology for Improved Wildlife Research, Management, and Conservation

Debbie Saunders* and Joshua Bobruk*
*Wildlife Drones, Australian National University; debbie@wildlifedrones.net

Radio-tracking is a well-established technique that is integral for many wildlife research, management and conservation programs. Given up to 70% of the world's wildlife are too small to track using GPS or satellite tags, Very High Frequency (VHF) radio-tracking remains a key technique for studying and understanding wildlife movements. However, traditional radio-tracking, whereby only one animal can be tracked at a time using a hand-held antenna from on the ground, is very labour intensive and time-consuming. This manual technique is often prohibitively difficult within rugged, remote and inaccessible areas, or when tracking small, highly mobile animals. However innovative drone-based radio-tracking technology now provides unprecedented capability to rapidly locate up to 40 tagged animals with unique tag frequencies simultaneously, wherever they move across vast landscapes. By creating a high point wherever the drone is launched, radio-tag signal detection is maximised, enabling researchers and land managers to collect more data, more often. This is achieved without needing to fly the drone close to the tagged animals, therefore minimising disturbance to both their natural behaviour and their habitats. In addition to rapidly locating tagged animals, mortality signals are also identified and flagged in real-time. This is of particular importance for threatened species captive release, translocation and survival studies, as well as invasive species and disease management programs, where rapidly locating and determining the fate of animals is of critical importance. The immediate identification of mortality signals, and the ability to locate these tags efficiently from the air, provides unprecedented capacity for rapid responses and active management by field teams on the ground. We provide examples of how this unique and rapidly advancing technology has been applied in wildlife research, management and conservation projects across the United States, Australia, New Zealand, and Vietnam.

Drone Type Impacts Detection Rate of Bats during Acoustic Surveys

Kayla N. Kuhlmann[1], Amelie Fontaine[1], Emile Brisson-Curadeau[1], David Bird[1], and Kyle H. Elliott[1]

[1]McGill University, Montreal, Quebec, Canada; nicole.kuhlmann@mail.mcgill.ca

A new way to survey wildlife populations may be possible with advancements in drones, or unoccupied aerial vehicles (UAVs), that render aerial technology more accessible and promote surveying in inapproachable habitats. While studies have focused on wildlife response to UAV trajectory or distance, it remains unclear how UAV sound or size influence wildlife. Thus, the objectives of this study address the viability of UAV use for wildlife research by comparing acoustic bat detections with and without the presence of three different UAV models. The results reveal that larger and louder UAVs deterred significantly more bats, and the smallest and quietest model had a bat detection rate similar to the control measurements. Drone noise was positively correlated with drone size, but drone size had little effect on the range of frequencies emitted. While detecting bats with small and quiet UAVs may be possible, complications still arise with acoustic detection and the species-specific effects of drone flight. Finally, the bats in this study did not habituate to drone flight, as the detection rate did not change during UAV operation. We urge wildlife researchers to consider drone size during bat acoustic surveys, and likely other wildlife surveys. Smaller and quieter models may have negligible impacts on wildlife.

An Autonomous Pest Bird Deterring System for Agriculture Using Unoccupied Aerial Vehicles

Zihao Wang[1], Daren Fahey[2], Andrea S. Griffin[3], Andrew Lucas[4], Gregory Chamitoff[1], and KC Wong[1]

[1]School of Aerospace, Mechanical and Mechatronic Engineering, The University of Sydney, NSW, Australia; zihao.wang@sydney.edu.au

[2]Orange Agricultural Institute, NSW Department of Primary Industries, NSW, Australia

[3]Animal Behaviour and Cognition Lab, Conservation Science Research Group, School of Psychology, University of Newcastle, Callaghan, NNSW, Australia

[4]Agent Oriented Software, Melbourne, Victoria, Australia

An autonomous pest bird deterring system for agriculture using unoccupied aerial vehicles (UAVs) is being developed. Damage to commercial crops caused by pest birds is a challenging global problem to solve due to the lack of a universally cost-effective bird deterring method. UAVs, or drones, are becoming commonplace in many everyday applications. They are also gaining popularity as tools for wildlife research. While the well-known ability of the UAVs to disturb wildlife is an issue for wildlife researchers, this issue can be exploited to deter pest birds. However, human operators are required to pilot the UAVs to deter the birds effectively, which makes cost-effectiveness challenging to achieve. In addition, birds may potentially habituate to simple UAV scaring, making these UAVs lose their effectiveness before crops are harvested. The proposed solution is an autonomous UAV system with fear-inducing elements that teach the pest birds that this UAV is the new predator. These elements include bird distress calls and a visual display of crow taxidermy hanging underneath the UAV. Furthermore, the UAVs are tethered to extend the endurance and make the system more deployable in various situation. Prototype of the UAV system was tested in vineyards, where the bird response was observed, and the efficacy was measured. The results from the field tests were used to develop trajectory planning algorithms and bird detection algorithms that may assist in the autonomous operation of the UAV. Field tests suggest the UAV system is an effective bird deterring tool with high crop protection efficacy comparable to netting. Simulation results indicate that trajectory planning algorithms can efficiently coordinate multiple tethered UAVs to deter pest birds from a 100-hectare crop field.

Classifying Wildlife from Aerial Imagery Using Deep Learning Neural Networks

Meilun Zhou[1] Jared Elmore[2], Morgan Pfeiffer[3], Bradley Blackwell[3], **Sathishkumar Samiappan**[1], Raymond Iglay[2], and Kristine Evans[2]

[1]Geosystems Research Institute, Mississippi State University, MS USA; sathish@gri.msstate.edu
[2]Department of Wildlife, Fisheries and Aquaculture, Mississippi State University, MS USA
[3]USDA, Wildlife Services, National Wildlife Research Center, Sandusky, OH USA

As small (<55 lbs) uncrewed aerial systems (UAS) become more prevalent for wildlife monitoring and management, effective methods of machine learning classification algorithms have also improved for processing the UAS imagery. High-resolution visible and thermal imagery obtained from UAS enables automated classification of wildlife. While traditional classifiers based on human engineered features have produced accurate classification of wildlife in the past, deep and deeper neural networks such as convolutional neural networks and residual neural networks can produce highly accurate classification with less human supervision. These networks can extract more features and improve upon existing classifiers. Deeper networks are especially useful for discerning wildlife from an aerial viewpoint such as those collected from a UAS as there are less features than classic image classification problems. In this work, we studied the efficacy of deep and deeper neural networks to classify four groups of wildlife (horse, cow, deer, geese) based on UAS imagery collected below a 400 ft altitude. We used a training step to feed aerial images of wildlife to learning models, and then a testing step to test the model on new images to evaluate model performance. This presentation will summarize the steps involved in UAS aerial image acquisition, outline the steps involved in preprocessing images, and development of the machine learning classifiers. We also discuss the results and findings from initial image tests and their application to current research endeavors.

Using Drones to Enhance Observations and Drive Outreach: A Case Study of an Overnight Winter Crow Roost in Lawrence, MA

Craig Gibson[1] and Will Bicks[2]

[1]Nuttall Ornithological Club, Cambridge, MA USA; cbgibson@comcast.net
[2]Rochester Institute of Technology, Rochester, NY USA

Over the last 15 years, Unoccupied Aircraft Systems (UASs) have advanced to such a degree that stable, high definition aerial photography and videography is available for use in citizen science projects. This presentation explores the utility of such systems for wildlife research by examining the methods utilized and results obtained from a multi-year citizen led project focused on observing a large overnight winter crow roost in Lawrence, Massachusetts. Our experiments explore how an aerial perspective, in combination with low light and infrared photography, can be utilized to count large numbers of densely packed roosting birds with increased accuracy. In contrast to existing methods, by conducting surveys once the birds have entered the roost for the night, our analysis shows that we are able to quantify the population with improved accuracy, allowing us to contribute data-backed counts to the Audubon's annual Christmas Bird Count. In addition, we have demonstrated these same aerial capabilities can be valuable tools in producing engaging photo and video content to drive outreach targeting local students, the community, and beyond.

UAV Meets AI: An Autonomous Egg-oiling Drone

Tim Shields[1] and William I. Boarman[2]

[1]Hardshell Labs, Joshua Tree, CA USA; t.shields@hardshelllabs.com
[2]Conservation Science Research and Consulting, Spring Valley, CA USA

Egg oiling via drone is becoming a standard tool for Common Raven (*Corvus corax*) management for both Mojave Desert Tortoise (*Gopherus agassizii*) and Greater Sage Grouse (*Centrocercus urophasianus*) conservation in California and Nevada. This includes nests found high in utility transmission towers and other artificial structures, as well as in cliff faces. As currently practiced, especially when raven nests are

in tower structures, it requires highly skilled, and consequently expensive, drone pilots. In an effort to reduce costs, expand the number of problem avian species treated and improve ease of operation our team (Hitron Technologies, Boardwalk Consulting Services, University of South Carolina and Hardshell Labs) under a contract with the Department of the Navy, is developing the Independent Remote Egg Oiling System (IREOS), a semi- or fully autonomous drone capable of independent navigation to a target nest for the treatment of eggs therein. This will require obstacle avoidance and the ability to recognize nests and to identify eggs of many different species, as well as positioning for oiling and the hardware necessary to accurately deliver that oil. We will describe the many technical challenges that confront us in this ambitious effort, including configuring the drone, acquisition of imagery of several species for training the image-object recognition programs needed, and integration of system components. The ultimate goal is a machine capable of relatively independent operation to facilitate the wider use of egg oiling as a management tool for problematic avian species and we will describe our path to that goal.

Using Unoccupied Aerial Systems to Manage Natural Resources in Complicated Landscapes with Dynamic Uses

Susan Cohen[1], **Troy Walton**[2], Tony Rodriguez[3], and Justin Ridge[4]

[1]Institute for the Environment, Univ. of North Carolina, Chapel Hill, NC USA; susanac@email.unc.edu
[2]Attollo LLC, New Bern, NC USA; Troy.Walton@attollouas.com
[3]Institute of Marine Science, Univ. of North Carolina, Chapel Hill, NC USA
[4]Duke Marine Robotics and Remote Sensing Lab, Duke University, Durham, NC USA

While flying on Department of Defense (DoD) lands can be complicated due to the multiple land uses and complex air space, small unoccupied aerial systems (sUAS) offer opportunities to anticipate and address a host of natural resource challenges. Coastal installations using sUAS can collect high-resolution measurements of the effects of coastal storms, shoreline erosion, and coastal wetland resilience. The application of this data can assist in managing critical habitats and wildlife species, while also providing information to land-use planning for future DoD training mission requirements. For natural resource managers charged with managing prescribed fires, sUAS provide the advantage of both real-time, situational awareness to monitor fire infrastructure (e.g. fire lines, escape routes, flaming front) and fire crews, as well as post-fire surveillance for hot spots and excessive smolder, and finally of mapping post-fire effectiveness, severity, and recovery. High resolution habitat information and real-time and/or rapid assessment of events are often difficult to achieve on the ground due to safety concerns, lack of access, and/or the large spatial scale of affected areas. Employing remotely-sensed data is the solution; however, traditional sensor platforms, such as satellites and airplanes, are often not well suited for these tasks because they are expensive, require significant coordination efforts, and may not be available during critical event periods. The same techniques that are employed for the above efforts can be broadly applied to a host of additional uses from monitoring logging and forestry site preparation efforts to monitoring coastal shorelines for loggerhead sea turtle crawls. The pathway for an organization to realize benefits from sUAS can be obstructed by real and perceived safety and capability concerns. For large organizations like DoD, with a unique set of drivers, a structured approach to adopting sUAS technology ensures a baseline of competencies, skills, and capabilities.

Use of sUAS and UAS to Monitor Nesting Golden Eagles

Robbie Knight[1] and Renee Parker[2]

[1]U.S. Army Dugway Proving Ground, Natural Resource Program, Dugway, UT USA; robert.n.knight.civ@mail.mil
[2]Select Engineering Services, Utah USA

The U.S. Army, Dugway Proving Ground (DPG) hosted an Environmental Security Technology Certification Program project to demonstrate the use of small unoccupied aircraft systems (sUAS) and military UAS to monitor golden eagle (*Aquila chrysaetos*) nesting. Located in Utah, DPG is a U.S. Department of Defense (DoD) test site for chemical and biological defensive testing; it is also home to

multiple breeding pairs of golden eagles. As the presence of an eagle nest has the potential to stop military testing and training due to potential nest disturbance, it is vital to DoD installations to fully understand the location and status of active eagle nests on their lands. The demonstration was to evaluate the use of sUAS and UAS, to obtain accurate locations and status updates of eagle nests on DoD lands more efficiently than can be accomplished on foot. To test this new technology, a blind study was developed which included conducting weekly golden eagle nest surveys on DPG during the 2019 and 2020 nesting seasons to compare the effectiveness of three survey systems: 1) ground-based human observer, 2) commercially available sUAS, and 3) military-grade UAS platform. During our pilot season, the sUAS observation team proved most efficient at locating active and previously unknown nests. The UAS team was the most efficient observer of nest status, completing visits in less than 10 minutes on average. Results differed significantly during the 2020 nesting season owing to changes in both the sUAS and UAS platforms and payloads. In 2020, the sUAS team struggled to locate nests or identify status due to a downgrade in payload resolution. The UAS team saw an increase in its effectiveness with a new high definition payload. Both sUAS and UAS platforms demonstrated promise as potential tools for monitoring nesting raptors effectively and efficiently while supporting the military mission.

Un-crewed aerial vehicle population survey of three sympatrically breeding seabird species at Signy Island, South Orkney Islands

M.J. Dunn*, S. Adlard*, A.P. Taylor*, A.G. Wood*, P.N. Trathan*, and N. Ratcliffe*

*British Antarctic Survey, Natural Environment Research Council, Cambridge, UK; mdunn@bas.ac.uk

Surveying seabirds in polar latitudes can be challenging due to sparse human populations, lack of infrastructure and the risk of disturbance to wildlife or damage to habitats. Counting populations using un-crewed aerial vehicles (UAVs) is a promising approach to overcoming these difficulties. However, careful validation of the approach is needed to ensure comparability with counts collected using conventional methods. Here, we report on surveys of three Antarctic bird species breeding on Signy Island, South Orkney Islands; chinstrap (*Pygoscelis antarctica*) and gentoo (*Pygoscelis papua*) penguins, and the South Georgia shag (*Leucocarbo atriceps georgianus*). We show that images from low-altitude UAV surveys have sufficient resolution to allow separation of chinstrap penguins from contiguously breeding Adélie penguins (*Pygoscelis adéliae*), which are very similar in appearance when viewed from overhead. We compare data from ground counts with manual counts of nesting birds on images collected simultaneously by low-altitude aerial photography from multirotor UAVs at the same colonies. Results at this long-term monitoring site confirmed a continued population decline for chinstrap penguins and increasing gentoo penguin population. Although both methods provided breeding pair counts that were generally within ~5%, there were significant differences at some locations. We examine these differences in order to highlight potential biases or methodological constraints that should be considered when analysing similar aerial census surveys and comparing them with ground counts.