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Applying UAV Systems in Wildlife Management

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ABSTRACT: Use of UAVs (unmanned aerial vehicles) in wildlife applications has been increasing in recent years as system costs have come down and regulations regarding their use have become more well-defined. Medium and larger UAVs can accommodate sophisticated payloads, allowing for missions using LIDAR to obtain measurements of vegetation height and fine-scale elevation data; high resolution video and thermal imaging for surveying wildlife; remote spraying for control of exotic plants; and broadcasting audio calls for hazing wildlife at oil spills. We have been developing some additional capabilities for potential use in wildlife research. The first is using UAV platforms as a means to remotely deliver anesthetic darts into larger wildlife species. This capability would allow for anesthetizing free-ranging deer, elk, bison, moose, etc. without the restriction of being close enough to use traditional rifle-based darting. Other drugs that could be delivered include those for immunocontraception and disease inoculation. We are also developing a drone-based remote net launcher system to allow for capture of both birds and mammals. Use of UAVs to aid in wildlife management activities that previously required more expensive aerial assets (e.g., airplanes or helicopters) or were not possible due to other restrictions, may allow managers to be more efficient and expand capabilities beyond what are currently available.

KEY WORDS: aerial surveys, drone, LIDAR, thermal imaging, UAV, wildlife surveys

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INTRODUCTION

The use of unmanned aerial vehicles (hereafter UAVs or drones), both recreationally and commercially, has greatly increased in popularity within the past decade. This is likely a result of drone manufacturers having more platforms available to cover a wide range of consumer needs, and drone users discovering the advantages of using these platforms for a variety of commercial applications (e.g., real estate, law enforcement, agriculture). Additionally, UAVs have become increasingly affordable, especially for the relatively basic platforms (i.e., small lightweight quadcopter with an HD camera). This increase in popularity is also supported by the number of peer-reviewed articles being published within the past few years (reviewed in Chabot 2018).

Most drones fall into one of two different design categories: either a fixed wing or rotary-style configuration (Sandbrook 2015). Fixed-wing UAVs are similar in appearance to an airplane whereas the rotary-style UAVs can have a variety of configurations (e.g., quad- or octo-copter) with a platform that generally resembles that of a helicopter with rotating blades allowing the UAV to hover. Both platforms have their advantages and disadvantages, although rotary-style designs have seemingly become the more popular choice for wildlife operations over the past few years (e.g., Goebel et al. 2015, Hodgson et al. 2016, Bushaw et al. 2019).

Advantages

Using drones to assist in wildlife conservation has numerous advantages for wildlife biologists. One of the most important considerations is that using UAVs can reduce risk of injury and death, as conducting surveys from airplanes or helicopters is one of the leading causes of death for biologists in the field (Sasse 2003). Another advantage is that UAVs are highly versatile. For example, a drone could be used to conduct a survey with an HD camera and later be equipped with a piece of specialized equipment for a different purpose (e.g., a spraying device). Most commercially available drones are also relatively easy to operate using the joysticks on a remote control or directly from a smartphone. However, some drones also have the option for conducting flights using pre-programmed waypoints, which is especially useful if the drone operator is not comfortable flying a survey route using the controller or if flying more precise transect routes is required. Lastly, most UAVs are smaller and quieter than manned aircraft, and therefore provide a relatively non-invasive method for conducting wildlife surveys compared to manned aircraft (reviewed in Christie et al. 2016).

Considerations

As with all new technology, UAVs have certain limitations, both legal and technological, that should be understood prior to their application. The Federal Aviation Administration (FAA) has developed regulations specific to the use of small UAVs (i.e., under 55 lbs) in commercial applications (14 CFR Part 107). Some of the regulations that we consider noteworthy to wildlife applications are that the drone 1) cannot be operated from a moving vehicle, 2) must remain in visual line-of-sight, and 3) must be flown during daylight hours. The FAA will grant waivers to these regulations, but the drone operator must apply for a certificate of waiver and the FAA must find that the drone operation can be safely performed under the terms of that waiver. The FAA also requires drone pilots to take and pass a remote pilot operator exam for all commercial operation of small UAVs.

In addition to legal restrictions, probably the most technologically restrictive component of UAVs is their flight time. The batteries of most small UAVs allow for an average of 15-20 minutes of flight time (Goebel et al. 2015, Bushaw et al. 2019). Flight time is further diminished by increasing the weight of the drone through attachment of payloads (e.g., large cameras). Therefore, for long duration UAV missions, an operator may need to plan their route to include a stop at "home" to exchange batteries. The future of UAV technology may allow for longer flight times as recent advancements have resulted in a "hybrid" UAV design that incorporates a gas-powered generator onto the UAV platform. These hybrid UAVs are larger and heavier because of the added weight of the generator, but they have estimated flight times of nearly four hours (e.g., https://www.harrisaerial.com/carrier-h4-hybrid-drone/).

Drones are also more susceptible to inclement weather than manned aircraft. As drones are powered by electricity and their circuitry is often not weatherproof, even a light mist could cause the drone to malfunction. Additionally, winds may blow drones off course and cause collisions if the operator is not cautious of their flight environment. The operator should also take into consideration the potential for wind speed to vary at the drone's altitude compared to ground level. Windy conditions can also affect video quality; thus, many drones utilize a gimbal to provide shock absorbency and stabilize the camera in flight. A gimbal is essential for conducting wildlife surveys as it allows collection of high-quality video footage under most conditions. Generally, drones used for wildlife surveys are equipped with a video transmitter/receiver that provide real-time video to the drone operator or ground crew and can also record video directly to a storage disk (e.g., micro-SD card) so the footage can be reviewed later for more careful evaluation.

APPLICATIONS

Aerial Surveys

The wildlife conservation field has identified numerous applications where drones can provide an advantage over traditional methodologies (reviewed in Chabot and Bird 2015). The most frequently documented use of drones in wildlife conservation is conducting aerial surveys using high-resolution cameras and on-board GPS units to provide georeferenced census data (reviewed in Linchant et al. 2015, Chabot and Bird 2015). These drone-based wildlife surveys have been utilized to obtain data on a wide range of taxa, for example: colonies of nesting seabirds (Sardà-Palomera et al. 2012, Hodgson et al. 2016), penguins (Goebel et al. 2015), nests of raptor species (Junda et al. 2015), and large mammals such as bison (*Bison bison*; Watts et al. 2010) or elk (*Cervus canadensis*; R. Jacobs, pers. commun.). The utility of UAVs for pest management is largely undocumented, but aerial surveys could provide valuable information for tasks such as locating and identifying sign of nutria (*Myocastor coypus*) or feral swine (*Sus scrofa*) to help control their spread.

Thermal Imaging

The next most frequent use of drones in wildlife conservation involves the use of thermal imaging equipment. Studies using UAV-based thermal imaging range from surveying for cryptic wildlife species to locating nests of songbirds (e.g., Israel 2011, Bushaw et al. 2019, Scholten et al. 2019). As with other applications using thermal imaging cameras, the best results are found on cool days, early mornings, or at night when there is the greatest contrast between the external temperature of the animal its immediate environment. Recent advances in thermal imaging technology, in addition to the increased popularity of UAVs, have prompted manufacturers of thermal imaging technology (e.g., FLIR Systems, Inc., Wilsonville, OR) to develop a system specifically designed for use on UAVs. The FLIR Vue® thermal camera allowed fairly seamless integration onto many UAV platforms and their updated DuoPro R® pairs one of their thermal imaging cameras with a high definition 4K resolution camera. There are multiple advantages with using this dual-camera approach: 1) picture-in-picture capability allows viewing of video from both the 4K and thermal camera simultaneously providing ease of inspecting heat signatures detected on the thermal camera with the 4K video to identify the source of the temperature contrast, 2) software for this camera allows use of a multi-spectral dynamic imaging (MSX) overlay to provide definition to objects observed on the thermal video by embossing detail from the 4K video onto the thermal display, and 3) a customizable isotherm that can constrain the thermal camera to only display heat signatures that appear within a selected range of temperatures.

The usefulness of thermal imaging equipment may be dictated by how close you can get to the target species and the quality/resolution of the thermal camera. High resolution (i.e., 640 × 512 pixels) cameras will allow for detection at longer distances but are more expensive than the mid- and low- resolution cameras (336 × 256 and 160 × 120 pixels, respectively). Thermal cameras are equipped with a fixed focal length lens which means the camera's view is adjusted only by changing the altitude at which the drone is flying. For example, a FLIR Duo Pro R with a 336 × 256-pixel resolution fitted with a nine mm lens provides a 35° field of view (FOV), whereas a 19 mm lens would provide a 17° FOV. Thermal imaging equipment has other inherent limitations, such as the inability to detect animals if their heat signature is blocked (i.e., through heavy vegetation and dense canopy cover) and false positives associated with warm objects on the landscape (e.g., rocks heated by the sun), but these are not necessarily unique to UAV applications (Butler et al. 2006, McCafferty 2013).

Other Applications

In addition to using UAVs to conduct aerial surveys, various types of instrumentation have been adapted for use in drone applications. For example, attachment of Light Detection and Ranging (LiDAR) equipment to drones has allowed surveyors to create detailed maps of vegetation/tree heights, obtain high-resolution topography data to create digital elevation models, and develop accurate maps depicting canopy cover (e.g., Chisholm et al. 2013, Wallace et al. 2014). Another example of instrumentation adapted for UAV technology is the use of spraying devices to remotely administer herbicides to noxious weeds (Harris Aerial has an example of this type of device on their website: https://www.harrisaerial.com/carrier-hx8-sprayer/). This application was developed primarily for agricultural uses but may also be beneficial in managing habitat for wildlife species. Another type of spraying device has been developed for use on drones to remotely oil eggs of pest bird species (e.g., birds nesting on power poles or in aircraft hangars) (Shields et al. 2019). Historically, removal of these nests or oiling of eggs required climbing to the nest; this innovative use of UAVs may reduce unnecessary risk to pest removal specialists.

At the Institute for Wildlife Studies (IWS), we are developing and testing additional innovative applications for use on UAVs. The first of these is a loudspeaker fitted with an amplifier as a hazing device to deter wildlife from areas such as an active oil spill. The speaker volume and sound that is being broadcasted can be controlled remotely by the pilot or another person on the ground crew. The sound could be in the form of predatory bird calls, people talking/yelling, or just a song that is blasted at high volume. As the speaker is mounted to a drone, it would act as both a visual and auditory deterrent. We have not field tested this equipment to evaluate the reactions of wildlife; however, we believe it will be an effective tool to complement current hazing techniques in certain situations (i.e., non-restricted airspace).

IWS has also developed a dart-launching system for remote delivery of anesthetics, vaccinations, or immunocontraceptives. The design uses pressurized CO_2 to launch the dart at targets directly beneath the drone. Similar to a CO_2-powered dart rifle, the force of gas propulsion increases the probability the dart will pierce the skin of larger mammals, and this added force helps overcome the propwash from the drone that might otherwise force the dart off-course. We mounted an additional camera to the drone that is in a fixed position to allow for aiming the dart. Our future directions for the dart launcher system involve 1) testing dart launching capabilities at various altitudes to determine how close we need to get to the target animal to administer the dart, 2) mounting the dart launcher using a gimbal so that the launcher will remain stable while targeting an animal, 3) fixing a camera directly to the dart launcher to improve accuracy and allow for fine tuning, 4) navigating the permitting process for FAA and state fish and wildlife departments to allow field testing of this system on wildlife, and 5) developing a gatling-style configuration to provide multiple opportunities to dart animals during a single flight [e.g., administering immunocontraceptives to a group of feral horses (*Equus caballus*)].

Finally, IWS is developing two different sizes of net launchers that can be remotely fired from a drone. The smaller sized net launcher is a commercially available design (www.net-gun.com) that has been mounted to one of our UAVs and can be remotely fired when the drone is over the target. This drone-mounted launcher would provide biologists with an additional tool to capture animals that cannot be approached close enough on foot to capture with a hand or throw net [e.g., pronghorn (*Antilocapra americana*) fawns or oiled birds on a beach]. The larger net launcher is still in the early design stages, as the FAA's 55 lbs weight limitation on small UAVs prohibited attaching this launcher to our largest drone. With advancements being made in the lift capacity of smaller drones, we hope to proceed with development of this larger net launcher on a smaller drone to ensure the takeoff weight of the drone remains below 55 lbs. This larger net launcher would be useful in capturing larger animals such as elk calves.

CONCLUSIONS

As the popularity of drones continues to increase, we expect that applications for their use in wildlife conservation will continue to expand. It should be noted, however, that although drones provide a novel and exciting method for surveying wildlife, we need to remain cognizant of the impact of disturbance to both wildlife (reviewed in Hodgson and Koh 2016) and recreationists enjoying the same landscapes. While UAVs may be considerably smaller and quieter than manned aircraft, wildlife species have been shown to have a physiological response to the presence of a drone overhead, even when a behavioral response is minimal or not detected (Ditmer et al. 2015, Mulero-Pázmány et al. 2017, Bennitt et al. 2019), although some research suggests that bears (*Ursus americanus*) can become habituated to drone disturbance (Ditmer et al. 2018). Consequently, pilots should attempt to fly at altitudes below the legal requirement for small UAVs, but as high as possible to minimize stress to wildlife while still obtaining the data needed to complete the survey.

Additionally, outdoor enthusiasts may not be thrilled with drones flying overhead on public lands when they are there to see and hear the beauty of nature. If a survey needs to be conducted in an area where recreationists are expected, attempts should be made to plan flights around heavy visitor traffic hours and keep flights as short as possible. Or, if flying over an area with very few visitors, be respectful of others present and either wait until they are out of sight or approach them and inform them of your intent to conduct a survey.

Overall, drones have shown promise to be a great tool for wildlife conservation, and if used appropriately can continue to further research in this field. Happy flying!

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