eco.mont – Volume 9, Number 1, January 2017
ISSN 2073-106X print version – ISSN 2073-1558 online version: http://epub.oeaw.ac.at/eco.mont
https://dx.doi.org/10.1553/eco.mont-9-1s30

Using drones as a monitoring tool to detect evidence of winter sports activities in a protected mountain area

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Keywords: Unmanned Aerial Vehicle, drone, capercaillie, snowshoe, ski touring, winter, monitoring, UNESCO Biosphere Reserve Entlebuch

Abstract

The capercaillie (*Tetrao urogallus*) is a mountain grouse species listed in the Red Lists of Switzerland and other countries of Europe. As a consequence of its conservation status, human activities are restricted in most of its remaining habitats. One sub-population of the capercaillie is located in the Entlebuch UNESCO Biosphere Reserve. The margins of one of its territories are increasingly used by snowshoe hikers and ski tourers at the capercaillie's most vulnerable time, during winter. In order to identify and monitor possible interferences, we tested whether drones can help to detect snowshoe and ski tourer tracks in the winter landscape and whether there is any reaction of wildlife to the drones. Results indicate that certain environmental conditions are needed to carry out accurate drone flights, but that with optimal technical and aeronautical settings, it is possible to gain aerial images that allow winter activities by humans to be identified, and even quantified. No disturbances to wildlife were identified. The findings indicate that drones can be used as a low-cost monitoring tool for detecting human winter activities in remote places, which represent a fast-growing threat to wildlife in mountain areas.

Profile

Protected area

UNESCO BR Entlebuch

Mountain range

Alps

Country

Switzerland

Introduction

Human disturbances and habitat fragmentation are major drivers for the loss of wildlife across the world (Ewers & Didham 2006; Salafsky et al. 2008). One species that is extremely fragile to human disturbances is the capercaillie (*Tetrao urogallus*), a mountain forest grouse species with declining populations throughout Europe (Storch 2007). In Alpine systems, the habitats of the capercaillie are increasingly used in wintertime by ski tourers and snowshoe hikers (Coppes & Braunisch 2013; Rupf et al. 2011), representing a major source of disturbance for capercaillies at their most vulnerable time of year (Arlettaz et al. 2007; Braunisch et al. 2011). To reduce these disturbances to acceptable levels, orchestrated efforts are needed, e.g. identifying and marking sensitive areas, distributing information or hiring rangers. However, investigations about how and where such actions are needed and effective are largely missing because they are time-consuming and costly (Immoos & Hunziker 2015). Drones (Unmanned Aerial Vehicles) could be an innovative tool in overcoming these problems. In recent years, they have proven good tools for monitoring large sensitive areas in a low-cost manner (Jones et al. 2006; Weissensteiner et al. 2015). The impact on wildlife from drone flights is, furthermore, reported to be quite low (Ditmer et al. 2015; Sarda-Palomera et al. 2012; Vas et al. 2015).

In order to assess whether drones can be used to map human winter activities in protected mountainous areas, we investigated: (1) which technical, aeronautical and environmental conditions allow accurate drone flights for detecting tracks of snowshoe hikers and ski tourers quantitatively and qualitatively, and (2), whether there are any visible reactions by wildlife that would indicate a disturbing effect of drones. These questions were addressed in a case study within the Entlebuch UNESCO Biosphere Reserve (EBR), which is home to remnant sub-populations of capercaillie, one of which is surrounded by an area that is frequented increasingly by winter tourists. Hence, the last question of interest was: (3) are snowshoe hikers and ski tourers in the case study region disturbing the capercaillie in its territory?

Figure 1 – The equipment used: Maja-D drone, a laptop containing a telemetry link as ground station, and the remote control. © S. Weber

Material and methods

The flights with a fixed-wing Maja-D drone (Bormatec Inc., 180 cm wingspan, Figure 1) were carried

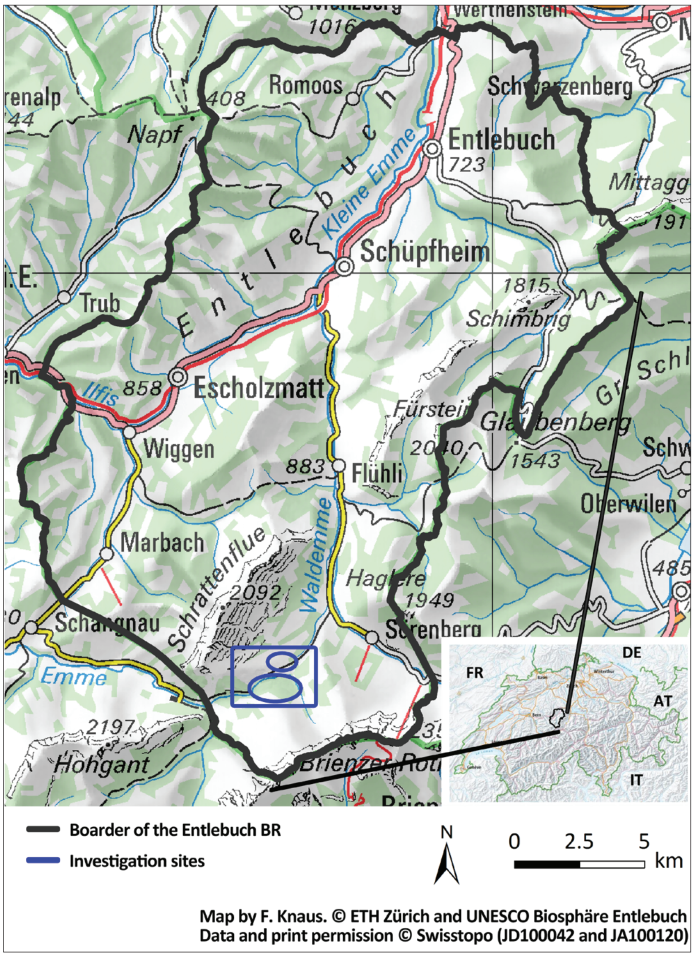

Figure 2 – Map of the Entlebuch UNESCO Biosphere Reserve.

out fully autonomously using the program Mission Planner (ArduPilot 2016), which allows the programming of an accurate flight path prior to the flight. During the flight, the drone was linked by telemetry to a laptop to monitor the flight and to make corrections to the flight path. In addition, it remained permanently linked to the manual remote control and was kept within sight distance at all time (a legal obligation in Switzerland). For safety and wildlife conservation reasons, it never flew below 50 m from the surface (including vegetation and other objects). An SX260HS camera (Canon Inc.) was installed in the fuselage of the drone to take images vertically downwards without a zoom. The camera software was modified with an intervallometer script to allow interval images every two seconds (DroneMapper 2015). A GoPro 3 camera (GoPro Inc.), with a downward tilt, was attached to the nose of the drone in order to film possible movements of wildlife in the direction of flight.

The flights were conducted in the EBR, in the Central Alps of Switzerland (Figure 2), during the winter months January to March 2016, always one or two days after fresh snowfall. The first study phase took place around *Wagliseichnubel*, a small hill at approximately 1400 m a.s.l. without protection status that is crossed by several snowshoe trails. On seven days, 12 flights were conducted to determine the environmental conditions, and the aeronautical and technical aspects necessary for accurate drone flights and optimal image quality. After determining the best settings, 10 flights were executed during five days at the second test site, *Laubersmadghack*, at approximately 1 350 m a.s.l. This site includes a strictly protected area where capercaillie are found, which is surrounded by official snowshoe trails. The site was chosen for the practical tests because it offers a typical setting for winter activities in a vulnerable area, is easily accessible, and is frequented by many snowshoe hikers.

In order to locate the snowshoe hikers' tracks, the images were first assessed individually with Windows Photo-Viewer, which allowed the deletion of diffuse images and produced information on how to best detect the tracks. Later, the images obtained from the regular flight grid were joined to Orthomosaics with Pix4Dmapper (Version 3.2.1, Pix4D SA) and ArcGis (Version 10.3.1, Esri Inc.). As a middle way between single photographs and Orthomosaic images, Photoshop (Version 12.0, Adobe Systems Inc.) was used to manually combine pictures. To estimate the number of snowshoe hikers having used a track, we produced snowshoe traces of our own, walking 1 to 20 times in each track. These tracks were used as calibrations and were compared with the tracks on the other pictures.

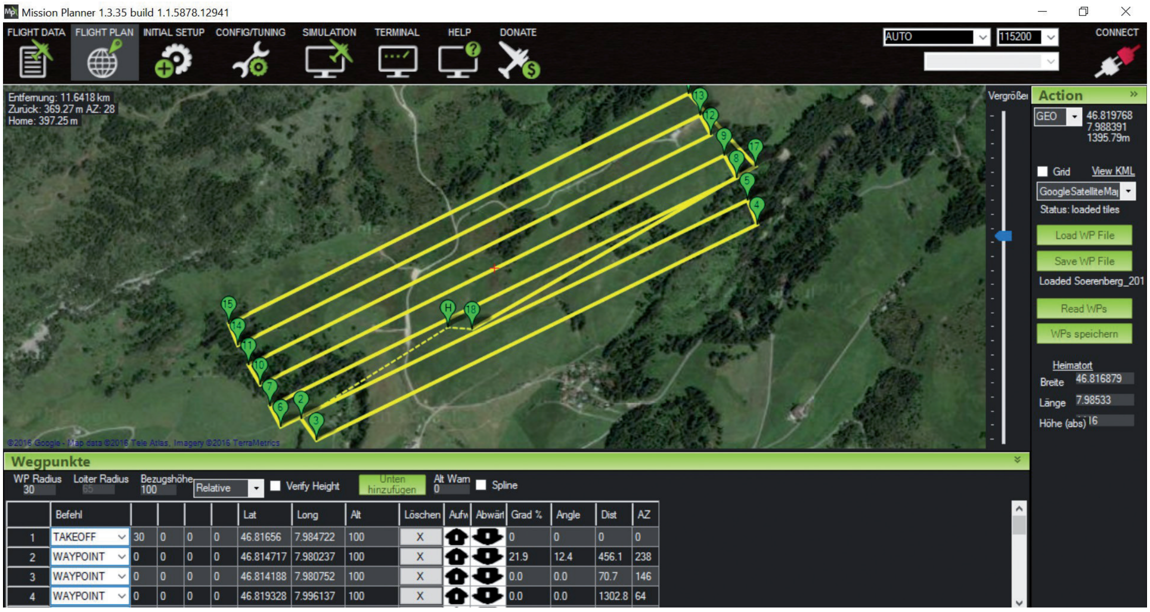

Figure 3 – Programmed flight grid over Wagliseichnubel. The flight height was about 100 m above ground and the transect lines were approximately 100m apart. © S. Weber

Results

Environmental conditions

The weather conditions played a crucial role for accurate drone flights. The biggest problems were caused by wind: once the average wind speed is over 8 km / h or if the wind gusts, the drone cannot be flown safely and the resulting pictures are blurred. These problems were also encountered in thermal lifts, as are typical in mountainous areas: when crossing ledges and hilltops, the drone frequently had problems flying steadily. Cloud cover was not particularly problematic. Only when it was raining, snowing or foggy could the drone not be flown. However, the lower visibility in cloudy weather conditions limited the maximum working range of the drone because of the legal requirement to keep eye-contact. For aerial photographs, only deep and repeatedly used tracks could be identified if clouds were present.

During the flights, the temperature was at times below 0°C (down to −8°C). These low temperatures caused some problems with the wireless connection between drone and laptop, which reduced the ability to control the flight. Where times of day are concerned, the time around noon, when the sun was at its highest, gave the sharpest pictures. For clearly visible tracks, the snow had to be powdery or wet. In slightly frozen snowpack, the tracks were less obvious. Another limiting factor were the requirements for take-off and landing points, which must be without trees or other higher objects (e. g. power lines) in the immediate vicinity. Moreover, the radio link to the drone should not be interrupted by any object in a direct line between the remote control and the drone, and the person controlling the drone should have a clear view of the whole flight area for the duration of the flight. For the landing, it is important that the ground is flat and uniform, which is often the case in snow-covered areas.

Aeronautical and technical aspects

An airspeed of 40 km / h has proven optimal for flying relatively long distances, for correcting disturbances caused by wind, and for obtaining sharp images. The most efficient way to cover large areas was by using parallel transects around 100 m apart and flying at an altitude of about 100 m above the ground (Figure 3). To allow for the manoeuvring of the drone, the flight grid has to extend slightly beyond the study area.

Feasibility of detecting tracks

Tracks of snowshoe hikers and ski tourers were clearly visible in most pictures (Figure 4). The photographs from the experiment using self-made tracks were of sufficiently good quality for use as calibrations for classifying the tracks found into quantity categories (1–2x, 3–5x, 6–10x, >10x). However, combining hundreds of pictures into one full GIS raster layer was time-consuming as the flight GPS positions were not very accurate, and hence the individual images did not overlap exactly. Using the most exact GPS signal for the drone and / or the camera is essential to obtain results that can be easily transferred to geodata.

Human activities and wildlife reactions detected

At the first test site, 80–90% of the tracks followed the official trails. The traces not following the marked routes originated mostly from ski tourers using different paths. We estimated that around 50 people per day use the trails. At the second test site, no trespassing into the restricted zone was observed. However, some tracks that deviated slightly from the official route were detected (Figure 5). We estimate that around 30

Figure 4 – Tracks from snowshoe hikers photographed from a flight altitude of about 100 m. © S. Weber

people per day use the official route. Considering the length of the route and the number of tracks left in the snow, those deviating from the official route represent only rare cases.

Reactions of wildlife to the drone flights were not observed at any time. No wild animals at all were seen in the images and videos, although it is known that the area contains many wildlife species (including ungulates). It seems that they were not disturbed by the drone.

Discussion

The results of this study indicate that drones can be used for monitoring conservation efforts in mountain areas during winter. They have proven to generate comprehensive data at high spatial resolution with low operational costs (Jones et al. 2006). However, in order for this tool to be superior to conventional methods like fieldwork on foot, it is a precondition that there should be no, or only very little, disturbance to wildlife. In this study, no wildlife movements were observed and hence disturbance was considered low, a finding that has been observed in other contexts (Ditmer et al. 2015; Sarda-Palomera et al. 2012; Vas et al. 2015). To draw a general conclusion from this result, however, would be risky as it is known that the aeronautical settings of the flights are critical. Bears, for example, show some physiological reaction to close flights (Ditmer et al. 2015). Given that flying 50 to 100 m above vegetation delivered useful data, we are confident that this flight altitude can be used successfully for flights in winter landscapes. By this means, tracks from snowshoe hikers and ski tourers can be detected and roughly quantified in areas that are not easily accessible on foot or should generally be left undisturbed. Equipped with more capable sensors than a standard camera, the drone could provide pictures with higher resolution, and hence could be flown at higher, even less disturbing, flight altitudes. Drones do, however, also offer inconveniences. As shown in this study and other similar studies (Anderson & Gaston 2013; Christie et al. 2016), drones generally have a low flight endurance, are sensitive to high wind speeds, and cannot be flown in bad weather. Other types of drones (e.g. Multicopters) could relieve some of these problems, but they would be restricted to smaller investigation areas due to their higher electricity consumption.

This case study covered only a small study area in which winter trails are waymarked and information

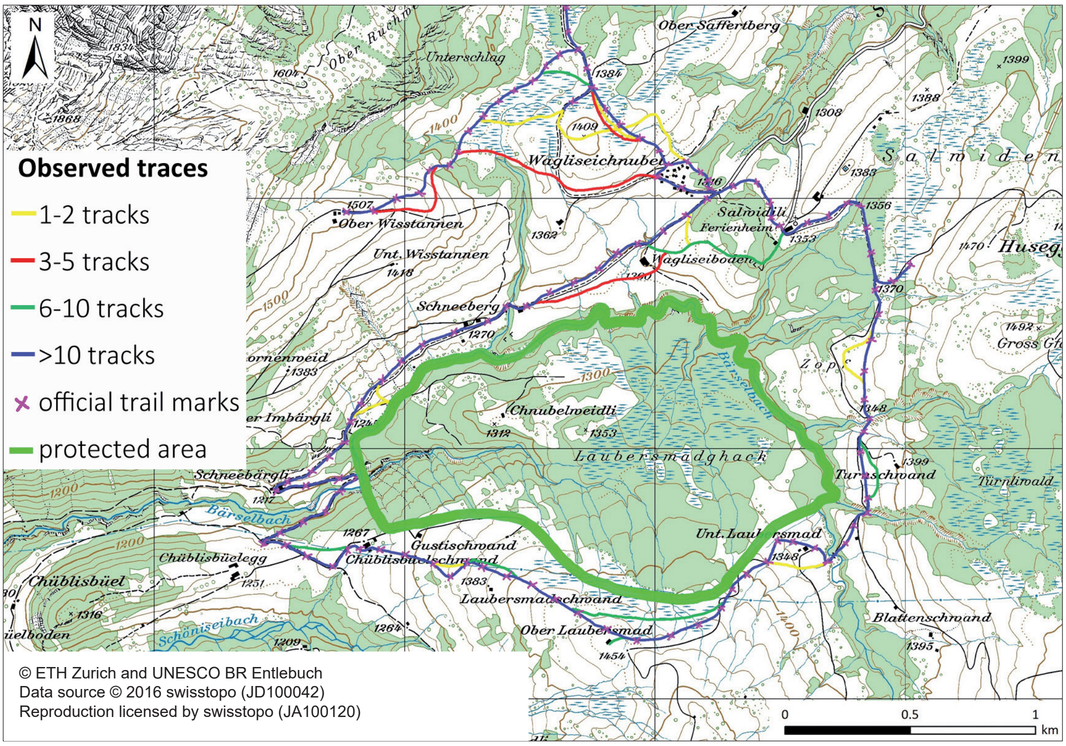

Figure 5 – Winter tracks of snowshoe hikers and ski tourers around the strictly protected capercaillie area.

about sensitive species is provided to snowshoe hikers. The results indicate that these measures offer an appropriate way to manage visitor flow in winter, confirming the results of Freuler and Hunziker (2007). Expanding the drone flight area would help EBR managers to identify other problematic zones of human-capercaillie encounter and to monitor the success of any future measures, thus constituting a further step towards true evidence-based management.

Conclusion

Drones provide a promising monitoring tool for the management of protected mountain areas in winter. They can cover large areas and allow tracks of snowshoe hikers and ski tourers to be detected using flight altitudes that are sufficiently high not to disturb wildlife. For visitor flow management in winter, way-marking trails and providing information about disturbance effects are a successful way to keep snowshoe walkers and ski tourers away from sensitive capercaillie habitats. For the long-term survival of the whole sub-population, management and monitoring measures should be expanded over larger areas.

References

Anderson, K. & K.J. Gaston 2013. Lightweight unmanned aerial vehicles will revolutionize spatial ecology. *Frontiers in Ecology and the Environment* 1(3): 138–146.

ArduPilot 2016. Mission Planner Overview. Available at: http://ardupilot.org/planner/docs/mission-planner-overview.html (accessed: 16.06.2016)

Arlettaz, R., P. Patthey, M. Baltic, T. Leu, M. Schaub, R. Palme & S. Jenni-Eiermann 2007. Spreading free-riding snow sports represent a novel serious threat for wildlife. *Proceedings of the Royal Society B: Biological Sciences* 274(1614): 1219–1224.

Braunisch, V., P. Patthey & R.L. Arlettaz 2011. Spatially explicit modeling of conflict zones between wildlife and snow sports: prioritizing areas for winter refuges. *Ecological Applications* 21(3): 955–967

Christie, K.S., S.L. Gilbert, C.L. Brown, M. Hatfield & L. Hanson 2016. Unmanned aircraft systems in wildlife research: current and future applications of a transformative technology. *Frontiers in Ecology and the Environment* 14(5): 242–252.

Coppes, J. & V. Braunisch 2013. Managing visitors in nature areas: where do they leave the trails? A spatial model. *Wildlife Biology* 19(1): 1–11

Ditmer, M.A., J.B. Vincent, L.K. Werden, J.C. Tanner, T.G. Laske, P.A. Iaizzo, D.L. Garshelis & J.R. Fieberg 2015. Bears Show a Physiological but Limited Behavioral Response to Unmanned Aerial Vehicles. *Current Biology* 25(17): 2278–2283.

DroneMapper 2015. CHDK for Canon SX260HS.

Ewers, R.M. & R.K. Didham 2006. Confounding factors in the detection of species responses to habitat fragmentation. *Biological Reviews* 81(1): 117–142.

Freuler, B. & M. Hunziker 2007. Recreation activities in protected areas: bridging the gap between the attitudes and behaviour of snowshoe walkers. *Forest Snow and Landscape Research* 81(1/2): 191–206.

Immoos, U. & M. Hunziker 2015. The effect of communicative and on-site measures on the behaviour of winter sports participants within protected mountain areas – results of a field experiment. *eco.mont* 7(1): 17–25.

Jones, G.P., L.G. Pearlstine & H.F. Percival 2006. An assessment of small unmanned aerial vehicles for wildlife research. *Wildlife Society Bulletin* 34(3): 750–758

Rupf, R., M. Wyttenbach, D. Kochli, M. Hediger, S. Lauber, P. Ochsner & R. Graf 2011. Assessing the spatio-temporal pattern of winter sports activities to minimize disturbance in capercaillie habitats. *eco.mont* 3(2): 23–32

Salafsky, N., D. Salzer, A.J. Stattersfield, C. Hilton-Taylor, R. Neugarten, S.H.M. Butchart, B. Collen, N. Cox, L.L. Master, S. O'Connor & D. Wilkie 2008. A standard lexicon for biodiversity conservation: Unified classifications of threats and actions. *Conservation Biology* 22: 897–911

Sarda-Palomera, F., G. Bota, C. Vinolo, O. Pallares, V. Sazatornil, L. Brotons, S. Gomariz & F. Sarda 2012. Fine-scale bird monitoring from light unmanned aircraft systems. *Ibis* 154(1): 177–183.

Storch, I. 2007. Conservation status of grouse worldwide: an update. *Wildlife Biology* 13: 5–12.

Vas, E., A. Lescroel, O. Duriez, G. Boguszewski & D. Gremillet 2015. Approaching birds with drones: first experiments and ethical guidelines. *Biology Letters* 11(2): 1–4

Weissensteiner, M.H., J.W. Poelstra & J.B.W. Wolf 2015. Low-budget ready-to-fly unmanned aerial vehicles: an effective tool for evaluating the nesting status of canopy-breeding bird species. *Journal of Avian Biology* 46(4): 425–430.

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