Editing example – changes visible

1 Introduction

Conservation and management of wildlife populations require regular monitoring, including the estimation of wildlife densities and information on factors that affect abundance over time (Laing et al. 2003, Jachmann 2012). Some species are difficult to detect in the field because they are either very elusive, their populations are very small, or they occur in densely vegetated habitats (Zero et al. 2013).

The Siberian red deer (*Cervus canadensis sibiricus*), also known as the maral, is a subspecies of the North American elk (*Cervus canadensis*). It is distributed across northern Mongolia and other parts of North Asia. Until recently, this ungulate could be found in high densities in forests and in parts of the steppe regions that exhibited sufficiently high vegetation cover. An assessment conducted in Mongolia in 1986 estimated a population of 130,000 individuals across 115,000 km^2 (Dulamtseren et al. 1989). The most recent census by the Mongolian government estimated the population at 8,000 to 10,000 individuals, which represents a 92% decline over the past 18 years (Zahler et al. 2004). Due to the low population size, the ungulate is listed as Rare under the 1995 Mongolian hunting law. Based on International Union for the Conservation of Nature (IUCN) Red List Guidelines, the Siberian red deer is "Critically Endangered" in Mongolia, due to drastic population decline, habitat loss, and exploitation (Clark *et al.* 2006). No recent population information is available on this large herbivore in Mongolia.

For deer (*Cervus ssp.)*, direct counts are most useful in open areas where the animals are more easily detectable than in thick vegetation (Smart et al. 2004). In forests and dense shrublands, reliable estimates from direct counts are more difficult to obtain (Marques et al. 2001). Direct count methods also tend to calculate animal densities at the time of the survey, which could lead to inaccurate estimates (Jachmann 1991).

Indirect surveys, such as dung counts, record the presence of a species across a period of time prior to the survey. They provide animal abundance and density estimates that are comparable to using direct methods (Barnes 2001), and can be used to assess the population status (Bailey and Putman 1981). For monitoring deer in habitat mosaics, dung counts tend to be the preferred survey method (Buckland et al. 2001). The fecal standing crop (FSC) method has been found to be the most cost-effective and efficient dung count method for estimating deer numbers, particularly in small populations (Laing et al. 2003; Alves et al. 2013). The FSC method estimates animal density based on the amount of recorded dung samples, the dung decay rate, and the dung production rate (Hemami & Dolman 2005). Dung decay rates tend to

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Commented [CS3]: Common names of animals and plants are generally not capitalized in English unless part of the name includes the name of a place or person (see also my next comment).

Commented [CS4]: You need to capitalize "North" here because it is part of the geographical name (North American elk).

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Commented [CS5]: Here you are referring to the cardinal direction, used as an adjective, so you need to use lowercase letters. If this was the actual name of the place (e.g., South America or North Pole), then you would need to capitalize it.

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STINN TRANSLATIONS
Translation – Editing – Proofreading

Editing example – changes visible

vary across habitats, seasons, and climates (Laing et al. 2003, Skarin 2003, Hemami & Dolman 2005). Estimating dung decay usually requires repeated visits to dung samples with a known deposition time over a long period and across different habitats. An advantage of the FSC method is that it is possible to develop a model to predict decay rate instead of having to conduct a decay rate experiment at every survey site at every time point (Laing et al. 2003). Moreover, it does not require distance measurements, and all dung detections on the survey transect are recorded, regardless of their age (Laing et al. 2003). Similar to dung decay, dung production (or its reciprocal, defecation rate) varies by season, habitat quality, and sex/age of individuals (Eberhardt and Van Etten 1956; Mitchell et al. 1985). Defecation rates are therefore ideally estimated for each population prior to the survey. To estimate defecation rate (in pellet groups per individual per day), a known group of individuals in an enclosed area which was previously cleared of all dung is observed over a fixed period of time. At the end, the total number of pellet groups are counted to determine the daily defecation rate per individual.

While ground surveys are cheaper than traditional aerial surveys, they are time-intensive and cover only small areas. In addition, for very small or sparsely distributed populations, a high survey effort is required to calculate reliable estimates (Bouché et al. 2012). Manned aerial surveys have been traditionally used as a wildlife monitoring method; however, they are very expensive and logistically challenging. Due to these limitations, survey intervals are long for many populations (Dunham 2012).

Over the past decade, a market of non-military, unmanned aerial vehicles (UAV) with high-quality cameras and precision flight capability as well as a Global Positioning System (GPS) has emerged and been made available to the general public. Also known as drones, they are becoming increasingly promising and affordable tools for wildlife surveys (Pierce Jones IV et al. 2006, Koh and Wich 2012, Anderson and Gaston 2013, Christie et al. 2016). Their main advantages are that they can be used for hard-to-reach populations and places, are much less expensive, safer to operate, and less invasive than manned aircraft (Watts et al. 2010, Anderson and Gaston 2013, Hodgson et al. 2016).

In this study, the abundance and density of a Siberian red deer *Cervus canadensis sibiricus* population in northern Mongolia are estimated using the FSC method. In addition, aerial imagery obtained with a drone will be used to assess the precision and efficiency of this method for population estimations. The results provide crucial information on the current population status of the Siberian red deer in a protected area in northern Mongolia. In addition, this is the first study to assess the applicability of a low-noise, consumer-grade drone for a wildlife survey.

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