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Poaching regulates the legally hunted wolf population in Finland

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ABSTRACT

Poaching may threaten population viability and can occur in both non-harvested and legally harvested populations. Telemetry facilitates the determination of the fates of individual animals, and the resultant mortality scenarios can be used to evaluate the role of poaching in population changes. Finland's legally hunted wolf (*Canis lupus*) population fluctuated between 100 and 300 animals during 1998–2016, and this cannot be explained by the rates of legal hunting and other known mortalities alone. We examined the role of poaching in wolf population changes. We created different scenarios based on multi-source information on poaching among 130 collared wolves. Poaching has been the primary cause of death followed by legal hunting. We calculated the survival rate and cause-specific mortality risk; wolves whose fates were unknown were censored. As one of the event alternatives (unknown fate or known mortality cause), censoring was related to social status; breeding adults were more often poached, whereas dispersers were censored. We created two sets of scenarios based on the censoring procedure (random and non-random), and for both sets, we created 4 scenarios ranging from high to no poaching based on decreasing confidence in the data. Annual survival ranged from 0.11–0.24 (high poaching scenario) to 0.43–0.60 (no poaching); survival dropped in mid-winter. The poaching rate varied between years from less than 0.09–0.13 up to 0.31–0.43. We consider poaching to be a regulatory factor; it focused on breeding adults and seemed to escalate as a response to increased population size. We conclude that tolerance for carnivores cannot be promoted by legal hunting alone, so more comprehensive conservation efforts are needed.

1. Introduction

The illegal killing of wild animals is a globally significant form of wildlife crime with ecological, economic and social aspects (Challender and MacMillan, 2014; Elianson, 2004; Europol, 2013; Gavin et al., 2009; Hilton-Taylor, 2000). In poor economies, poaching is motivated by monetary profit (Gavin et al., 2009), but in developed countries, it seems to be driven more by social intolerance, especially in the case of large carnivores (Gangaas et al., 2013; Treves and Bruskotter, 2014). Large carnivores are often seen in a negative light at the local level (Bisi et al., 2010; Pohja-Mykrä and Kurki, 2014) although their conservation is valued nationally and globally (Boitani et al., 2015; Dickman, 2010; Trouwborst, 2015).

The global distribution and population sizes of large carnivores have substantially decreased relative to their historic levels because of habitat loss and human intolerance (Ripple et al., 2014; Treves and Bruskotter, 2014; Woodroffe, 2000). Large carnivores are apex predators that play a significant role in human-wildlife conflicts in most of the areas where they exist outside protected areas (Woodroffe, 2000), and owing to their high energetic requirements, slow life histories and low population densities, their populations are vulnerable to persecution (Fuller et al., 2003; Ripple et al., 2014).

Large carnivores have recently been expanding in many regions in North America and Europe (Chapron et al., 2014, Moss et al., 2016), but their rebound is a conflictual process with serious local frustration and displeasure (Dickman, 2010; Graham et al., 2005; Treves and Bruskotter, 2014) that might fuel illegal actions aimed at preventing the return of carnivore populations or at least controlling their size and expansion. There is relatively little biological research on the poaching of large carnivores due to the cryptic nature of illegal activities, leading to methodological challenges and difficulties in obtaining data (Chapron and Treves, 2016; Liberg et al., 2011; Person and Russell, 2007; Treves et al., 2017a, 2017b).

The wolf (*Canis lupus*) is a classic example of a conflict-prone top predator, especially in human-dominated landscapes (Bisi et al., 2010; Dressel et al., 2014; Pohja-Mykrä and Kurki, 2014; Pohja-Mykrä, 2016), because of livestock damages, competition for game such as moose (*Alces alces*) and personal fear. Poaching has been identified as a

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potential threat to wolf populations (Chapron and Treves, 2016, but see also Pepin et al. 2017; Liberg et al., 2011; Olson et al., 2014), but wolf populations can remain viable in human-dominated landscape if harvesting is not excessive (Fuller et al., 2003; Karlsson et al., 2007; Linnell et al., 2001; Mladenoff et al., 1995; Thurber et al., 1994).

Estimates of sustainable harvest rates for wolves vary from < 30% (Adams et al. 2008; Creel and Rotella 2010) up to approximately 70% (Fuller et al., 2003; Gude et al. 2011) depending especially on the productivity of the population. Breeding adult survival is a key parameter for the recruitment rate in a wolf population (Borg et al., 2015), and selective harvesting of breeding animals increases the risk of pack dissolution (Borg et al., 2015; Brainerd et al., 2008; Milleret et al., 2016) and may affect the hunting success of the pack (Sand et al., 2006). Therefore, human-caused mortality can have a super-additive effect (Milleret et al., 2016) and regulate population dynamics, especially in human-dominated landscapes.

Hunting has strong communal value in rural areas of Northern Europe (Gangaas et al., 2013; Pellikka et al., 2007). Hunters often view wolves negatively (Bisi et al., 2010), but poaching has also been described as part of a general rural protest against centralized conservation administration (Pohja-Mykrä, 2016). In Finland, wolves were extirpated in the late 19th century but recolonized the country in the 1990s (Kojola et al., 2014; Mykrä and Pohja-Mykrä, 2015). Since the beginning of telemetry-assisted wolf monitoring in 1998, the population has fluctuated between approximately 100 and 300 wolves independent of known mortalities (Jansson et al., 2012; Kojola et al., 2014).

In this study, we estimated the influence of poaching on the Finnish wolf population. Our aim was to examine how different poaching rates may explain the observed annual changes in population size.

2. Materials and methods

2.1. Study environment

Finland is situated in the mid-boreal coniferous forest zone. The landscape is dominated by commercial forestry, so the forest road network is extensive, with an average forest road density of 0.4 km/km^2, which increases to 0.8 km/km^2 if all backcountry roads are included. Permanent snow cover appears in mid-November and melts in early May, although there is a high degree of annual variation, and snow depth reaches its peak in early spring. Other large carnivores in Finland include brown bear (*Ursus arctos*), lynx (*Lynx lynx*) and wolverine (*Gulo gulo*).

Human density in Finland is approximately 18 inhabitants per km^2, but due to urbanization, the density in rural areas is even lower. Hunting plays an important role in the lifestyle of rural people. Hunters represent approximately 6% of Finns; approximately 90% of them are men, and 90% live outside the urban area. Hunting is administered under the Ministry of Agriculture and Forestry, which determines the annual national hunting quotas that are largely based on population size estimates provided by the Natural Resources Institute Finland (hereafter, 'official estimates'). Local hunters have a major role in delivering observational abundance data, which are used to calculate the official estimates of game species (Kojola, 2005; Kojola et al., 2014; Pellikka et al., 2007).

The legislative status of the wolf in Finland is a protected game species (the Hunting Act and related decrees), and wolves are also protected by the European Union's (EU) Habitats Directive (Habitats directive, Council Directive 92/43/EEC). Therefore, hunting is allowed only by so called exceptional permits: targeted permits are issued for removing individual wolves causing damage to, e.g., livestock, and a second type of permit can be issued for management purposes based on socio-political issues. Additionally, local police can permit an individually targeted wolf hunt in the case of danger or damage. Permits are usually approved and implemented in mid-winter, since snow cover facilitates wolf hunting.

2.2. Wolf data

During the period of 1998–2013, 135 wolves in Finland were equipped with very High Frequency (VHF; Telonics, Mesa, Arizona, USA) or Global Positioning System (GPS; Televilt, Lindesberg, Sweden and Vectronic, Berlin, Germany) collars (Kojola et al., 2004a). In this study, we restricted the use of mortality data of collared wolves to May 2014 because the wolf management policy changed after this date. Five animals were excluded from the analysis: two died in Russia; one died under anesthesia; one was re-captured and euthanized directly after capture; and one was culled because it was a wolf-dog hybrid. The remaining 130 wolves comprised 57 females and 73 males.

We identified individuals by a letter code referring to sex (F for female and M for male) and a serial number according to the collaring order by sex (F1 to F57, M1 to M73). Social status at the time of the event (known mortality or censoring, i.e., unknown fate after last detection) was determined, and the following categories were used: i) alpha (breeding, stationary adult wolf), ii) sub-adult (stationary single wolf without partner), iii) disperser (non-stationary wolf dispersing from the natal territory), and iv) pup (< 1-year-old juvenile in the company of alphas).

Most wolves (91 of 130) died during the study, and we carefully investigated the cause and date of death for all wolves (Table 1). For the legally hunted individuals (n = 29), the exact date of the kill was reported by the hunter. In total, 46 collared wolves were examined in autopsy by the Natural Resources Institute Finland or the Finnish Food Safety Authority (EVIRA), and X-rays of some of the wolves were also taken to detect shots in the body. Eight wolves were known to be alive at the end of the study (30th April 2014), and they were treated as wolves of unknown fate (included in censored, n = 39).

To determine the date of death as accurately as possible, we surveyed the timing of the last detection of being alive versus proof of the

Table 1
Number and causes of death of wolves collared in Finland, 1998–2014.

Event	n	Females	Males	Alphas	Sub-adults	Dispersers	Pups
Illegal killing[a]	52	24	28	37	2	5	8
Legal hunting	29	13	16	14	4	6	5
Traffic accident	4	1	3	2	0	2	0
Euthanized[b]	3	3	0	2	0	1	0
Prey defense[c]	2	2	0	2	0	0	0
Intraspecific	1	1	0	1	0	0	0
Total (deaths)	91	44	47	58	6	14	13
Censoring	39	13	26	10	1	25	3
Total (events)	130	57	73	68	7	39	16

[a] Modus operandi unknown: n = 27, weapon: n = 15, car: n = 5, snowmobile: n = 3, poison: n = 2.
[b] Seriously injured individuals killed by authorities.
[c] Defensive kills by prey (moose).