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# Monitoring rare or elusive large mammals using effort-corrected voluntary observers

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ABSTRACT

Populations of rare or elusive large mammals are difficult to monitor, because they usually are secretive, solitary, occur at low densities, and have large home ranges. The global trend of generally decreasing large carnivore populations necessitates new, feasible, reliable, and cost-effective monitoring methods. We evaluate an index method developed for monitoring populations of moose (*Alces alces*) based on voluntarily and systematically collected observations from hunters, corrected for effort, for use in monitoring populations of large carnivores in Sweden. For our evaluation, we used independent estimates of minimum brown bear (*Ursus arctos*) densities from DNA-based scat surveys and brown bear distribution from mandatory reports from successful bear hunters. We verified that the index correctly reflected bear distribution. We also found strong linear relationships between the indices and the independent density estimates for bears at the scale of local management units (about 1000–2000 km$^2$) in all three regional study areas (adjusted $R^2$ = 0.88–0.60). Our results suggest that systematic, effort-corrected reports of observed animals can be an alternative and accurate monitoring method for the conservation and management of large mammals occurring over large areas when large numbers of willing volunteers are available (effort >30,000 h).



## 1. Introduction

Monitoring can be defined as the process of gathering information about variables in some systems, such as a population, at different points in time and space to characterize their status (Yoccoz et al., 2001). Density and distribution are considered key parameters for the conservation and management of most animal species (Wilson and Delahay, 2001). Large carnivores are typical examples of rare and elusive mammals that are vulnerable or endangered with declining habitat or numbers (Weber and Rabinowitz, 1996; Gittleman and Gomper, 2001). Their secretive characteristics and low abundance make monitoring a difficult task for this group (Kendall et al., 1992; Linnell et al., 1998; Thompson, 2004).

Although there are many available methods for monitoring (Schwarz and Seber, 1999; Williams et al., 2002), few are suitable for low-density mammals or other elusive species (Mills et al., 2000). Many of these methods either are too expensive or not suitable to cover large areas, at least on a regular basis (Link and Sauer, 1997; Schwarz and Seber, 1999; Zhou and Griffiths, 2007). Because it normally is difficult to determine absolute densities, managers often must rely upon indices to determine abundance and trends (Eberhardt and Simmons, 1987; Skalski et al., 2005). When detection

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probability is unknown, counts are normally treated as indices. Indices are usually cheaper than other methods of monitoring trends, and can be very useful for managing populations, if they accurately reflect relative abundance. Several studies have shown that indices can be highly correlated with abundance (Hochachka et al., 2000; Slade and Blair, 2000; Wilson and Delahay, 2001; Romain et al., 2004), but indices also have received much criticism (Anderson, 2001).

In Scandinavia direct or indirect observations of primarily family groups, and snow tracking, have been used to monitor lynx (*Lynx lynx*) and wolf (*Canis lupus*) populations (Andrén et al., 2002). These methods are often time consuming, costly, may have serious biases, and/or rely on favorable weather conditions (Elgmork, 1991; Linnell et al., 1998; Andrén et al., 2002). Analyses of standardized observations of female brown bears (*Ursus arctos*) with cubs made by approved observers have been used successfully to estimate the minimum population size and population growth rate in the Yellowstone Ecosystem, USA (Knight et al., 1995; Eberhardt and Knight, 1996; Mattson, 1997; Keating et al., 2002; Harris et al., 2007; Schwartz et al., 2008). However, Solberg et al. (2006) evaluated observations of female brown bears with cubs that were reported by the general public (i.e., not an organized effort) to the hunters' organization in Sweden and found that it greatly underestimated the population size. Solberg et al. (2006) considered compiling unorganized reports of females with cubs by the general public, as practiced in Sweden, to be inadequate for population monitoring. In addition, brown bear litter sizes reported by the general public in Sweden were lower than those documented in the same area by researchers (Zedrosser and Swenson, 2005).

A simple, straight-forward method, such as observations combined with a measure of effort, has been used to monitor moose (*Alces alces*) populations since the mid-1970s in Norway, mid-1980s in Sweden, and in parts of North America (e.g. Ericsson and Wallin, 1999; Solberg and Sæther, 1999). Substantial research effort has been invested in testing and verifying the theoretical and the practical assumptions of observation indices. For example, we know that effort-corrected observations of moose accurately, and linearly, reflect annual reproduction or recruitment (Fryxell et al., 1988; Crête and Courtois, 1997; Ericsson and Wallin, 1999; Solberg and Sæther, 1999; Sylvén, 2000).

A similar method could potentially give valuable information about population size, distribution, and trends of large rare or elusive mammals (i.e., large carnivores). Although Elgmork (1991) and Swenson et al. (1994) suggested using effort-corrected bear observations collected by hunters during moose hunting as a method for estimating relative densities of bears that was independent of harvest data, the applicability of this method remains to be verified with independent data.

The large carnivore observation index (LCOI) was introduced in Sweden in 1998 as an add-on module to the nationwide monitoring program for moose (Linnell et al., 1998). During the first 7 days of the moose hunting season (during September–October), hunters register observed large carnivores (i.e., brown bears, lynx, wolves, and wolverines [*Gulo gulo*]) and the total observation effort in hours. We evaluate the general applicability of these systematically and effort-corrected observations as a means of monitoring populations of large rare or elusive mammals. As a case study, we use observations of brown bears from the LCOI program in Sweden. We focus on two central questions; can the LCOI be used as an accurate index of the density and of the spatial distribution of brown bears? We test these questions using independent data from on-going research and management.

## 2. Materials and methods

### 2.1. Study areas

We used data from the provinces (län) in Sweden with established bear populations and with available independently collected density estimates (Fig. 1). We analyzed data at the scale of the local management unit (LMU), which is the scale where hunters collect data and implement general wildlife management strategies decided by the regional authorities. A LMU usually consists of $\geqslant 1$ parishes within a municipality or an en-

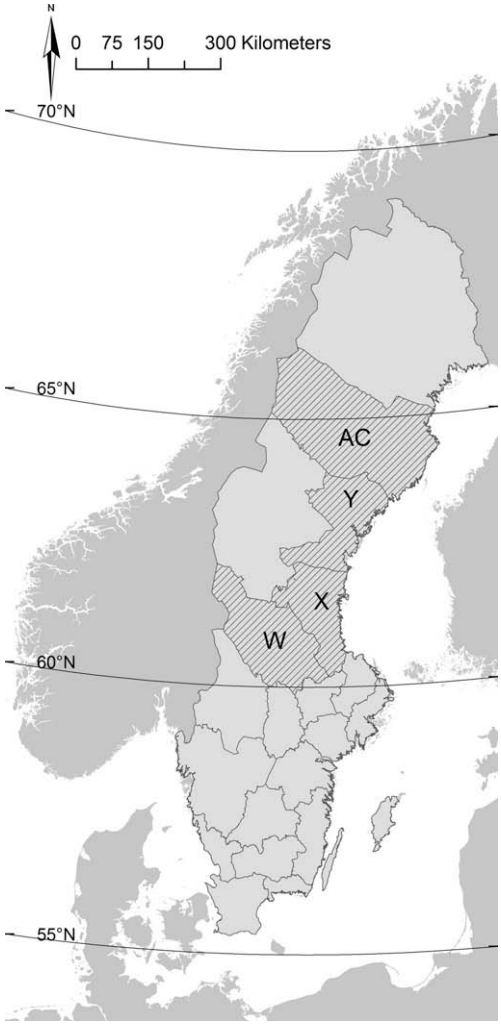


**Fig. 1 – The map of Sweden (light gray) showing province (län) borders. The large carnivore observation index data for brown bears used in this study were from the provinces marked with hatched lines; Dalarna (W), Gävleborg (X,) Västernorrland (Y), and Västerbotten (AC).**