Sign surveys for estimating trend of a remnant brown bear Ursus arctos population in northern spain

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SHORT COMMUNICATION

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Sign surveys for estimating trend of a remnant brown bear *Ursus arctos* population in northern Spain

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Brown bears *Ursus arctos* in Spain's Cantabrian Mountains are continuing to decline in numbers despite their protected status. Recovery plans for this population stress the need for monitoring of occupied habitat using non-intrusive methods. A population monitoring program to estimate bear abundance indices by quantifying tracks and scats (sign surveys) along a network of survey routes was designed. Each route was divided into consecutive 1.6-km segments, which comprised the basic sampling unit, and were assumed to provide independent observations. During a 3-year pilot study surveys were run twice per year, totaling 70 routes, including 950 segments, and covering over 1,500 km annually. Averages of 0.06 sign per segment were observed; only 4% of the segments had sign. It is concluded that the present sampling scheme does not provide enough statistical power to accurately detect significant declines in population level. The difficulties of monitoring trends of low density populations using surveys are recognized. However, by increasing the sampling intensity, more reliable information and greater precision of the population trend estimate should be obtainable. Thus, a future monitoring strategy should be based on increasing sampling intensity and closely monitoring bear distribution and occurrence.

Key words: brown bear, monitoring, population trend, sign survey, Spain, statistical power, Ursus arctos

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The Cantabrian Mountains in northern Spain remain one of the last strongholds of Eurasian brown bears *Ursus arctos* in southwestern Europe and harbour one of the largest of the four remnant populations surviving (Clevenger et al. 1987, Servheen 1990). Starting in 1973, Spanish brown bears have been legally protected by two national decrees for endangered species' protection and Europe's Bern Convention, whose goals are to assure bear conservation and protection of occupied habitats. Despite the weighty legal safeguarding, brown bear numbers appear to continue declining (Clevenger & Purroy 1991); future viability of the population is uncertain and of great concern (Council of Europe 1989).

Beginning in 1989, governments from the four Autonomous Communities, Asturias, Cantabria, Castile-León, and Galicia, within the Cantabrian bear range have prepared plans which provide guidelines and measures for the bears' recovery. One objective common to all four plans is to estimate principal demographic parameters for proper monitoring and management of the population. The plans specify that this should be based on 1) counts of distinct females with cubs-of-the-year, 2) population-wide censuses, and 3) evaluation of population trends using non-intrusive techniques (e.g. Naves & Palomero 1993).

Counts of females with cubs-of-the-year (COY) is one of several methods used to evaluate population trends of grizzly bears in the Yellowstone ecosystem; however, it is highly sensitive to unquantified effort and is a technique which requires that adult females be individually recognizable and readily observable or radio-marked (Eberhardt et al. 1986, 1994, Knight et al. 1995). The difficulties of radio-marking Cantabrian bears are numerous, and in contrast to their North American counterparts, their usually nocturnal, secretive, and forest-dwelling behaviour makes direct observations extremely difficult. To date no satisfactory methods have been developed for censusing populations of large predators under such conditions. Non-intrusive means of measuring population changes of carnivores have received considerable attention (Linhart & Knowlton 1975, Roughton & Sweeney 1982, Rau et al. 1985, Raphael & Rosenberg 1993, Diefenbach et al. 1994), but their ability to detect real trends is questionable (Harris 1986).

Population trend monitoring is a key element of a large carnivore management strategy. Because most carnivores are highly mobile, oftentimes secretive, and occur in low densities, population trends are difficult to monitor. Nonetheless, population trend monitoring schemes, if planned properly, can provide reliable estimates of changes in population size over time (de la Mare 1984, Gerrodette 1987, Peterman 1990, Kendall et al. 1992, Taylor & Gerrodette 1993, Zielinski & Stauffer 1996). The use of sign from varied groups of mammals has long been used to monitor populations (Neff 1968, Keith & Windberg 1978, Mason & Macdonald 1987); however, counts of scats or tracks (hereafter referred to as sign surveys) have only been used to a limited degree in large predator population monitoring schemes (van Dyke et al. 1986, Clevenger & Purroy 1991, Kendall et al. 1992, Smallwood & Fitzhugh 1995).

Sign surveys are influenced by variable tracking conditions and seasonal behaviour of the target species, which can produce highly variable results (Harris 1986). Nonetheless, it is a low-cost, geographically extensive method which is simple to conduct and which allows multiple within-year sampling (Clevenger 1994). Despite the shortcomings of sign surveys, we recognize that there is an urgent need for an effective, non-intrusive monitoring scheme for brown bears in the Cantabrian Mountains. In this paper we present the results of a 3-year pilot study to monitor population trends of Cantabrian bears using sign surveys. Our objective was to test the feasibililty of this non-intrusive technique to monitor bear abundance over time. We assess the effectiveness of our sign survey design for monitoring trends of low density populations of large carnivores such as the Cantabrian brown bear, discuss the statistical considerations of survey work, and suggest a future monitoring strategy for the Cantabrian population.

Study area

The Cantabrian Mountains extend roughly 300 km along an east-west axis, parallel and adjacent to the Cantabrian Sea in northern Spain (42°50'-43°10'N, 4°20'-6°55'W). Brown bears are distributed over an area of approximately 5,500 km² and divided in two subpopulations roughly equal in area (Fig. 1). The current population is estimated at 50-70 bears (Clevenger & Purroy 1991). Practically all of the bear range is situated within National Hunting Reserves governed by the four previously mentioned Autonomous Communities. Elevations range from 600 m

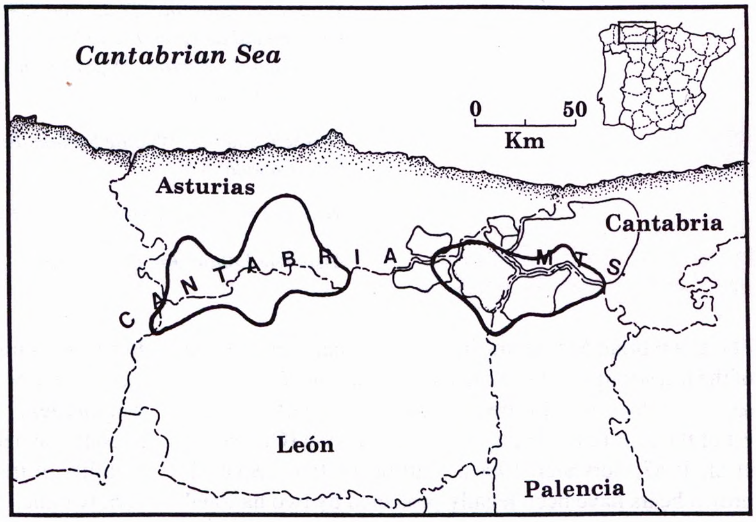

Figure 1. Distribution of the two subpopulations of brown bear in the Cantabrian Mountains (shown by continuous bold lines). National Hunting Reserves are shown by continuous thin lines.

to 2,500 m a.s.l., yet the mean altitude along the divide is 1,200-1,600 m. The north and south sides of the range differ in physiography and climate as they represent the union of Mediterranean and Eurosiberian biogeographic regions (Rivas-Martínez et al. 1984). The climate on the south side (León, Palencia provinces) is continental and mean monthly temperatures range from 0.5°C to 16°C. Maritime conditions prevail on the north side (Asturias, Cantabria) as monthly mean temperatures vary between 5°C and 17°C.

Three broad types of habitat occur within the bear range: 1) scrublands of heath and broom (*Cytisus*, *Genista*, *Erica* and *Calluna* spp.) being most prevalent at mid-to-low elevations where grazing pressure and periodic burnings have lessened over the years; 2) maintained lowland hayfields and upland grazing pasture; and 3) mixed deciduous forest cover predominantly of beech *Fagus sylvatica* and oak *Quercus* spp., while birch *Betula celtiberica*, chestnut *Castanea sativa*, and reforested areas of Scots pine *Pinus sylvestris* form a secondary woodland component. The main economic activity in the region is raising livestock, primarily cattle. From May to October, resident herds utilize the numerous pastures throughout the mountains. Other activities include small and large game hunting, coal mining in the lower elevations, and recently tourism has been promoted by the Autonomous governments. Road density is low, approximately 0.25 km/km^2, primarily due to the rugged terrain and relatively low human density in the area.

Methods

We initiated a population trend monitoring program in 1990 utilizing a network of sign survey routes, consisting of foot trails and unimproved dirt roads designed to sample the entire Cantabrian brown bear range. Survey route selection was based on geographical representation and logistical considerations. Surveys were run twice per year, when bears were active (Clevenger et al. 1993) and tracking conditions optimum. In our study area, because livestock densities are high, we minimized sign trampling by conducting surveys in spring (mid-April) prior to the time when livestock are released in the mountains, and in autumn (mid-November) once livestock are returned to the villages.

Each route was divided into consecutively numbered segments. From our information on Cantabrian bear movements (Clevenger et al. 1990), we selected 1.6-km segments for our sampling scheme which we considered long enough to provide reasonably independent observations between adjacent segments. Only experienced field observers participated in the sign surveys. However, inexperienced observers accompanying field personnel during two full survey sessions could gain sufficient experience in sign identification to later participate in the surveys. Observers walked the survey routes counting the number of bear sign found in each segment. Tracks and scats were the sign types recorded because they are the most prevalent in the field, and relatively easy to age and quantify. We only recorded bear scats and tracks that could be positively identified. We noted the total number of tracks and scats found on each segment and presence was determined by ≥1 scat or track. All scats were collected for food habits analysis, while tracks were measured to provide some measure of differentiation between individuals. We ran our surveys in the shortest amount of time possible to minimize non-independent observations, i.e., counting sign from the same animal on more than one route segment. We repeated all the same survey routes during each sampling session; however, occasionally a small number of them could not be surveyed.

For this exercise we only evaluated the effectiveness of our surveys to detect significant changes in population size over time by determining the number of segments needed to measure changes in sign occurrence between two samples (Snedecor & Cochran 1980). However, for detecting trends, repeated measures analysis can be used to test for significant change over repeated sampling periods or successive estimates can be compared with one or more previous estimates (Kuehl 1994). Multiple comparison tests may be used to establish groupings over time (e.g. Tukey's test, Fishers test, Duncan's test). Regression analysis can also be used to estimate trend from a series of proportion estimates (Gerrodette 1987).

Results

Our sign survey sampling scheme consisted of 67-72 routes distributed throughout the brown bear range. We surveyed sampling routes twice each year during spring and autumn, from 1990 to 1992. During the 3-year period, between 139 and 141 routes were sampled per year, including between 928 and 957, 1.6-km route segments (Table 1). The mean number of segments per route ranged from 6.6 to 6.9. The total distance surveyed annually was roughly 1,500 km and between 696 and 819 km for any given sampling session. The average duration of the six survey sessions was 26.6 days (SD = 4.9).

Tracks were more abundant than scats during each sampling session except for one. The total number of tracks recorded per survey ranged from 6 to 26, while the number of scats found was between 4 and 20. There were seasonal differences in the number of tracks and scats counted the first two years. Tracks were more common than scats, however, they were equally abundant the third year. The total number of combined sign recorded during

Table 1. Results of trend surveys of brown bear sign per 1.6-km segment of survey routes in the Cantabrian Mountains, Spain, 1990-1992.

	1990			1991			1992			
	Spring	Autumn	Annual	Spring	Autumn	Annual	Spring	Autumn	Annual	Total
Distance surveyed (km)	789	696	1,485	819	712	1,531	819	712	1,531	4,547
No of routes surveyed	71	70	141	72	67	139	72	67	139	419
No of segments surveyed	493	435	928	512	445	957	512	445	957	2,842
No of segments/route										
Mean			6.6			6.9			6.6	
Range			3-13			2-13			2-13	
Total no of sign recorded										
Tracks	15	7	22	26	8	34	7	6	13	69
Scats	5	20	25	12	7	19	4	4	8	52
Total no of sign/route segment										
Mean	0.05	0.07	0.06	0.10	0.04	0.07	0.05	0.04	0.04	0.06
Range	0-4	0-4	0-4	0-6	0-2	0-6	0-3	0-5	0-5	0-6
No of segments with sign	17	19	36	24	13	37	10	6	16	89
Proportion of segments with sign	0.03	0.04	0.04	0.04	0.03	0.04	0.02	0.03	0.03	0.04

the 3-year period was 47, 53, and 21, respectively. For our analysis, sign was defined as the sign type most prevalent on each segment.

The number of segments with sign ranged from 6 to 24 per survey, and 16 to 37 per year. Finally, our surveys resulted in observation of an average of 0.06 sign per route segment, and sign was observed on only 4% of the segments. The required sample size necessary for detecting a 20% decrease in sign occurrence at a significance level of 0.10 (Type 1 error) and statistical power of 0.80 (1-Type 2 error [0.20]) was 1,361 segments per year.

Discussion

Many investigators have recognized the attractiveness of monitoring wildlife populations using sign (De Vos 1952, Lockie 1964, Dzieciolowski 1976, Pulliainen 1981). Pellet and track counts are popular among wildlife managers because they are easy to replicate, and are a relatively inexpensive and reliable means of monitoring wildlife populations (Mooty et al. 1984). Nevertheless, count data are highly variable and observed trends may be misleading (Harris 1986). Variation can be caused by factors other than changes in sign density. Sign may occur non-randomly due to seasonal changes in behaviour (van Horne 1983), and it's detectability may be affected by weather or other factors (Putman 1984). Sign surveys are not capable of detecting annual population fluctuations, but sampling schemes, when carefully designed, may have adequate power to monitor long-term trends and detect potentially threatening declines (Gerrodette 1987, Kendall et al. 1992, Taylor & Gerrodette 1993, Zielinski & Stauffer 1996).

Harris (1986) analysed trends obtained from variable counts. He suggested that variability in count data can be reduced by proper survey design and strict standardisation of procedures. But he suggested that greater precision will be achieved by increasing the number of replicate counts each year, and/or lengthening the monitoring period (>12 years).

In a recent paper, Kendall et al. (1992) examined the abililty of different survey designs to detect changes in grizzly bear sign deposition (mainly tracks and scats) in Montana, USA, using 1.6-km trail segments. Bear scats were found much more often than tracks along segments. The power of various sampling schemes which would detect a 20% decline in sign occurrence, i.e. the proportion of segments with scats, were explored. They concluded that for their monitoring program, the greatest power is achieved: by maximizing the number of trails surveyed, even if it means reducing their total distance; by conducting multiple within-year replicate surveys to lower variance; and by pooling data from multiple years.

Our efforts to monitor Cantabrian bears are complicated by the population being highly dispersed and occurring in low densities (approximately 1 bear/100 km^2, Clevenger & Purroy 1991). The average number of sign/segment while running our surveys during the 3-year period was 6%, indicating that sign density in the Cantabrian bear range was remarkably low. The low index resembled bear track count data from the Montana study, despite the fact that we conducted surveys twice a year and sampled 10 times more segments per year than the Montana program. We can conclude that our sampling scheme provided little power for monitoring the brown bear population trend, inasmuch as the 925-950 segments sampled annually were well below the number required to accurately detect real changes in population size. If sign surveys are to be our monitoring tool in the future, we must obtain higher sign density estimates by adding more within-year replicate counts, or pooling data over multiple years.

Increasing sign density estimates appear to be the best alternative, as pooling data at our present level of coverage to obtain successive estimates would likely require many years' data before obtaining adequate sample sizes to be able to test for changes in population level. A survey designed to sample the Cantabrian bear range at monthly or bi-monthly intervals may provide sufficient data and adequate power to monitor the bears' population trend; however, for the moment this is logistically impossible. Presently, there is a narrow window-of-time for sampling in the Cantabrian Mountains due to the abundance and intensity of livestock grazing activity during a large part of the year. Tracking conditions are optimal for running surveys during just four months out of the year; the combined months of April-May (spring), and October-November (autumn).

A hypothetical sampling scheme would need to consist of 25 trained observers (e.g. district game wardens, volunteers) each sampling roughly 32 km (20 1.6-km segments) of survey routes per sampling period. Each survey session would require approximately 2-days' fieldwork, and sample 500 segments, corresponding to our present level of coverage. By increasing the number of replicate counts per year, variance will be lowered and sign density increased, and at the same time will afford the survey design greater statistical power (Harris 1986, Kendall et al. 1992). Using our mean index of 6% sign per segment/sampling session for computation, pooling annual data from four monthly surveys would hypothetically raise sign density four-fold and sample annually 2,000 segments.

Although few activities in conservation are more important than monitoring, it is rarely done well (Noss & Cooperrider 1994). Monitoring programs for carnivores are not an exception. They are a fundamental part of wildlife agency programs, however, power analyses of monitoring designs are rarely performed and as a result, the effectiveness of most sampling schemes to detect even large declines is questionable.

In Europe, most management programs have placed monitoring low on their list of research priorities and therefore tend to allocate insufficient funding to carry out the task correctly. Among the remnant brown bear populations in southern Europe, most resource agencies conduct sign surveys once or twice per year whereby total counts of tracks and scats are recorded per distance surveyed, without taking into consideration biases of non-independent observations. This method is subject to many other biases of unmeasurable magnitude and the results therefore yield information which is of little value in helping to chart population trends. Similarly, inquiries or questionnaires of bear occurrence produce highly variable data for monitoring populations other than on a crude spatial scale. We believe that it is imperative that resource managers responsible for the management of species of special concern that use trend information obtained from sign counts know something about the accuracy and precision of their trend estimate (Harris 1986, Taylor & Gerrodette 1993, Zielinski & Stauffer 1996).

The concept of statistical power in the field of ecology has received much attention in recent years (Quinn & Dunham 1983, Green 1989, Peterman 1990, Forney et al. 1991), however, it is most critical in the field of conservation biology because failure to detect a diminishing population can have serious consequences (Taylor & Gerrodette 1993). Currently our objectives for monitoring population trend cannot be met due to the low density of sign in the Cantabrian bear range. By increasing sampling intensity we may be able to obtain more reliable information and more precision of the population trend estimates from our sampling scheme. But we are faced with the problem that it is inherently difficult to accurately monitor trends in low density carnivore populations because power decreases as populations become smaller (Nottingham et al. 1989, Taylor & Gerrodette 1993, Diefenbach et al. 1994).

Taylor & Gerrodette (1993) concluded that at low densities, a demographic approach can be more powerful than estimation of population trend through surveys. Yet the demographic method, which attempts to estimate population growth rate (or decline) from estimates of birth and death rates, would require substantial intervention, manipulation, financial resources, and even then would probably fall short of an acceptable number of marked individuals to provide reliable data on the Cantabrian demographic parameters. The dilemma of how to effectively monitor bear population trend in the Cantabrian Mountains is real. We believe that a reasonable monitoring strategy, given our situation, for detecting substantial changes in population level in the future could comprise two concurrent activities based on: 1) increasing the number of replicate counts in the Cantabrian range to lower variance and increase the power of our sampling scheme, and 2) a 2-dimensional approach consisting of monitoring bear distribution and occurrence at a scale which will permit a reasonable assessment of the temporal and spatial population trends, e.g. dispersion and recolonization of secondary or peripheral ranges, significant reduction in areal distribution, or increases in vacated high-quality habitats. Increased survey intensity (1) will provide greater resolution to the monitoring of occurrence in (2). Coordinated information from this strategy should provide sufficient evidence for detecting declines before it is too late to reverse them. Finally, being optimistic we would hope that the bear conservation measures from the recovery plans (primarily reducing poaching, managing bear habitat, public education and agricultural damage compensation) will soon be reflected by increased sign abundance in the Cantabrian bear range.

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