Using sign at power poles to document presence of bears in Greece

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Abstract: The endangered brown bear (*Ursus arctos*) population in Greece is in urgent need of effective protection and management; that management should be based on information that is both reliable and quickly attained. After observing bears marking and rubbing on power poles, we initiated a study to collect information on this behavior and develop an effective method for documenting bear presence in Greece. Thirty-nine power poles in the main study area were fitted with barbed wire and inspected monthly for a year. The information and experience gained in the main study area was used to survey 3 additional areas, covering a representative sample of the species distribution in the country. Power pole-related behaviors were associated with mud smears, hair deposits, and bite and claw marks (hereafter referred to as marks). Tracks and scats also have been used to document the presence of brown bears in Greece, but fewer of these were found in all areas surveyed. Deterioration rate of marks was slower than that of tracks and scats. Our results suggest that power pole-related behavior is not a localized phenomenon. A monitoring scheme in Greece documenting the presence of the species that would include the regular inspection of power poles could take advantage of the higher abundance and slower deterioration rate of power pole-related signs and be time efficient and easily staffed by volunteers. The ability to identify individual bears through genetic analysis of hair collected from power poles is an additional advantage of this approach.

Key words: behavior, brown bears, conservation, Greece, marking, power poles, presence–absence data, rubbing, *Ursus arctos*

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The brown bear (*Ursus arctos*) is the most widespread bear in the world, with a Holarctic distribution in Europe, Asia, and North America. In Europe, the species has disappeared from large parts of its original range due to human persecution and to habitat loss, fragmentation, and degradation. Brown bears in the western and Mediterranean parts of Europe survive mainly in small, fragmented populations (Swenson et al. 2000).

The species reaches its southernmost European distribution in Greece (Mertzanis 1999); despite protected status and conservation actions dating back to the 1990s, the population in Greece remains threatened (Servheen et al. 1999) and numbers are thought to be decreasing (Swenson et al. 2000). Effective protection and management actions in Greece should depend on reliable, but quickly attained, information on several poorly understood aspects of the general status and biology of brown bears (Mertzanis 1999, Mertzanis et al. 2005). Methods for studying bears in Greece have relied on telemetry as well as the observation and compilation of bear sign such as tracks and scats (Mertzanis 1994, Mertzanis et al. 2005); however, both methods have limitations. Telemetry is expensive, time consuming, and requires handling an endangered species, thus requiring a high level of technical expertise (Stanley and Royle 2005); in Greece, such studies have resulted in small sample sizes. Apart from the difficulties that arise from monitoring trends of small, low-density bear populations (Kendall et al. 1992, Clevenger and Purroy 1996), sign surveys are limited in Greece by the fast deterioration rate of tracks and scats due to weather conditions.

In 2003, we recorded marking and rubbing activity of brown bears on power poles in the prefecture of Grevena in northwestern Greece. Marking and

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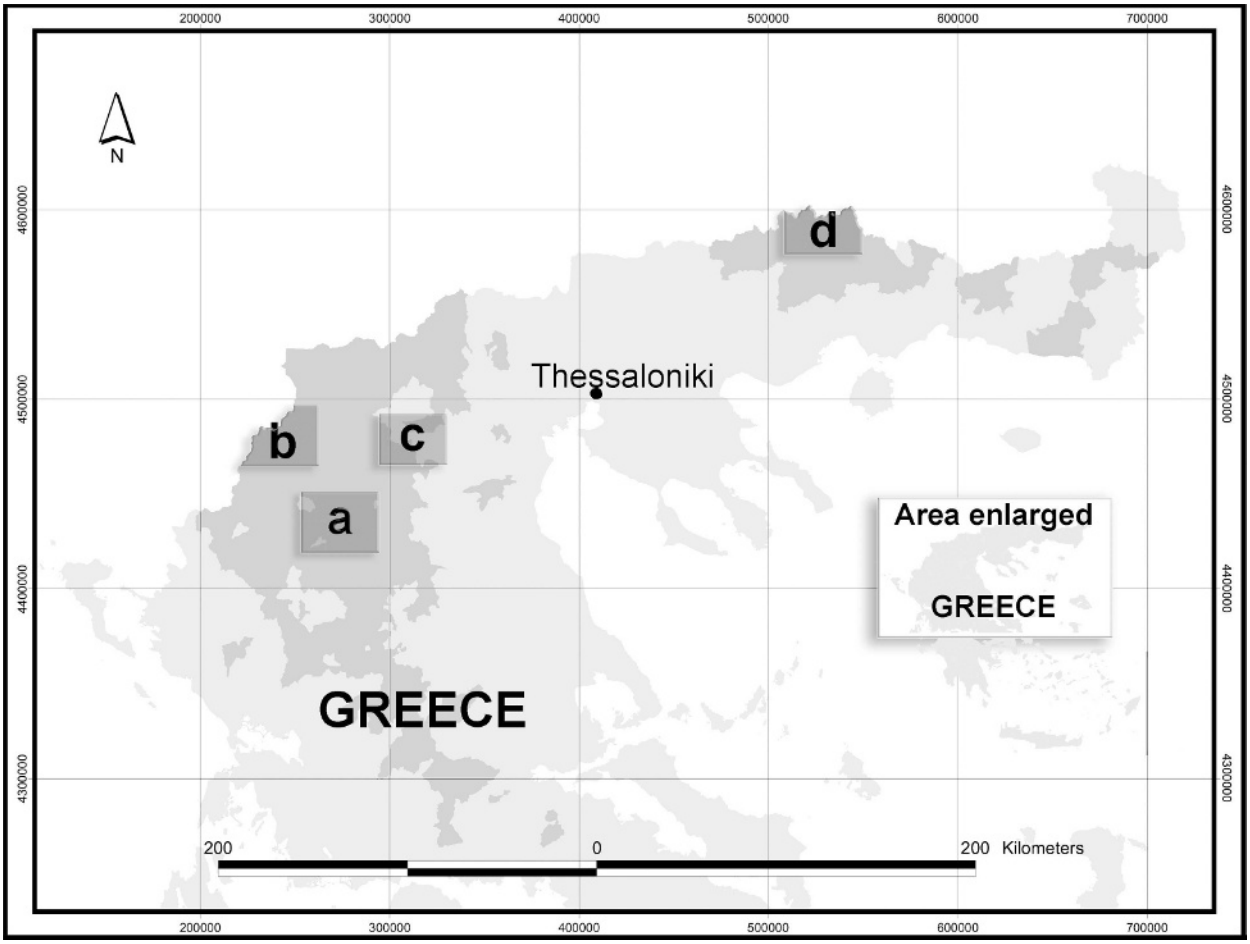

Fig. 1. Map of Greece indicating the location of the study areas for a study of brown bears in Greece: a. main study area; b. Mount Grammos study area; c. Mount Askio study area; d. Rodopi Mountain complex study area. The shaded areas indicate the approximate distribution of the brown bear in Greece based on the evaluation of compensation claims.

rubbing activity involved more than 60% of all poles ($n = 648$) in this area, with marking intensity on one occasion being so high that a pole had to be replaced by the Hellenic Public Power Corporation (unpublished data). Due to the endangered status of the brown bear in Greece and the lack of information associated with it, we initiated a study to determine if observations of bears marking and rubbing on power poles could be used to develop a methodology for studying the species. Our specific objectives were to (1) describe power pole-related behaviors of bears and the types of signs (ie., marks) associated with them, (2) compare the quantity of marks and our ability to detect them through time with those of tracks, scats, and other bear sign currently used in Greece, and (3) test whether the methodology developed in the main study area could be used to document bear presence in other regions of Greece.

Study areas

Brown bears occur in Greece in 2 disjunct populations which consist of 4 regions termed Units by Mertzanis (1999). Units I–III are interconnected and make up the western nucleus of the species in the country. They are disjunct from Unit IV, which makes up the eastern nucleus of the population (Fig. 1). We selected one study area in each of these units (Fig. 1). Bear depredation data indicated that bears were present in each of the study areas at the initiation of our study (Karamanlidis, Aristotle University of Thessaloniki, Thessaloniki, Greece).

Main study area — Prefecture of Grevena

The main study area extended over almost 1,000 km^2 and was located at the easternmost fringe of Unit III (Mertzanis 1999), in the central part of the Pindos Mountain range in northwestern Greece (Fig. 1). Major forest vegetation types consisted of oak (*Quercus* sp.) and black pine (*Pinus nigra*). The area was characterized by a mosaic of dense forest, openings, and small scale cultivations. Elevations were 500–2,200 m, and human activity at lower elevations was intensive.

Mount Grammos

The study area in Mount Grammos extended over almost 1,500 km^2 and was part of Unit II (Mertzanis 1999) in the northern part of the Pindos Mountain range in northwestern Greece (Fig 1). Major forest vegetation types consisted of oak, black pine, beech (*Fagus sylvatica*) and mixed fir (*Abies* sp.)–beech stands. The area was characterized by a mosaic of dense forest, small scale cultivations in lower altitudes, and medium to intense human activity; elevations were 600–2,500 m.

Mount Askio

The study area in Mount Askio extended over almost 500 km^2 and was part of Unit I (Mertzanis 1999) in the central part of northern Greece (Fig. 1). Major forest vegetation types consisted of oak and beech. Mount Askio was characterized by rocky limestone outcroppings and was forested only in its northern part. It was characterized by a mosaic of dense forest, small scale cultivations in lower altitudes, and medium human activity. Elevations were 400–2,100 m.

Rodopi Mountain complex

The study area at the Rodopi Mountain complex extended over almost 1,700 km^2 and was part of Unit IV (Mertzanis 1999) in northeastern Greece (Fig. 1). Main forest types included oak at lower elevations and beech, spruce (*Picea excelsa*), Scots pine (*Pinus sylvestris*), and black pine at higher elevations. The area was a granite complex characterized by low human density and scattered human settlements. The terrain was generally rugged and broken by perennial, cold water streams and rivers. Elevations were 500–1,300 m.

Methods

Power poles are made of wood, processed with a preservative (usually creosote) to resist decay and insect damage. Depending on topography, poles are placed 50 to 100 m apart, and vegetation 5 m from each side of the pole line is cleared. Forest animals use these belts as travel corridors, with animal paths often leading from pole to pole.

In 2003 we inspected all 648 poles that made up the 15 major power lines in the main study area for signs of bear use. All power poles with signs of bear rubbing and marking activity were identified and mapped. Forty of the poles with the highest activity were selected and inspected monthly, November 2004–October 2005. To provide proportional representation of major habitat types in the study area, we allocated the 40 sampled poles as follows: 12 in pine forests, 16 in oak forests, 7 in cultivated fields, and 5 in mixed oak–pine stands. Prior to initiation of the study, we cleared all signs of previous bear activity from each pole as well as from a radius of 50 m around them. To maximize the probability of leaving hair when rubbed, poles were fitted with a single piece of barbed wire (starting at ground level, wrapped in a spiral around the pole at approximately 30 cm intervals to a height of approximately 2 m). All new signs (hair deposits, marks, mud smears, scats, tracks, feeding signs, marked trees) on or around the pole were considered evidence of bear activity and counted as 1 instance of new sign in their respective category.

We photographed and drew the initial state of any mark found on poles and created a file with the mark history of each pole. During subsequent visits, we photographed the state and location of each new bear sign. We also photographed and documented the location of each new bear sign found within a 50 m radius as well as within 100 m of the power line right-of-way. Changes in the state of previously recorded sign were recorded by comparing photographs. We followed the condition of each bear sign until its presence could no longer be detected, or in the case of longer-lasting sign such as bite and claw marks on the poles, no difference between sign produced during our study and those produced prior to it could be detected.

We conducted additional surveys at the Mount Grammos, Mount Askio, and the Rodopi Mountain complex study areas once during October–November 2005. During these surveys, the location of the entire power pole network and the number of lines composing it were identified and mapped. At each

Table 1. Number of poles inspected, surveys carried out and signs found in the main study area (Nov 2004–Oct 2005) and additional study areas (Oct–Nov 2005) in a study of brown bears in Greece.

Study area	Power poles inspected	Surveys done	Sign type					
			Marks	Hair deposits	Mud smears	Tracks	Scats	Other[a]
Main study area	39	12	64	144	9	32	8	4
Mt. Grammos	150	1	50	34	8	2	1	0
Mt. Askio	60	1	18	11	0	1	0	0
Rodopi Mountain complex	150	1	2	2	0	0	0	0

[a]Other represents feeding signs and marked trees.

study area, we considered 10 consecutive poles along each major power line to constitute a single sample set. We attempted to provide proportional representation of major habitat types. We inspected 15 sets in the Mount Grammos and the Rodopi Mountain study areas, and 6 sets in Mount Askio. During each visit, marks on poles and signs within a 50 m radius were recorded and time since deposition estimated using guidelines defined in the main study area.

Results

Main study area: Power pole-related behavior and types of associated sign in the main study area. We recorded 217 marks on 39 poles in the main study area (Table 1). Mud smears were found on poles, even when no other mark was detected. Most smears were at pole base or at 1.4 m from the ground. Anecdotal evidence from direct observations and from remote monitoring video cameras, which were used on a behavioral study in that area, indicated that these marks resulted from the effort of bears to sniff either at the base of the pole, or at a height of approximately 1.8–2.0 m while standing on their hind legs and leaning against the pole with their front legs. Hair was deposited all around the pole up to a height of 1.8 m. Bite and claw marks were found mainly at a height of 1.0–1.2 and 1.8–2.0 m, creating 2 distinctive rings of marks around heavily used poles. Some marks were found at the base of the pole and as high up as 2.6 m.

Main study area: Power pole-related behavior through time

Of the 40 poles initially selected, 1 pole could not be accessed during winter and was excluded from further analysis. We recorded 261 signs of bear activity on or around the power poles (Fig. 2). Of these signs, 217 (83%) were directly associated with power pole-related behavior; the remaining 44 (17%) were related to the general presence of bears in the area and their approach to the pole (scats, tracks, feeding signs, marked trees; Table 1). The number of marks per pole per survey was significantly higher (Wilcoxon signed ranks test $Z = -3.064$, $P < 0.005$) than sign not related to power poles: 0.3 hair samples, 0.13 bite and claw marks, and 0.01 mud smears, versus 0.06 tracks, 0.01 scats, and 0.008 other sign (feeding signs and marked trees). We collected 186 hair samples for genetic analysis from the barbed wires. Barbed wire on the poles did not seem to discourage the marking and rubbing behavior of bears in our study area.

Inspecting the poles for an entire year enabled us to define general guidelines for estimating the time since bear signs were deposited in the field (Table 2). None of the 40 tracks and scats found during our study in the main study area persisted longer than 2 months. Mud smears were generally present on the pole for 2–3 months, although 3 smears could be detected for up to 6 months. Their persistence appeared to depend on the force with which the front legs of a bear were rubbed against the surface of the pole, but also on rain frequency following the deposition. We were unable to determine a distinct pattern of how such signs deteriorated in the field. The persistence of hair deposits depended greatly on weather conditions, with hair lasting longer under dry conditions. None of the 144 hair deposits found on the poles lasted $>$6 months, but bite and claw marks lasted through the duration of the study.

Other study areas: Power pole-related behavior

We inspected 360 poles in the Mt. Grammos (n = 150), Mt. Askio (n = 60), and the Rodopi Mountain complex (n = 150) study areas and found 130 recent signs (1–6 months old) of bear activity, 125 (96%) of which were associated with power pole-related behavior. Thirty-three percent, 30%, and 1% of the poles inspected in the Mt. Grammos, Mt. Askio, and the Rodopi Mountain complex, respectively, had marks on them. Bite and claw marks on poles, the

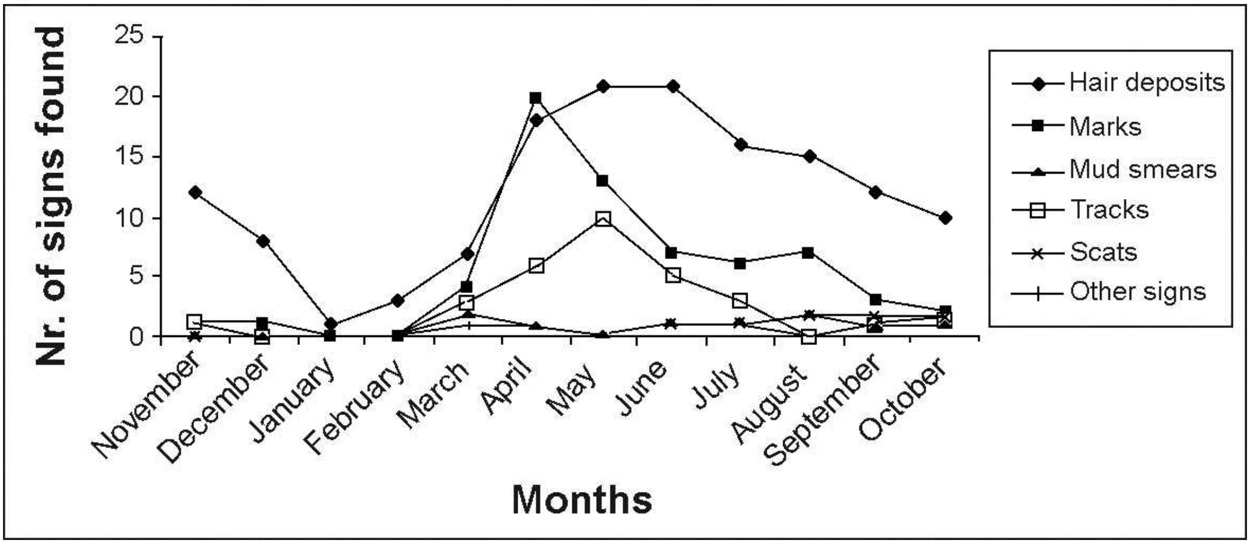

Fig. 2. Number of new signs found per sign type per survey in the main study area, Nov 2004–Oct 2005, for a study of brown bears in Greece.

type of signs that lasted longest in the field, were most frequently found, followed by hair deposits and mud smears (Table 1). We encountered significantly more marks per survey at Mt. Grammos and Mt. Askio than tracks, scats, and other signs (Mt. Grammos: Mann-Whitney test $Z = -4.466$, $P < 0.005$; Mt. Askio: Mann-Whitney test $Z = -1.964$, $P < 0.05$). No significant difference was found in the Rodopi Mountain complex (Mann-Whitney test $Z = -1.438$, $P = 0.15$).

Discussion

According to the Action Plan for the Conservation of the Brown Bear in Europe (Swenson et al. 2000), scientific research on brown bears is among the priority actions required to protect the species in Greece. Considering how little is known about this population, the development of efficient methods of studying it is a logical starting point of such research. Our results indicate that power pole-related behavior is not a localized phenomenon within Greece, as it occurred throughout the country and in areas with different habitat types and varying human activity. The use of sign surveys to document species distribution has a long tradition in bear research and management, especially in small endangered populations and in situations where logistic and financial constraints are an issue (Klein 1959, Clevenger et al. 1997, Cuesta et al. 2003). Patterns of bear distribution found in all our study areas were similar to those found by analyzing compensation claims (Karamanlidis, unpublished data). The quantity of marks was significantly higher and deteriora-

Table 2. Deterioration rate of power pole-related signs for a 2004–2005 study of brown bears in Greece.

Type of sign	Stage	Time since deposition	Characteristic features
Hair deposits	I	1–2 months	Long, curly, brownish hair; found in locks on the surface of the pole. Hair is flexible and breaks with difficulty.
	II	3–6 months	Short, straight, bleached hair; found as individual hairs on the surface of the pole. Hair is stiff and breaks easily.
Bite and claw marks	I	1–2 months	Intense creosote smell; small pieces of pole horizontal from surface; distinctive color difference between newer (lighter) signs and older (darker) signs.
	II	2–8 months	Medium creosote smell; small pieces of the pole scattered around; small difference between new and old signs.
	III	8–12 months	No creosote smell; difference between newer and older signs fading.

tion rate was slower than that of tracks and scats, the types of sign mainly used to document bear presence in Greece, in all types of habitat inspected.

Marking behavior of bears is still a poorly understood aspect of the species' behavior (Burst and Pelton 1983). Our results indicate that marking and rubbing activity in Greece is present throughout the year, reaching a peak around the breeding season in April and May. This is in accordance with observations from American black bears (*U. americanus*) in the USA (Harger 1974, Rogers 1987). Preliminary results from genetic analyses of hair found on power poles indicated that rubbing is carried out mainly by males (Karamanlidis, unpublished data), as has also been the case for bears in North America and Japan (Rogers 1987, Y. Sato, Nihon University, Japan, personal communication, 2005). The intensity of the marking behavior recorded throughout Greece resembles that of the frequent clawing and biting on trees by American black bears (Burst and Pelton 1983, Rogers 1987) rather than that of rubbing on trees by grizzly bears (*U. arctos*) in North America (Green and Mattson 2003) and is at variance with the assumption that the two species might have fundamentally different marking behaviors. The greater frequency of marks in the main study area and Grammos and Askio study areas than the Rodopi Mountain complex could have resulted either from different marking behaviors of these disjunct bear populations or from differences in population density. This difference merits further investigation.

Recent advances in molecular techniques have prompted the genetic study of bear species throughout the world (Waits et al. 1999). To overcome the inherent difficulties of collecting genetic material, many methods have been developed to collect hair from free-ranging bears (e.g., Woods et al. 1999, Beier et al. 2005). In Greece, the tendency of brown bears to rub against power poles, in conjunction with the simple deployment of a piece of barbed wire on the pole, provide a noninvasive, relatively cheap, efficient way to overcome such difficulties. Genetic material collected from power poles could be analyzed to identify individuals and gender, to examine family relationships within a study area, and to assess the genetic diversity of the brown bear population within the country. Of particular interest would be a comparison of genetic diversity between the disjunct populations in western and eastern Greece.

Management implications

Information on the presence–absence of a species is an important tool for wildlife researchers and managers and has been used as a surrogate for estimating population size or species abundance (Trenham et al. 2003), for identifying habitats that may be of high conservation value (Ball et al. 2005), for identifying range contractions of endangered species (Ceballos and Ehrlich 2002), and for identifying habitat patches with potentially high levels of persistence (Moilanen 2002). Despite its endangered status (Hellenic Zoological Society and Hellenic Ornithological Society 1992), protection and management of the brown bear in Greece is hampered by logistic constraints, lack of funding and technical and scientific expertise, and political unwillingness to protect the species (ongoing delays in protecting and managing important habitat; ARCHELON et al. 2005). Consequently, Greece still lacks a permanent, effective, nationwide monitoring and management scheme and thus accurate information on the presence of the species. Considering these difficulties, a monitoring scheme with the greatest chance of being implemented is one that relies on inexpensive, indirect techniques that can be used within a random stratified sample of habitats and applied by volunteers with a minimum of training (Sadlier et al. 2004). The approach used in this study fits these requirements.

A monitoring scheme aiming to document occupancy and habitat use of bears in Greece that would rely on the systematic inspection of power poles would take advantage of the fact that marks have higher encounter rates and longer persistence than other bear sign. It would require a minimum of knowledge of bear habitat selection and use, because pole locations are set and accessible. Thus, such a survey would be time and cost efficient and could be easily applied by volunteers. The ability to collect information on spatial and temporal activity of bears and thus identify individuals through genetic analysis is an additional advantage of this approach. However, data regarding site occupancy and habitat use resulting from such surveys should be treated with caution. Our findings indicate that the methodology developed is associated with imperfect detection throughout seasons and across genders and locations (Rodopi Mountain complex versus other study areas). Ignoring imperfect detection may result in misleading inferences over the biological system monitored (Moilanen 2002, Gu and Swihart

2004). Further research, following the general guidelines suggested by MacKenzie et al. (2002, 2003) and Stanley and Royle (2005) accounting for unequal detection probability and enabling the creation of an indirect detection index for estimating species abundance in Greece would be extremely useful. A similar methodological approach, using hair collected from bait sites, has been used to estimate grizzly bears in British Columbia and Alberta (Mowat and Strobeck 2000).

Despite methodological shortcomings, the approach described in this pilot study enabled the first genetic study of brown bears in Greece (S. Vittas, Aristotle University of Thessaloniki, Greece, personal communication, 2005) and the assessment of the species distribution in the country within a single year (Karamanlidis, unpublished data). Because bears worldwide tend to mark and rub a variety of natural and man-made objects, power pole surveys may be useful in monitoring other bear populations. For example, sampling of power poles is part of a study to estimate population size for black and brown bears in northwestern Montana, USA (K. Kendall, US Geological Survey, West Glacier, Montana, USA, personal communication, 2005).

Inspecting power poles is certainly not a panacea for providing all information needed to protect brown bears in Greece. However, considering the species' enduring endangered status and the financial constraints associated with scientific research and management, we believe that this approach could develop into a valuable tool for the conservation of brown bears in Greece.

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