DISTRIBUTION OF WOLVES IN THE ABSAROKA-BEARTOOTH WILDERNESS
- HABITAT SELECTION AND RESPONS TO HUMAN PRESENCE

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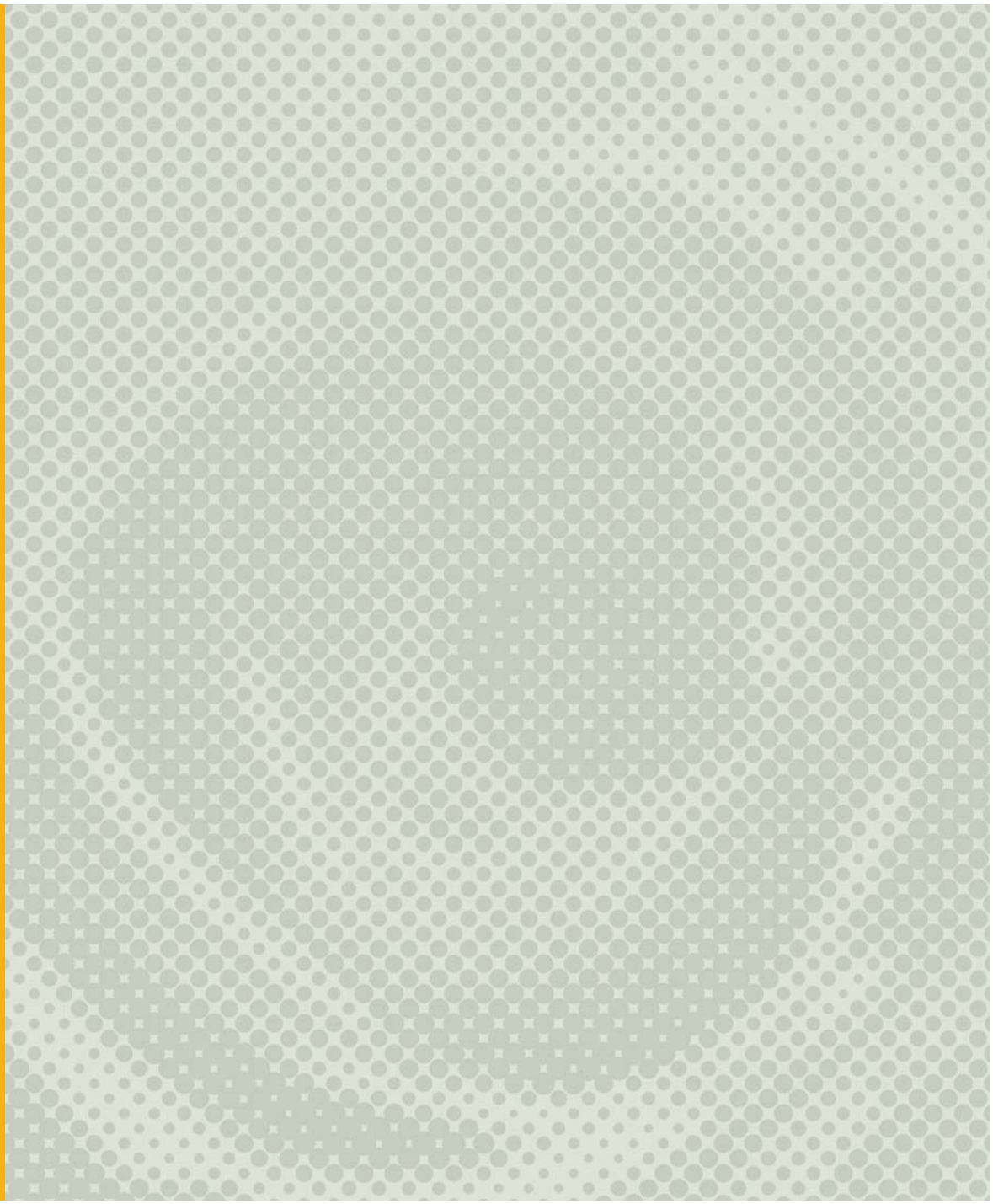

Preface

I would like to thank Dan Tyers at the United States Forest Service for this wonderful opportunity for studying wolves. The opportunity to study a large carnivore in a wilderness area in Montana was truly a dream come true. Thanks also to Heidi Bergsjø for making the connection.

Also, I would like to thank my supervisor, Jon Swenson, for useful insight into the exiting world of carnivores and helpful guiding with the paper. Thanks also to Herbjørg Arntsen and Kristine Ulvund for commenting the paper as it was taking form, and Jeremy Zimmer, Siri Framness, Craig Olwert, and Hans Ole Ørka for help with the data.

Last but not least; a big thanks goes to everybody that participated in the Forest Service's trail crew in 2005 and 2006. Without you I would not have had all the data that I needed for writing this thesis. A special thanks goes to all the people I met during the summer for all the amazing experiences I had.

Ås, 12 May 2007

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Abstract

Since the reintroduction of wolves (*Canis lupus*) into Yellowstone National Park in 1995 and 1996 the wolves have made a recovery in the park and spread into adjacent areas. The distribution of wolves in the Absaroka-Beartooth Wilderness, Montana, USA, was documented in 2005 and 2006, with special emphasis on habitat selection and human avoidance. This was done by registering tracks and scat along US Forest Service trails. Known packs detected during the survey were Casey Lake, Eagle Creek, Hellroaring Creek, Buffalo Fork, Beartooth, and Carbonate Mountain. In addition to these, the survey showed the presence of an unidentified wolf pack in the Slough Creek drainage. I found that wolves in the Absaroka-Beartooth Wilderness first, are located mainly in the vicinity of Yellowstone National Park; secondly, that they do not prefer forested habitats; thirdly, that they do not avoid Forest Service cabins or outfitter camps; and lastly that they do not differentiate between cabins and camps.

Key words: Distribution, sign survey, Canis lupus*, Absaroka-Beartooth Wilderness, habitat, humans, camps, cabins, wolves.*

Sammendrag

Siden reintroduksjonen av ulv (*Canis lupus*) til Yellowstone Nasjonalpark i 1995 og 1996 har ulvene gjenvunnet tidligere territorier og spredd seg ut over parkens grenser. Utbredelsen av ulv i Absaroka-Beartooth Wilderness, Montana, USA, ble dokumentert i 2005 og 2006, med spesiell vekt på habitat valg og unngåelse av mennesker. Dette ble gjort ved å kartlegge spor og ekskrementer langs stier vedlikeholdt av US Forest Service. Kjente flokker påvist gjennom kartleggingen var Casey Lake, Eagle Creek, Hellroaring Creek, Buffalo Fork, Beartooth og Carbonate Mountain. I tillegg til disse viste kartleggingen tilstedeværelsen av en uidentifisert flokk i Slough Creek dalføre. Jeg fant at ulv i Absaroka-Beartooth Wilderness for det første, er lokalisert hovedsakelig i nærheten av Yellowstone Nasjonalpark; for det andre, at de ikke prefererer skog; for det tredje, at de ikke unngår Forest Service hytter eller midlertidige leirer; og for det fjerde, at de ikke skiller mellom hytter og leirer.

Stikkord: Utbredelse, spor undersøkelse, Canis lupus*, Absaroka-Beartooth Wilderness, habitat, mennesker, leirer, hytter, ulv.*

Contents

Introduction

The gray wolf (*Canis lupus*) has been intensively persecuted by humans since European settlers came to North America (Bangs and Fritts 1996). In 1884, Montana initiated wolf bounties as part of the official eradication effort (U.S. Fish and Wildlife Service et al. 2006). The last known wolf in Yellowstone National Park (NP) was shot in 1926 (Smith 2005) and by the 1930s wolf populations had disappeared from Montana, Idaho and Wyoming (Bangs and Fritts 1996). Gradually the wolf was extirpated from the contiguous 48 states except Minnesota (Bangs and Fritts 1996). The wolf was protected by law in 1974 under the federal Endangered Species Act of 1973 (Smith 2005, U.S. Fish and Wildlife Service et al. 2006). Wolves sometimes crossed the border from Canada, but reproduction in the northern part of Montana was not reported before 1986, when a wolf den was discovered in Glacier NP (Ream et al. 1989). Wolf restoration plans were discussed for two decades before wolves finally were reintroduced into Yellowstone NP and Central Idaho in 1995 (Fritts et al. 1997). The recovery plan identified three recovery areas; northwest Montana, central Idaho and the Greater Yellowstone Area (U.S. Fish and Wildlife Service 1987). The primary goal of the plan was to remove the wolf from the threatened and endangered species list in the Northern Rocky Mountains by maintaining a minimum of ten breeding pairs in each of the recovery areas for three successive years (U.S. Fish and Wildlife Service 1987). This was later changed to a recovery goal of thirty total breeding pairs for all three recovery areas (Smith 2005). In addition to the biological criteria, all three states must have a Fish and Wildlife Service approved wolf management plan (Smith 2005). The wolves were reintroduced as a nonessential experimental population, i.e. not essential for the survival of the species, so it could be managed with more flexibility (U.S. Fish and Wildlife Service et al. 2006). A total of 66 wolves were captured in Alberta and British Columbia, Canada, and released in 1995 and 1996; 31 of these in Yellowstone NP (Smith 2005). Estimates of wolf numbers at the end of 2006 were 739 wolves in the Central Idaho Recovery Area, 390 in the Greater Yellowstone Recovery Area and 171 in the Northwest Montana Recovery Area (U.S. Fish and Wildlife Service et al. 2007). Of 173 packs, 86 were defined as breeding pairs, making 2006 the seventh year that the biological recovery criterion was met (U.S. Fish and Wildlife Service et al. 2007).

The key components to wolf habitat are a sufficient prey base year round with alternate prey, suitable and somewhat secluded denning and rendezvous sites, and sufficient space with minimal exposure to humans (U.S. Fish and Wildlife Service 1987). Wolves have historically been found in many different habitats, including nonforested habitats such as deserts, prairies, swamps and tundra (Fuller et al. 2003). They are still found in nonforested habitats in Spain (Fritts et al. 2003, Blanco et al. 2005), but studies from Poland (Jedrzejewski et al. 2004, Jedrzejewski et al. 2005), Italy (Ciucci et al. 1997, Massolo and Meriggi 1998) and North America (Mladenoff et al. 1995, Johnson et al. 2005, Oakleaf et al. 2006) have shown that they prefer forests in some areas.

Numerous studies have been conducted on the effects of human presence on wolves. Early studies have shown that wolves avoid areas when road density reaches a threshold value, such as 0.45 (Mladenoff et al. 1995, Mladenoff et al. 1999), 0.58 (Thiel 1985, Jensen et al. 1986, Mech et al. 1988) or 0.70 km/km^2 (Fuller et al. 1992). Roads serve as an indicator of human presence, and because humans are a major contributor to wolf mortality (Mech 1977, Forbes and Theberge 1992, Wydeven et al. 1992, Boyd and Pletscher 1999), the wolves face increased mortality from trapping, shooting, and collisions with vehicles when in the vicinity of roads (Jensen et al. 1986, Mech et al. 1988). More recent studies have moderated the negative view on roads, by discovering that low-use roads can benefit wolves by creating easy paths of travel (Thurber et al. 1994, James and Stuart-Smith 2000, Pedersen et al. 2003, Whittington et al. 2005). Merrill (2000) reported wolves breeding successfully at road densities of 1.42 km/km^2, and Thiel et al. (1998) found wolves denning close to areas with high degrees of human activity, illustrating the point that the main concern is the attitudes of local people, not the roads themselves (Carroll et al. 2003). Studies that have investigated wolf responses to towns, villages, houses and holiday residences have found that wolves avoid these structures in some areas (Theuerkauf et al. 2003a, Jedrzejewski et al. 2004, Jedrzejewski et al. 2005, Kaartinen et al. 2005), but that they are not affected by them (Pedersen et al. 2003), or actively seek them out in search of food in other areas (Fritts et al. 2003). To my knowledge no studies have been conducted to investigate whether wolves differentiate between permanent and temporary structures.

The main goal of this study was to document the distribution of wolves in the Absaroka-Beartooth Wilderness (ABW), south-central Montana. This was done using relative densities of tracks and scats along Forest Service trails. Areas with higher densities of wolf sign will be prioritized for later searches for dens, rendezvous sites and hunting areas.

The following hypotheses were tested;

1. Population increase

   The general population increase in the Greater Yellowstone Ecosystem (GYE) should have been reflected in a greater abundance of wolves in the ABW in 2006 than in 2005. If the results show that there were more trail segments with sign in 2006 than in 2005, I will consider that to be an indicator that the methods are reliable enough to document relative population density, and that the results from the following tests were trustworthy.

2. Habitat selection

   Because several studies from North America have found wolves to prefer forested habitat, I predict that there will be more sign on trails in forested areas than in nonforested areas.

3. Human avoidance

   If wolves actively avoid humans, I expect that there will be less sign on trails near outfitter camps and Forest Service cabins than on trails far from these structures.

4. Permanent and temporary structures

   If wolves habituate more easily to permanent structures, there will be a difference between wolf occurrence in relation to outfitter camps that are temporary and Forest Service cabins that are permanent.

Study area

The study area was the Absaroka-Beartooth Wilderness (ABW), which is located in south-central Montana just north of Yellowstone NP (Fig. 1). The administration of the area involves three National Forests (Gallatin, Shoshone and Custer) and five Ranger Districts (Gardiner, Beartooth, Big Timber, Clarks Fork and Livingston). The ABW was established in 1978 and has a total area of 3,819 km^2, of which the vast majority is in Montana while a small portion is in Wyoming (www.wilderness.net). The Gardiner Ranger District portion, about 1/3 of the ABW, shares a boundary with Yellowstone NP and was the focal area of this study. As a designated Wilderness, use or possession of motorized and mechanized equipment is prohibited (www.wilderness.net), which creates a favorable environment for wildlife.

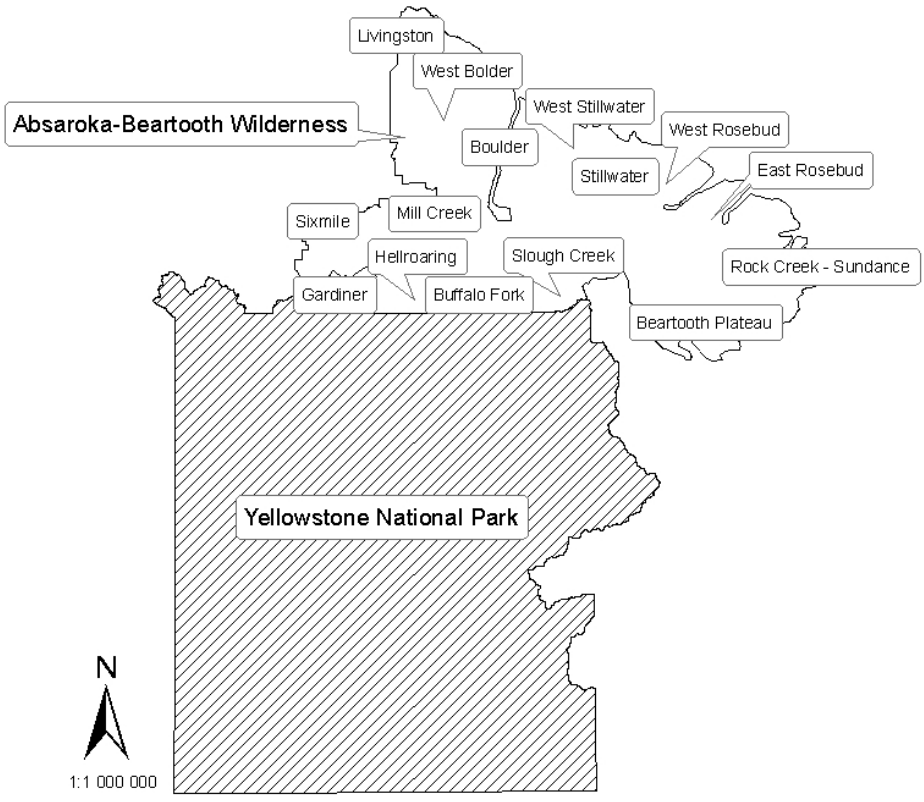

Figure 1: Yellowstone National Park and the Absaroka-Beartooth Wilderness, located in Montana and Wyoming.

The terrain is remote, rugged, and mountainous and consists of deeply incised glacial valleys and high plateaus (www.wilderness.net). Vegetation includes montane forests dominated by Douglas-fir (*Psedotsuga menziesii*), aspen (*Populus tremuloides*), Engelmann spruce (*Picea engelmannii*), lodgepole pine (*Pinus contorta*) and limber pine (*P. flexilis*), and subalpine forests dominated by subalpine fir (*Abies lasiocarpa*) and whitebark pine (*P. albicaulis*) (Alden et al. 1999, DeBlander 2001). The highest peak reaches 3900 meters above sea level (www.wilderness.net), and the vegetation at high elevations includes tundra and perennial snowfields. Riparian areas are comparatively limited, but are ecologically important. Predators include grizzly bears (*Ursus arctos*), black bears (*U. americanus*), mountain lions (*Felis concolor*), lynx (*F. lynx*), wolverine (*Gulo gulo*), wolves, coyotes (*Canis latrans*), and red foxes (*Vulpes vulpes*). Ungulate species include elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), whitetailed deer (*O. virginianus*), bighorn sheep (*Ovis canadensis*), moose (*Alces alces*), and mountain goats (*Oreamnos americanus*) (Alden et al. 1999).

The topography of the Rocky Mountains creates a wide range of weather conditions and unique local climates (Alden et al. 1999). Winter is characterized by heavy snows, spring by thunderstorms and tornadoes in the plains and blizzards and avalanches in the high peaks, summer is warm at high elevations and hot on the lower plains, and fall is crisp and cool (Alden et al. 1999). At high elevations, there is snow from early October to early July, and at lower elevations, from late October to late May (Despain 1990). The annual rainfall in the Rocky Mountains ranges from 7 to 43 inches (Alden et al. 1999).

Methods

The Gardiner Ranger District is the most likely portion of the ABW to be used by wolves. It is the region closest to Yellowstone NP and known wolf pack territories, and it has the largest concentrations of ungulates. Consequently, this project emphasized searches for wolf sign in this administrative unit. The other four Ranger Districts, none of which share a boundary with Yellowstone NP, comprise the remaining 2/3 of the ABW. Registration of wolf sign was also done in these districts, but not as intensively as in the Gardiner district.

Sampling

The ABW has about 1,437 km of trails, which have been delineated into 379 labeled and easily defined segments, generally from one trail junction to another. The segments vary in length from 0.2 to 13.4 km. The trail segments were traveled by the Gardiner Ranger District's trail crew between 15 May and 1 November, with 278 and 216 trail segments traveled in 2005 and 2006, respectively. The number of wolf scats and tracks representing individual wolves was recorded by segment on each trip. The crew was trained in determining wolf scats and tracks by Jim Halfpenny, director of "A Naturalist's World" in Gardiner.

Distinguishing wolf from dog

Several methods exist to differentiate between wolf and dog (*Canis familiaris*) sign, but the methods are not always reliable. Most dog breeds have smaller paws than wolves, but certain breeds can have matching sizes e.g. Irish Wolfhound, Pyrenean Mountain Dog, Great Dane and St. Bernard (Aronson and Eriksson 1992, Landa 1999, Montana Fish Wildlife & Parks 2006). The Irish Wolfhound can also match the length of the stride of a wolf (Aronson and Eriksson 1992). Using the assumption that dogs wander and waste more energy than wolves to distinguish tracks is not reliable, because dogs soon acquire a more energy-saving behavior when they are separated from their owner (Aronson and Eriksson 1992). Scats from dogs and wolves can be difficult to distinguish if the dog has fed on game (Landa 1999). In this study, dogs and wolves were separated by how frequently the trail segment was traveled by hikers. If the crew encountered hikers with

dogs, or the trail was known to be a popular recreation hike, the probability of a large canine track belonging to a dog was considered high and any sign was disregarded. However, Yellowstone NP has a ban on dogs; therefore, sign on popular trails originating in Yellowstone NP was not disregarded.

Distinguishing wolf from coyote

Coyote tracks are easily distinguishable from wolf tracks, because wolves have larger paws than coyotes (Murray and Lariviere 2002, Montana Fish Wildlife & Parks 2006). It is more difficult to distinguish coyote scats from wolf scats, because of the large overlap in diameter (Weaver 1979, Reed et al. 2004, Prugh and Ritland 2005). Thompson (1952) used a diameter of 24 mm to separate the two species. This study used Halfpenny's (1986) cutoff diameter and classified all canine scat larger than 23 mm as wolf scat. This gave bias because some of the collected scats could be from coyotes, and small wolf scats would be classified as coyote and not included in the sampling. Wolves and coyote could also be spatially distributed differently, e.g. coyotes are found near camps and cabins while wolves avoid these structures, which would bias the results.

Analyses

To conduct an analysis of the relative distribution of wolf sign, data were standardized as the number of tracks and scats found on each designated trail segment divided by the number of times each segment was traveled. In this fashion, the density of sign could be compared among trail segments. This is referred to here on as relative wolf sign. Wolf sign located on trails were displayed with GIS technology. Maps were created using ArcGIS 9.1 and the data were analyzed using a combination of tools in ArcGIS 9.1, Hawth's Analysis Tools 3.26 and ET Geo Wizards 9.6. Forested and nonforested trail segments were determined from vegetation maps provided by the Gallatin National Forest. The three Forest Service cabins in Slough Creek, Buffalo Fork and Hellroaring Creek, together with the Silver Tip Ranch in Slough Creek, were the permanent structures included in the analysis and 13 outfitter camps were the temporary structures. The period of time each outfitter camp stood in the ABW varied from two weeks to four months. The Forest Service cabins were used between May and November.

Statistics

To determine if there was a difference in frequency of wolf sign on trail segments between 2005 and 2006, I used a chi square test (Moore and McCabe 2003). To test which year had the highest relative wolf sign, a Mann Whitney test was used (Moore and McCabe 2003). This was done both for all trail segments traveled in 2005 and/or 2006, and for trail segments traveled at least once in both 2005 and 2006. The remaining hypotheses were tested using binary logistic regression (Agresti 2002). To test for other variables, the distance to Yellowstone NP was included in the model, and to correct for sampling effort, the average number of times a trail was traveled was also included. In this test, only trail segments that were located within the Gardiner Ranger District were used. The distance from each trail to the nearest camp/cabin and the boundary of Yellowstone NP was measured from the center of the trail segment. The dominant vegetation type for each trail was used for the whole trail. All statistical tests were set to 5 % significance level, and the tests were made using MINITAB 14 Statistical Software (Minitab Inc).

Results

The total number of trail segments monitored decreased from 278 in 2005 to 216 in 2006 (Table 1), comprising 1050 and 709 km, respectively. The number of times a trail segment was traveled varied, but the average number increased from 3.08 (range 1-22) in 2005 to 6.24 (range 1-52) in 2006. The total amount of sign in 2005 was 115; 74 tracks and 41 scats. In 2006, this doubled to 241; 137 tracks and 104 scats. The average relative wolf sign index increased from 0.186 to 0.252 from 2005 to 2006.

Table 1: Wolf sign survey summary statistics for the Absaroka-Beartooth Wilderness, south-central Montana, in 2005 and 2006.

	2005	**2006**
No. trail segments	278	216
No. times a trail was traveled		
Mean	3.08	6.24
SD	2.85	6.70
Range	1-22	1-52
Scats per trail segment		
Mean	0.15	0.48
SD	0.47	1.14
Range	0-3	0-6
Tracks per trail segment		
Mean	0.27	0.63
SD	0.64	1.22
Range	0-4	0-6

The highest densities of wolf sign were found in the south, close to the boundary of Yellowstone NP (Fig. 2 & 3). In 2005, the majority of sign was located from the eastern part of the Gardiner basin, eastwards through the Hellroaring, Buffalo Fork and Slough Creek drainages, to the southern part of the Stillwater drainage. There was also a high density of sign in the southern part of the Beartooth Plateau and the western part of the Boulder drainage, close to the Mill Creek drainage. Observations of single wolf sign were registered on four different trail segments on the north-eastern boundary of the ABW. In

2006, the areas with the highest density of sign had shifted slightly. Sign density was greater along the southern boundary of the ABW; i.e. from the middle of the Gardiner basin, eastwards through the Hellroaring, Buffalo Fork and Slough Creek drainages. There was, however, a gap in the presence of sign between the Gardiner basin and Hellroaring/Buffalo Fork/Slough Creek. The density of sign in the southern part of the Beartooth Plateau was still present, but the sign in the western part of the Boulder drainage continued over to the Mill Creek drainage.

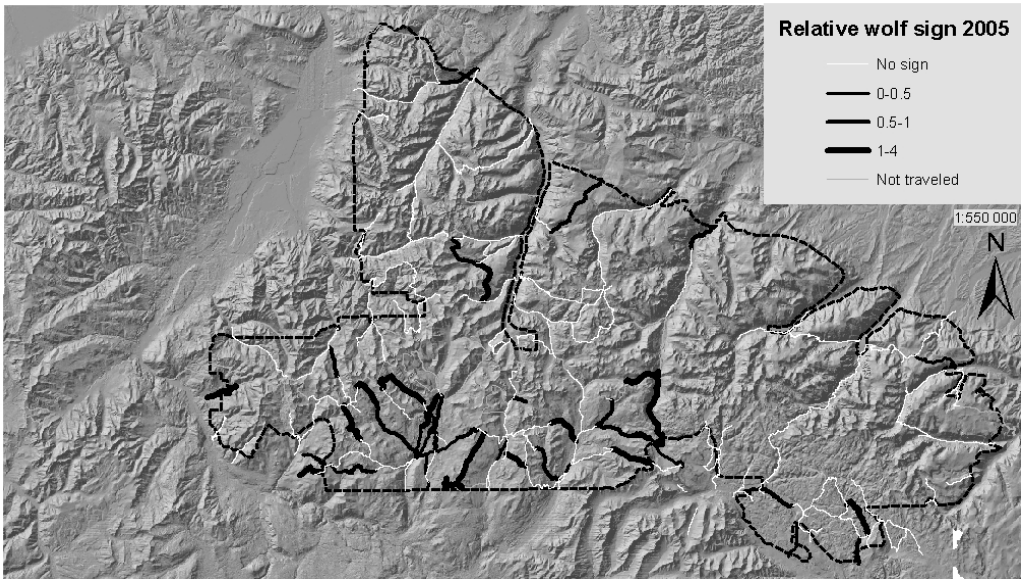

Figure 2: Relative wolf sign in the Absaroka-Beartooth Wilderness, south-central Montana, 2005.

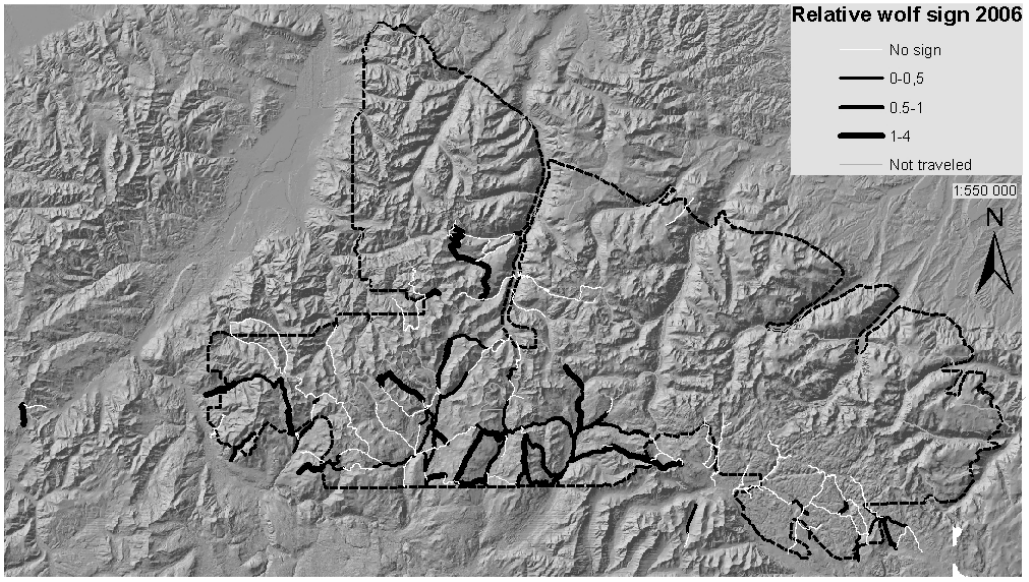

Figure 3: Relative wolf sign in the Absaroka-Beartooth Wilderness, south-central Montana, 2006.

In addition to the collection of wolf sign, wolves were observed once (Fig. 4) and wolf howls were heard by the trail crew four times during 2006. The observation took place at the Forest Service cabin in Slough Creek on 5 July, when five adult wolves ran past the cabin. One of the wolves carried a radio collar. The pack was heard at the same location two days before and on the same day as the observation. Another team heard wolves howling on two successive days two weeks later, six km northeast of the Slough Creek cabin.

Figure 4: Wolves by the Forest Service cabin in Slough Creek, Absaroka-Beartooth Wilderness, south-central Montana, 5 July 2006. Photo by Kasper Engelhardt.

Difference in wolf sign between 2005 and 2006

A significantly greater frequency of trail segments (all segments) showed wolf presence in 2006 than 2005 ($\chi^2 = 22.282$, d.f. = 1, p-value > 0.001). A Mann Whitney test showed that 2006 had more sign than 2005 (W = 63251.5, $N_{2005} = 278$, $N_{2006} = 216$, p-value > 0.001, Fig. 5). The increase in relative wolf sign was 35 % (mean ± S.D. 2005: 0.186 ± 0.54, 2006: 0.252 ± 0.45).

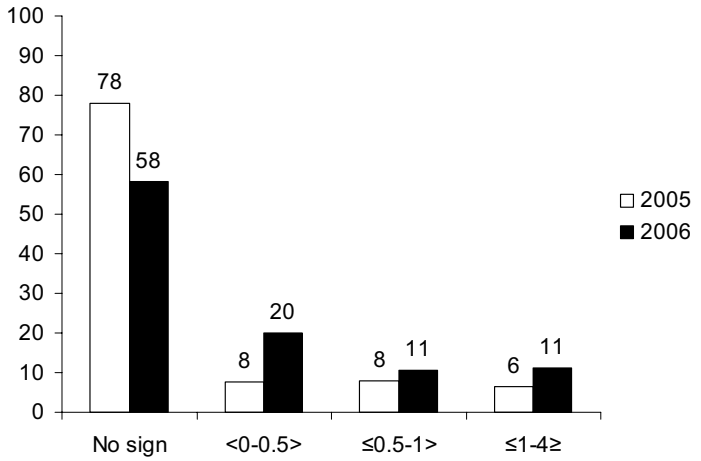

Figure 5: Relative wolf sign on trails traveled in the Absaroka-Beartooth Wilderness, south-central Montana, in 2005 and/or 2006. Numbers are given in percent.

Using only trail segments traveled in both 2005 and 2006, the difference in frequency of trails showing wolf presence was also significant between 2005 and 2006 ($\chi^2 = 6.851$, d.f. = 1, p-value = 0.009). The Mann Whitney test showed that 2006 had more sign than 2005 (W = 32025.5, $N_{2005} = 184$, $N_{2006} = 184$, p-value = 0.014, Fig. 6). The increase in relative wolf sign was 7 % (mean ± S.D. 2005: 0.225 ± 0.57, 2006: 0.240 ± 0.44).

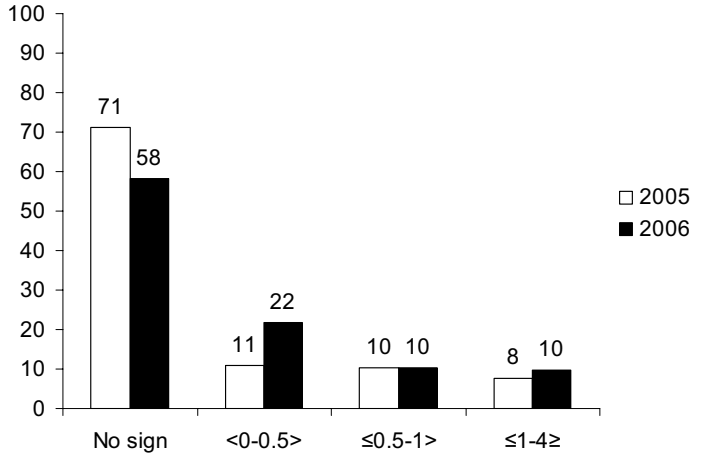

Figure 6: Relative wolf sign on trails traveled in the Absaroka-Beartooth Wilderness, south-central Montana, in both 2005 and 2006. Numbers are given in percent.

Variables explaining wolf presence

According to the best model explaining wolf presence in the Gardiner Ranger District, wolves did not differentiate between temporary outfitter camps and permanent Forest Service cabins, nor did they avoid camps or cabins (Table 2). There was also no difference in the amount of wolf sign between forested and nonforested areas. Distance to Yellowstone NP showed a significant negative correlation. For a ≥50 % chance to find wolf sign, the trail segment had to be within 21.5 km of the boundary to Yellowstone NP. The variable "average number of times a trail segment was traveled" was added to correct for effort in the model, and naturally showed that there was a higher probability of encountering wolf sign if the trail had been traveled often. The interaction term shows that trail segments located far from camps and cabins were traveled less by the crew. The fit of the model was not very good, however, with a Pearson goodness-of-fit of only 0.353. This indicated that there was much variation in the wolf distribution that had not been explained in the model.

Table 2: Model explaining wolf presence in the Gardiner Ranger District, Absaroka-Beartooth Wilderness, south-central Montana, in 2005 and 2006 (Pearson goodness-of-fit test = 0.353)

Predictor	**Coefficient**	**P-value**
Constant	1.962	0.125
Distance to camps/cabins (km)	0.029	0.374
Distance to Yellowstone National Park (km)	-0.091	0.013
Camp type (categorical)	0.239	0.687
Forest (categorical)	-1.260	0.304
Average number of times a trail segment was traveled	0.301	0.005
Distance camps/cabins (km) * Average number of times a trail segment was traveled	-0.039	0.002

Discussion

Reliability of the methods

Track surveys and other noninvasive methods are becoming more popular in wildlife and conservation research, because of few negative effects, such as immobilizing and handling the animals, in addition to being less time-consuming and expensive (Kendall et al. 1992, Smallwood and Fitzhugh 1995, Alexander et al. 2005). Although population estimates and trend monitoring can be difficult, studies have shown that, given certain criteria, noninvasive surveys can be reliable (Harris 1986, Kendall et al. 1992, Clevenger and Purroy 1996, Alexander et al. 2005). Methods to increase the reliability of the survey methods include monitoring over long time periods (≥12 years), using multiple counts each year (Harris 1986), maximizing the number of trail segments, and pooling data from multiple years (Kendall et al. 1992). This study was based on only two years, but had multiple counts for each year. The trail segments were of varying length, however, which may reduce the power of the tests (Kendall et al. 1992). As a test of the methods reliability, I determined whether the method detected the reported 20 percent increase in wolf numbers in the Greater Yellowstone Recovery Area from 2005 to 2006 (U.S. Fish and Wildlife Service et al. 2007). Both the chi square and the Mann Whitney test showed that there had been a population increase. The increase was roughly between 7 and 35 %. From this I conclude that the method was reliable for the purpose of this study.

Distribution of wolves

The maps suggested that the wolves in the ABW were located mainly in the vicinity of Yellowstone NP. This was confirmed with logistic regression, which was corrected for effort. Given the dispersal capabilities of wolves, it is surprising that wolves have not traveled further into the wilderness area. Wolves have been recorded dispersing long distances such as 670 (Van Camp and Gluckie 1979), 732 (Ballard et al. 1983), 840 (Boyd and Pletscher 1999) and 886 (Fritts 1983) km. Even though wolves have a great capacity for dispersal, they maximize their chance of breeding rather than maximizing resources (Mech and Boitani 2003). Studies have shown that territorial species are attracted to areas that already are inhabited (Stamps 1988, Smith and Peacock 1990, Ray

et al. 1991) presumably because areas that are occupied by conspecifics offer mates and an assurance of good habitat ("cuing") (Stamps 1988). For wolves this is seen in the Greater Yellowstone Ecosystem, where they only have a recolonization rate of 9.78 km/year, which is considerably lower than would be expected from the high reproductive rate and long distance dispersal of wolves (Hurford et al. 2006). That my model also showed this is an independent indicator of the suitability of these methods for this type of study. In addition to the drainages located close to Yellowstone NP, higher densities of sign were also detected on the southern slope of the Beartooth Plateau and in the Boulder/Mill Creek drainages. Single tracks and scat were observed on separate trail segments in 2005. These trail segments were located on the wilderness boundary from the north to the east.

Although wolves in the Greater Yellowstone Ecosystem generally are carefully monitored (Smith et al. 2006, U.S. Fish and Wildlife Service et al. 2007), there is little knowledge about wolves residing in the ABW. The maps presented in Figures 2 and 3 were compared to maps showing known territories in the Greater Yellowstone Ecosystem provided by the Rocky Mountain Wolf Recovery Interagency Annual Report from 2005 and 2006, the Yellowstone Wolf Project Annual Report from 2005, and Yellowstone's website by the National Park Service (www.nps.gov/yell/naturescience/wolves). From this comparison I conclude the following:

- The sign in the Gardiner basin in 2005 could have been from the Casey Lake pack, which consisted of three adults. The pack no longer existed in 2006, and the wolves were believed to have died of mange. The territory was later occupied by the Eagle Creek pack, which consisted of two adults and two pups. It was most likely this pack that produced the sign in the Gardiner basin in 2006 (U.S. Fish and Wildlife Service et al. 2006;2007).
- The presence of sign in the Hellroaring drainage in 2005 and 2006, probably was from the Hellroaring Creek pack, which had its core area in Yellowstone NP (Smith et al. 2006). This pack consisted of seven adults in 2005 (Smith et al. 2006), and five adults and one pup in 2006 (www.nps.gov/yell/naturescience/wolves).

- The sign in the Buffalo Fork drainage in 2005 and 2006 probably came from the Buffalo Fork pack, which consisted of two adults in 2005 and ten adults in 2006 (U.S. Fish and Wildlife Service et al. 2006;2007).
- The sign in the Slough Creek drainage in 2005 and 2006, and in addition the wolf howls and the observation in 2006, are not consistent with any known pack territory. The sign could be the result of traveling wolves from either the Slough Creek pack that reside in Yellowstone NP (Smith et al. 2006) or the Buffalo Fork pack (U.S. Fish and Wildlife Service et al. 2006;2007), or it could be a new pack. The continuation of the sign into the Stillwater drainage in 2005 might suggest the latter.
- The Beartooth pack most likely produced the sign detected on the southern slope of the Beartooth Plateau in 2005 and 2006. The pack was comprised of six adults in 2005, and five adults plus two pups in 2006 (U.S. Fish and Wildlife Service et al. 2006;2007).
- The sign in the Boulder drainage in 2005 and Boulder/Mill Creek could have come from the Carbonate Mountain pack, which consisted of five adults in 2005 (U.S. Fish and Wildlife Service et al. 2006). The pack was not detected by hunters or local game wardens in 2006 (U.S. Fish and Wildlife Service et al. 2007), but the trail crew detected a total of three tracks and eleven scats during 2006, indicating that the pack is still present.
- The Rosebud pack, which comprised of three adults in 2005 (U.S. Fish and Wildlife Service et al. 2006), could have been picked up by one single trail segment in the Rock Creek Sundance drainage in 2005. However, only one single scat was located, and it is therefore reason for caution.
- Sign was detected on three additional single trail segments. These were located on the northern border of the ABW in the West Boulder, Main Boulder and Stillwater drainages, where one data point (wolf sign) where detected one each. Because the sample size was small, it is difficult to speculate, but the sign might indicate the presence of the Moccasin Lake pack, and the Mission Creek, SW 28 or SW 57 pack (U.S. Fish and Wildlife Service et al. 2006).

Future searches for dens, rendezvous sites and preferred hunting regions should be concentrated in the areas with the highest relative wolf sign, i.e. the Gardiner basin, the Hellroaring, Buffalo Fork, and Slough Creek drainages, the southern part of the Stillwater drainage, the southern slope of the Beartooth Plateau, and from the western part of the Boulder drainage to the Mill Creek drainage. Studies that have investigated how wolves select den and rendezvous sites have pointed to the importance of canopy cover, and loose, sandy soil for excavating dens (Ballard and Dau 1983, Fuller 1989, Norris et al. 2002, Theuerkauf et al. 2003c). When pup raising is successful, wolves will reuse the same rendezvous site (Ballard and Dau 1983, Fuller 1989, Theuerkauf et al. 2003c, Capitani et al. 2006). Searches for dens and rendezvous sites should, therefore, be concentrated in areas with forest and loose, sandy soil. This will provide cover for the wolves and a suitable substrate for digging dens. Given that the wolves in the wilderness area are not hunted, these sites may be used for several years.

Habitat preferences

I detected no preferences for forested habitats by wolves. This may have been an error due to definitions used in the study. First, the vegetation maps used in the analysis divided vegetation into only four categories; aspen (forest), conifer (forest), sagebrush grassland (nonforest) and willow (nonforest). This grouping may have been too coarse to allow any patterns of selection to be manifested. Secondly, the trail segments often crossed several vegetation types, but only the dominant vegetation type was recorded for each trail. The dominant vegetation type was usually forest, so the number of trail segments with nonforest habitat was low compared to the number of trail segments with forest. Given that the result was not a statistical error, the results do not support my hypothesis, but fits well with the fact that wolves can make use of many different habitats (Fuller et al. 2003), and are limited only by the access to a sufficient prey base when not hunted by humans (U.S. Fish and Wildlife Service 1987). The main prey for wolves in Yellowstone NP is elk (*Cervus canadensis*) (Smith 2005), which have shifted their habitat preferences during summer to less open habitats, specifically burned forest, after the reintroduction of wolves (Mao et al. 2005). In Yellowstone NP wolves avoid burned areas, possibly because burned forest in Yellowstone NP are abundant in fallen timber

which represent difficult hunting areas (Mao et al. 2005). However, wolves in northwestern Montana have been shown to prefer burned forest for hunting, possibly because the understory provides good cover while stalking (Kunkel and Pletscher 2001, Arjo and Pletscher 2004). My data only differentiated between forested and nonforested areas, and it is therefore impossible to say if wolves in the ABW preferred or avoided burned forest. Wolves may change their habitat use throughout the year, in response to changes in their diet (Meriggi et al. 1991). In the ABW, it is therefore reasonable that wolves do not favor any habitat, but follow the habitat preferences of their prey. Another possible explanation is that the methods used did not allow the documentation of the true preference for forested and nonforested areas, but only showed if wolves used trails more or less in these habitats. Because the trails represent easy paths of travel (Thurber et al. 1994, James and Stuart-Smith 2000, Whittington et al. 2005, Shepherd and Whittington 2006), there is no reason why wolves should leave the trails once entering a different habitat.

Human avoidance

No evidence was found that wolves either differentiated between temporary outfitter camps and permanent Forest Service cabins, or avoided camps or cabins. The outfitter camps and Forest Service cabins in the ABW differ in two main aspects. First, the cabins are permanent structures, whereas the camps are temporary. Secondly, the camps are always occupied by one or more people who look after the camp, whereas the cabins are occasionally vacant of people. The results do not support my hypothesis, and suggest that wolves view these structures equally.

A study conducted in the Canadian central Artic found that wolves selected mineral exploration sites and outfitter camps, probably because of the availability of food rewards (Johnson et al. 2005). However, with the “leave no trace” policies in the ABW, i.e. packing out all trash, leftover food, and litter (www.wilderness.net), there is little or no food around camps and cabins to attract wolves. Generally, wolves are believed to avoid human contact spatially in areas with low human density, and temporally in areas with high human density (Vilà et al. 1992, Ciucci et al. 1997, Pedersen et al. 2003, Theuerkauf

et al. 2003a). In Poland, where human density is high, wolves avoid being in the same place at the same time as humans (Theuerkauf et al. 2003a, Theuerkauf et al. 2003b). Wam (2003) studied wolf behavior towards humans in densely populated parts of Norway, and found that when approached, wolves ran away with a mean tolerance distance of 257 meters. Because my data only included sign indicating wolf presence, I was not able to determine whether wolves in the ABW avoid humans temporally. In areas with no legal or illegal hunting, however, wolves are thought to be less wary of humans (Thiel et al. 1998, Merrill 2000, McNay 2002, Whittington et al. 2005), and wolves are currently colonizing a wide range of habitats that previously was not thought to be suitable wolf habitat (Mech 1995). A study investigating carnivore responses to big-game hunting on the boundary between ABW and Yellowstone NP found that wolves did not change their movement patterns during the pre-hunt and hunting periods (Ruth et al. 2003). Because wolves in the ABW and Yellowstone NP are not hunted by humans, it is reasonable to conclude that wolves do not avoid humans in this area.

Conclusions and management implications

I found no evidence that wolves in the ABW selected between forested and nonforested habitats, differentiated between temporary outfitter camps and permanent Forest Service cabins, or avoided camps or cabins. The latter can be an indicator that no illegal hunting of wolves is taking place in the ABW. However, the model gave a poor fit, suggesting that there were unidentified factors explaining wolf presence that were not included in the model. One possible factor is location of prey, which is important for the distribution of wolves. Therefore the model could be improved by incorporating the seasonal distribution of ungulates. The results suggest that, at present, no special precautions are needed to ensure the survival of wolves in the ABW. This can change, however, if management practices are altered, i.e. hunting is allowed. The USFWS will not delist the wolf in the recovery area until all three states (Montana, Idaho and Wyoming) have an accepted wolf management plan (U.S. Fish and Wildlife Service et al. 2007). Until then, wolves are protected from hunting.

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