



The National Park Service

WILDLIFE RESPONSES TO MOTORIZED WINTER RECREATION IN YELLOWSTONE

2007 ANNUAL REPORT
(December 18, 2006 through March 29, 2007)

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Executive Summary

Staff from the Yellowstone Center for Resources and Resource Management & Visitor Protection Office monitored wildlife responses to motorized winter recreation during December 18, 2006 through March 29, 2007. The winter of 2006-07 was moderate in terms of snow pack and temperatures. Over-snow vehicle traffic by visitors was slightly higher than in winter 2005-06, but low in comparison to previous winters.

We used snowmobiles to conduct repeated surveys of wildlife responses to motorized winter vehicles and human activities along four groomed road segments in areas of both low and high intensity human and wildlife use. Our sampling unit was the interaction between over-snow vehicles and an observed group of wildlife within 500 meters (547 yards) of the road. We focused our efforts on monitoring the responses of bison, elk, and trumpeter swans owing to the proximity and/or perceived sensitivity of these species to motorized recreation activities during winter.

The behaviors of humans traveling in over-snow vehicles in response to observing wildlife groups were as follows: 57% demonstrated no visible reaction; 32% stopped; 7% dismounted their vehicles; 2% approached wildlife; and 2% impeded or hastened wildlife on the roadway.

We suggest that training for guides, park staff, and concessionaires include the following recommendations: 1) stop at distances >100 meters (109 yards) from groups of wildlife, when possible; 2) reduce the frequency of multiple groups of motorized vehicles stopping in the same area to observe wildlife; 3) reduce the number of stops to observe wildlife and, 4) reduce human activities away from vehicles during these stops.

METHODS

We examined the behavioral responses of bison, elk, and swans to motorized recreation to evaluate the following management objectives regarding human use and its potential adverse effects on wildlife during winter in Yellowstone National Park:

- Minimize the avoidance, displacement, or harassment of wildlife from noise, vehicles, or other human activities;
- Minimize vehicle-caused wildlife deaths or injuries;
- Minimize human conflicts with ungulate (e.g., bison, elk) movements on plowed roads;
- Minimize incidents of wildlife trapped by snow berms on plowed roads; and
- Minimize the facilitation of ungulate use of groomed roads.

Weather Data: We collected weather data from four automated SNOTEL sites to assess the effects of snow pack on wildlife behavior, distribution, and stress levels. The Madison Plateau (ID 11e31s) and Canyon (ID 10e03s) SNOTEL sites were located within Yellowstone National Park, while the West Yellowstone (ID 11e07s) and Northeast Entrance (ID 10d07s) sites were located near the park's boundary. The West Yellowstone site was located at 2,042 meters (6,700 feet) elevation, while the Northeast Entrance, Madison Plateau and Canyon sites were located at 2,240 meters (7,350 feet), 2,362 meters (7,750 feet), and 2,466 meters (8,090 feet) elevation, respectively. Data from each site was obtained from the Natural Resources Conservation Service website (<http://www.wcc.nrcs.usda.gov/snotel/>).

Snow water equivalent (i.e., the amount of water in the snow pack) was either measured or estimated at each SNOTEL site. Snow water equivalent appears to strongly influence where ungulates are located during winter because of increased energy expenditures for movements and accessing forage through snow with higher water content. Ungulates can tolerate higher levels of snow pack early in the winter than later in the winter but, in general, tend to concentrate in areas with lower local snow water equivalent as landscape snow pack increases.

Motorized Use Data: In coordination with the Visitor Services Office, we analyzed daily visitation statistics for the 2006-07 winter season. The Visitor Services Office routinely compiles data from entrance stations, Business Management Office operations, entrance studies

and visitor surveys to determine visitation statistics. Park staff at the west, south, and east entrances recorded numbers and types of over-snow vehicles that entered the park each day.

Human Behaviors and Wildlife Responses: Since the winter of 2002-03, we have focused our efforts on monitoring the responses of bison (*Bison bison*), elk (*Cervus elaphus*), bald eagles (*Haliaeetus leucocephalus*), and trumpeter swans (*Olor buccinator*) to motorized winter use vehicles owing to the proximity and/or perceived sensitivity of these species to motorized recreation activities during winter. During winter 2006-07, two 2-person crews used snowmobiles to conduct repeated surveys of wildlife distribution and responses to motorized winter use vehicles and human activities along four groomed road segments. Portions of these road segments that were only open to travel by snow coaches (i.e., Riverside Drive, Freight Road, Firehole Canyon Drive) were also sampled. The sampled road segments and their endpoints were as follows (note: “(C)” denotes snow coach-only portions):

<u>Road Segment</u>	<u>End-point</u>	<u>End-point</u>
1. West Yellowstone to Madison (C) Riverside Drive	West entrance station Drive entrance	Madison junction Drive exit
2. Madison to Old Faithful (C) Firehole Canyon Drive (C) Freight Road	Madison junction Canyon Drive entry Lower Geyser Basin entrance	Bridge south of Old Faithful Canyon Drive exit Midway Geyser Basin exit
3. Madison to Norris	Madison junction	Norris junction
4. Norris to Mammoth	Norris junction	Golden Gate bridge

Survey crews were based in Old Faithful and Mammoth Hot Springs. The Old Faithful crew sampled the roads from Madison to West Yellowstone and from Madison to Old Faithful. The Madison road segments included surveying along Riverside Drive, Firehole Canyon Drive and the Freight Road, all of which are designated for snow coach-only travel. At the request of sub-district law enforcement, the Madison survey snowmobiles were marked with “Wildlife Research” decals to reduce confusion for visitors and enforcement personnel if snowmobiles were seen on these restricted roads. The Mammoth crew sampled the Norris to Mammoth and Madison to Norris road segments via snowmobile.

Each crew determined the order in which their assigned road segments were sampled using a restricted randomization design. The crew selected the order of monitoring for road segments without replacement, so that each segment was monitored before re-sampling occurred. The direction that a given road segment was traveled by the crew was reversed each time the segment was surveyed. Crews conducted surveys on weekdays, weekends, peak-use periods, low-use periods, and holidays. This sampling design enabled us to record daily and weekly variations in human and wildlife activities.

Surveys were only conducted during daylight hours for safety and efficiency reasons. Surveys were conducted by a pair of observers driving snowmobiles at ≤ 50 kilometers (30 miles) per hour. Beginning and ending times of the survey were recorded as a measure of survey effort. Visibility was categorized as good, fair (i.e., small, patchy areas of low visibility), or poor (large areas of low visibility within 100 meters (109 yards) of the road). Precipitation was categorized as none, light rain, heavy rain, light snow, heavy snow, or fog. If conditions or visibility varied substantially along the road segment, then observers recorded the predominant condition for the segment. While traveling along each road segment, observers used various pullouts and overlooks that provided vantages of wildlife in areas that could not be observed from the main road corridor.

While traveling a given road segment, observers documented the responses of wildlife to motorized winter vehicles and associated human activities. The observers traveled until a group (i.e., ≥ 1 animal) of a species was detected with the unaided eye. The observers then stopped in a position where they could observe the group without disturbing the animals and observe approaching motorized winter vehicles. The observers recorded the following information: 1) time of observation; 2) species; 3) habitat type for the majority of the group (i.e., aquatic, burned forest, unburned forest, wet meadow or riparian, dry meadow, geothermal); 4) group size and composition (i.e., adult males, adult females, young-of-the-year); and 5) predominant activity of the group of animals (i.e., if two animals are bedded and three are feeding, then the predominant activity was listed as feeding). Activity was recorded as standing (i.e., stand, perch, feed), traveling (i.e., walk, swim, fly), or resting (i.e., bed, float). Traveling was defined as animals walking, swimming, or flying in sustained movement. Animals were recorded as resting when they were stationary (i.e., lying, perching, floating). Owing to the difficulties of observing

precise behaviors at large distances with binoculars, activity was only classified for that portion of the group that was within approximately within 500 meters of the road.

If several assemblages of animals of the same species were located in the same vicinity, then the observers defined group membership based on how the assemblages of animals were distributed and moving in space. Following Clutton-Brock et al. (1982), factors that were considered included the relative distances between individuals, degree and form of interaction, similarity or synchrony of behavior, and similarity of orientation.

Our sampling unit was the interaction between motorized vehicles and associated humans and an observed group of wildlife within 500 meters of the road. Though this definition of an “interaction” is somewhat arbitrary, the proposed 500-meter “interaction zone” enabled us to evaluate the influence of distance from a disturbance on wildlife responses to human activities. If any wildlife group member was within 500 meters of the road, then the observers remained in a position along the road to observe the group until ≥ 1 motorized vehicle (other than the observers’ snowmobile or vehicle) entered a zone within 500 meters of the group. Motorized winter vehicles could enter the 500-meter zone from either direction along the road corridor. The observers categorized the motor vehicle/human activity and associated wildlife response during a single interaction (i.e., one group of vehicles and the response by the group of wildlife) and then continued the survey to locate the next group of wildlife along the road segment. If motorized vehicles and/or humans were already present within 500 meters of a group of wildlife when the observers detected the wildlife group, then the observers began recording the interaction upon detection. If an interaction did not occur within 10 minutes of the observers detecting a group of wildlife within 500 meters of the road, then the observers recorded that no interaction occurred and continued the survey to locate the next group of wildlife.

Prior to departing an area with a group of wildlife, the observers drove up to a position on the road approximately perpendicular to the group of wildlife and recorded the location using a global positioning system (GPS) unit. Observers also recorded the perpendicular distance and direction from the road to the nearest animal using a laser range finder. If the group was farther from the road than the maximum capability of the range finder, or the range finder could not focus on the animals, then the observers estimated the distance using 7.5 minute quad maps.

During an interaction, observers recorded the following information regarding human activity within the interaction zone: 1) number and type of motorized winter vehicles in the

group; 2) if the group of motorized winter vehicles stopped within the interaction zone; 3) distance from the stopped motorized winter vehicles to the nearest animal in the group; 4) if the motorized winter vehicle group was guided by a commercial operator familiar with the park and its winter regulations; 5) duration that the motorized winter vehicles remained within the interaction zone; 6) whether humans dismounted the motorized winter vehicles (e.g., stepped off snowmobile or stepped out of snow coach); 7) if humans approached the animal group and their distance from the road and nearest animal; 8) if humans initiated behaviors to attract the attention of wildlife (e.g., yelling, whistling, throwing objects); and 9) if wildlife movement was impeded, altered, or hastened by motorized winter vehicles.

The observers recorded the highest level of human activity (i.e., most potential for disturbance) during the interactions. Activities were categorized as follows:

- No visible reaction to wildlife;
- Stop (time in seconds);
- Dismount the motorized winter vehicle (i.e., exit the snow coach or get off the snowmobile);
- Approach the wildlife (i.e., move from the location where the motorized winter use vehicle was parked in the direction of the animals); or
- Impede and/or hasten (e.g., chase wildlife, force animals to move faster ahead of motorized winter vehicle traffic, or block wildlife movement).

The observers also recorded the behavior of animals in the group to the motorized winter vehicle group and associated human activity. Response behaviors were categorized as follows (Chester 1976):

- No visible reaction to motorized winter vehicles or human activity;
- Look at motorized winter vehicles or human activity and then resume their behavior;
- Travel (e.g., walk/swim) away from motorized winter vehicles or human activity;
- Attention/alarm behavior, including rising from bed or agitation (e.g., buck, kick, bison tail rise);
- Flight (e.g., move quickly (e.g., run) away from motorized winter vehicles or human activity); or

- Defense (e.g., attack/charge at motorized winter vehicles or human activity).

The number of individual animals in the group displaying each response was recorded. The response behavior was only recorded for those animals within approximately 500 meters of the road.

The observers continued monitoring and recording the interaction until all members of the initial motorized winter vehicle and/or human group departed the area within 500 meters of the wildlife group. The observers recorded the number, type, and response of all motorized winter vehicles and associated humans that traveled within 500 meters of the wildlife group during the interaction (i.e., until all members of the initial motorized winter vehicle and associated human group departed the area within 500 meters of the wildlife group). No single interaction was monitored for >30 minutes.

Once the survey of a selected road segment was completed, the observers traveled to the next randomly selected road segment and began the next survey. If no animals of species of interest were detected along the selected road segment, then the observers traveled to the next randomly selected road segment and began that survey. Thus, it is possible that the same road segment was sampled more than once per day (e.g., morning and afternoon).

RESULTS

In general, average snow water equivalent values per month in winter 2006-07 were lower than the overall monthly averages since 1981. Values at three SNOTEL stations in the park (Northeast Entrance, West Yellowstone, and Madison) were 70-80% of average (1980-81 through 2006-07) for December, January, February, and March, but snow water equivalent at the Northeast Entrance and West Yellowstone decreased in April due to early-season warm temperatures. The Canyon site had the highest snow water equivalent values, ranging from 86% to 150% of average. Ambient temperatures during surveys ranged from -13°F to 55°F (-25°C to 13°C) in the Mammoth area and -17°F to 48°F (-27°C to 9°C) in the Madison area.

The public winter season was 84 days from December 18, 2006, through March 11, 2007, when all park grooming operations ceased. Plowing operations began at Mammoth Hot Springs on March 5, 2006, and progressed southward into the interior of the park. Monitoring of interactions between motorized vehicles and wildlife began on December 11, 2006, seven days

prior to the scheduled opening for public use, and continued until March 29, 2007, approximately two weeks after roads closed to the public.

Total over-snow vehicles entering the park included 244 snowmobiles and 11 coaches through the East Entrance Station, 9,360 snowmobiles and 592 coaches through the South Entrance Station, and 15,660 snowmobiles and 1,453 coaches through the West Entrance Station (Appendices A and B). Data from the North Entrance Station were not available at the time of this report. The maximum number of snowmobiles and coaches entering the West Entrance Station on any given day was 356 snowmobiles and 32 coaches (these numbers include administrative and non-recreational traffic). The maximum daily number of snowmobiles and coaches entering the South Entrance Station was 191 snowmobiles and 16 coaches. The maximum daily number of snowmobiles and coaches entering the East Entrance Station was 30 snowmobiles and 2 coaches.

Hardy (2001) reported that levels of stress hormones in central Yellowstone elk were higher after exposure to >7,500 cumulative vehicles entering the West Entrance Station. This threshold was reached on December 31st during both winters of her study (i.e., 1998-99, 1999-2000), but progressively later in following winters (January 20, 2003; February 1, 2004; February 22, 2005; and February 2, 2006). During winter 2006-07, the cumulative total of over-snow vehicles entering the West Entrance Station surpassed 7,500 vehicles on January 25th, which was similar to winter 2003, but earlier than in winters 2003-04, 2004-05, and 2005-06. According to the Visitor Services Office, the daily number of snowmobiles entering the West Entrance Station during the winter of 2006-07 did not exceed 400 machines, which was the daily snowmobile entry limit under the Temporary Winter Use EA. The numbers of snowmobiles entering the South and East Entrance Stations during winter 2006-07 did not exceed the daily snowmobile entry limits for each station during the winters of 2003-04 and 2004-05 (i.e., South = 220 snowmobiles; East = 40 snowmobiles).

Winter use crews conducted 208 surveys of road segments, covering 5,154 kilometers (3,203 miles). Observers recorded 1,663 groups of wildlife during these surveys, including 353 groups of elk, 809 groups of bison, 266 groups of swans, 154 groups of bald eagles, 56 groups of coyotes, and 26 groups of other species (e.g., foxes, bobcats, golden eagles, wolves, etc.). Observers recorded human behaviors and the responses of wildlife to motorized winter vehicles during 983 over-snow vehicle interactions, 111 wheeled vehicle interactions, and 16 pedestrian

interactions (e.g., skiers, snowshoers; Appendix C). No groups of wildlife were observed during three surveys of road segments.

Human Responses - The behaviors of humans associated with over-snow vehicles in response to observing wildlife groups were as follows: 59% had no visible reaction to wildlife; 30% stopped; 7% dismounted their vehicles; 2% approached wildlife; and 2% impeded or hastened wildlife (Appendix D). Groups of only snowmobiles, only snow coaches, and only pedestrians were involved in 52 ($n = 575$), 25 ($n = 274$), and 1 ($n = 13$) percent, respectively, of the observed wildlife-human interaction events with wildlife during winter 2006-07. Ten percent ($n = 111$) of observed interactions involved wheeled vehicles on plowed roads. The remaining 12 percent ($n = 137$) was comprised of mixed groups, which were usually snowmobiles and coaches, but occasionally mixed groups of over-snow vehicles and pedestrians.

Wildlife Responses - Overall, the responses of wildlife to over-snow vehicles and associated humans were as follows: 76% of the observed responses by groups of wildlife were categorized as no apparent response, 18% look/resume, 1% attention/alarm, 4% travel, and 1% flight. Wildlife responses to motorized winter use were slightly lower for most species than in previous winters, with the “no apparent response” and “look-and-resume” categories accounting for greater than 80% of the bison, elk, and swan observations (Appendices E and F).

Bison were observed on groomed roads during 73 of 723 observations of bison groups from December 18, 2006 through March 29, 2007. Thus, the majority of observed bison groups were using areas off the groomed roads. Fifty of the bison groups observed on groomed roads were traveling, whereas 21 groups were categorized as stationary (two groups were uncategorized). Bison use of groomed roads occurred throughout the daylight survey hours, with no apparent peak in daily time of road use. Elk groups were observed using groomed roads less than bison.

A total of 54 interaction events between over-snow vehicles and ungulates were documented when animal groups were on groomed roads, including 29 ungulate groups interacting with only snowmobiles and 9 ungulate groups interacting with only snow coaches. In 16 interaction events, mixed groups of snowmobiles and snow coaches encountered ungulates on the road (Appendix G).

Borkowski et al. (2006) reported that, during 1998-99 through 2003-04, elk responded three times as often (52%) as bison (19%) during interactions with groups of snowmobiles and snow coaches due to increased vigilance responses (elk: 44%; bison: 10%). The frequency of higher-

intensity movement responses during this period by both bison and elk were 6–7% travel, 1–2% flight, and 1% defense. The overall pattern of species-specific responses continued in winter 2006-07 (i.e., elk responded three times as often as bison). However, monitoring during 2006-07 indicated there were fewer movement responses by both bison and elk, amounting to less than 3% of each species' total responses. There are several factors which could have contributed to the observed differences between previous winters and winter 2006-07. One factor, likely related to commercial guiding, was the temporal change in traffic patterns. As noted by project staff and discussed in the soundscapes section (3.7) of the Winter Use Plan Draft EIS, much of the over-snow vehicle traffic from the West Entrance to Old Faithful occurred during two relatively short periods, (1) in the morning when most guided groups of snowmobiles and coaches were entering the park for the day, and (2) in the late afternoon when guided groups were returning to West Yellowstone. The resulting traffic pattern was different than prior to winter 2002-03, and these busy periods can become sharply defined when weather and daily routines of guiding operations dictate when groups enter the park, schedule their arrival at destinations, and leave the park. This change in the timing of traffic does not mean that interactions between over-snow vehicles and wildlife did not occur during the rest of the day. However, this change does suggest that a number of the interactions between over-snow vehicles and wildlife along the West Yellowstone to Old Faithful corridor, which in the past were spread out over daylight hours, now occur in a more-constrained time period.

Another possible factor that may have contributed to fewer responses during winter 2006-07 was that bison left the Hayden Valley and migrated westward to the Madison-Firehole area at a later date in winter 2006-07, probably in response to relatively mild snow and weather conditions. Thus, a smaller number of bison were present in the Madison-Firehole for much of the over-snow vehicle season, and these animals may have had a longer history of interacting with visitors. Given the higher vehicle traffic on the west entrance road compared to the Hayden Valley, the bison found in the Madison-Firehole area during winter 2006-07 may have been less naïve, more habituated to, and less likely to respond to winter recreational activity.

Elk have also undergone decreases in abundance and distribution in response to wolf recolonization of the Madison-Firehole area that could contribute to a change in their responses to human activity. The proportion of the central elk herd found in the Madison River drainage has increased from approximately 30% in winter 2000-01 to 80% in winter 2006-07, with

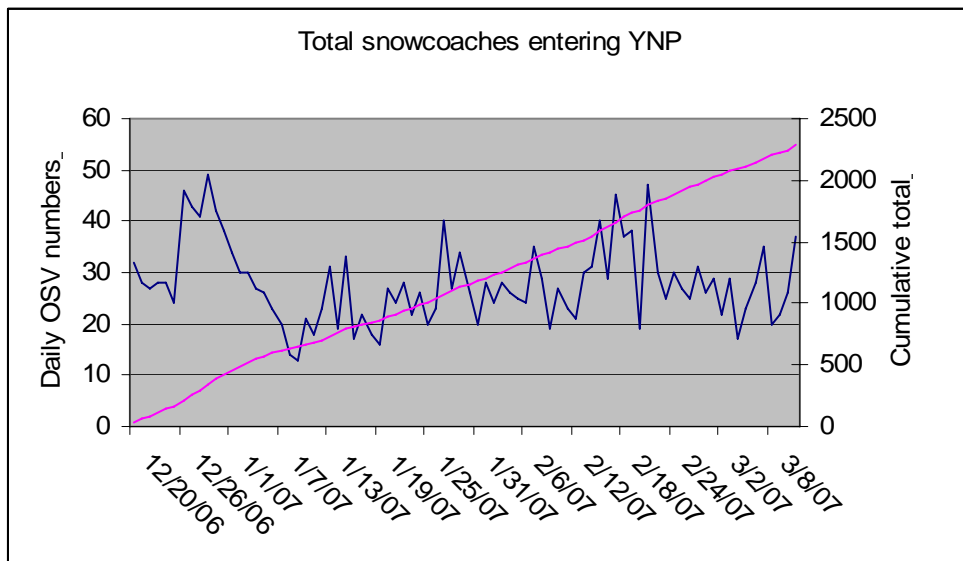
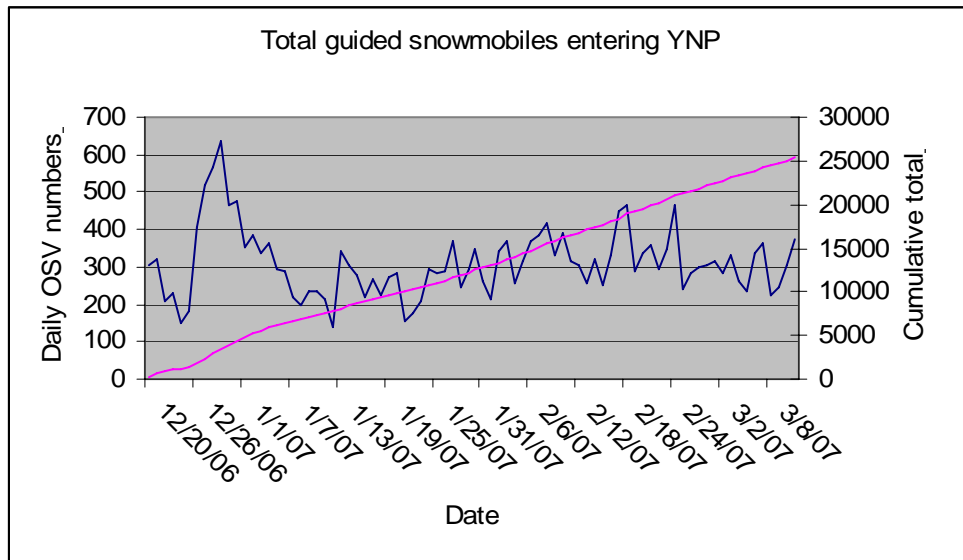
concurrent decreases in the Firehole and Gibbon River drainages (R. Garrott, Montana State University, unpublished data). Along the West Yellowstone to Old Faithful corridor, elk now appear to primarily use portions of large meadows and geothermal areas close to deep, wide sections of rivers and away from transitional edges between habitats. These areas (e.g., Seven-mile bridge meadow; Biscuit basin) have good visibility and room to maneuver during encounters with wolves. Additionally, many of these meadow complexes are adjacent to roadways where wolves may be less likely to hunt due to human activity. In Banff National Park, Canada, high human activity in an area of the Bow Valley temporarily displaced wolves, thereby reducing predation by approximately 60% (Hebblewhite et al. 2005). This creates, in effect, a feedback loop in which elk residing near human activity could experience reduced predation pressure, resulting in higher adult and calf survival and increased density. As the proportion of the Madison-Firehole elk herd that preferentially uses these geothermal and meadow areas increases, more elk could spend more time in proximity to human recreational activity (over-snow vehicles, roads, ski trails) and, thereby, become more habituated, and less likely to respond, to human activity.

Patterns of bald eagle behavior in the Madison-Firehole drainage also appeared to differ from previous winters. A large proportion of the bald eagle sightings and interactions in previous winters were of a nesting pair adjacent to the West Entrance Road, which consisted of vigilant birds. In winter 2006-07, according to observers, this pair sat deeper in the nest, which caused some visitors to think the nest was empty and not stop to observe the birds. A focused effort by National Park Service employees to educate local guide companies about the possible disturbance and traffic issues in this area also likely reduced interactions in this area. During the winter of 2006-07, the majority of bald eagle sightings and interactions in the Madison-Firehole area were not in the immediate vicinity of this nest and involved less vigilant birds farther from the road.

LITERATURE CITED

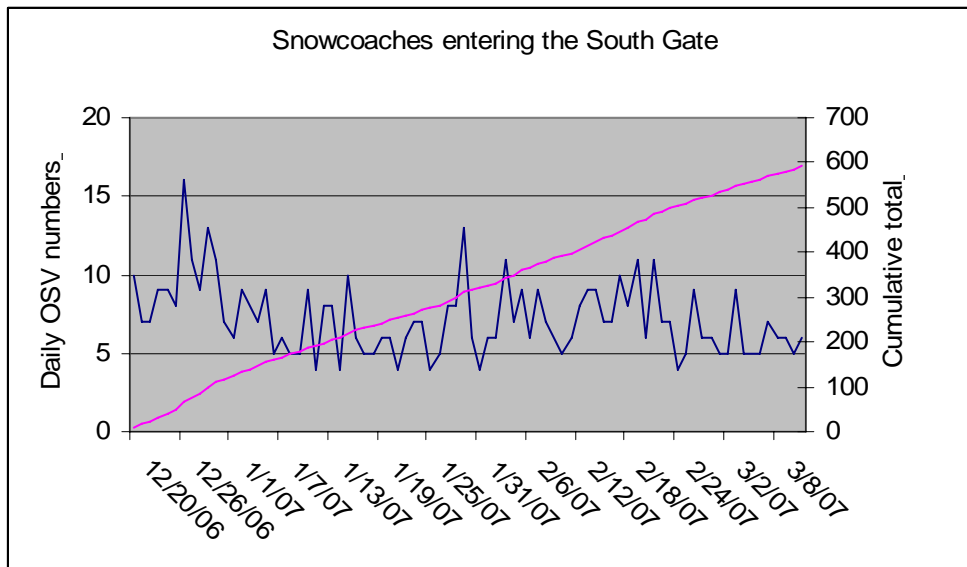
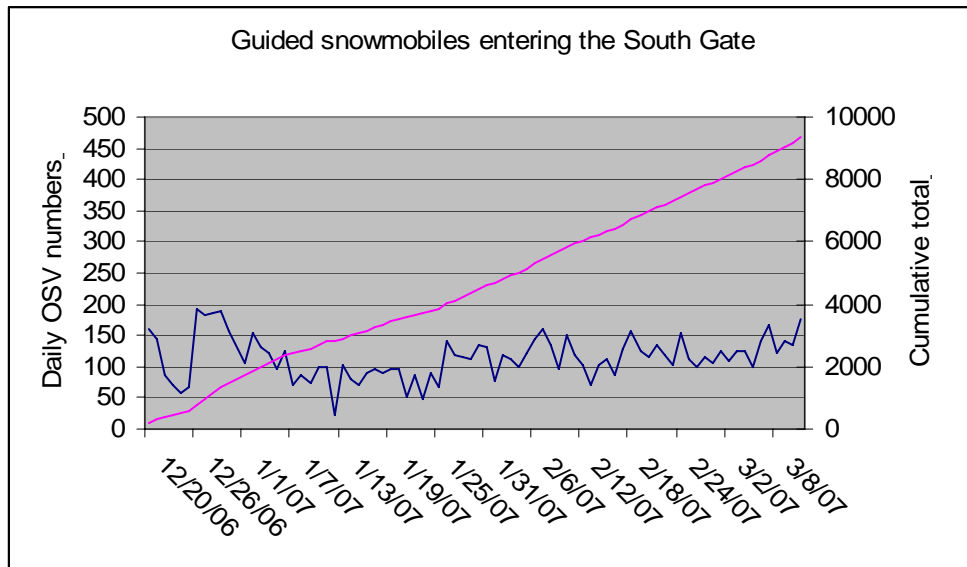
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Appendix A: Daily and cumulative numbers of commercially guided snowmobiles and snow coaches entering Yellowstone National Park during winter 2006-07. Daily totals are displayed on the left axis, while the winter's cumulative total is displayed on the right axis. Note that the scales of the Y axes vary among figures.

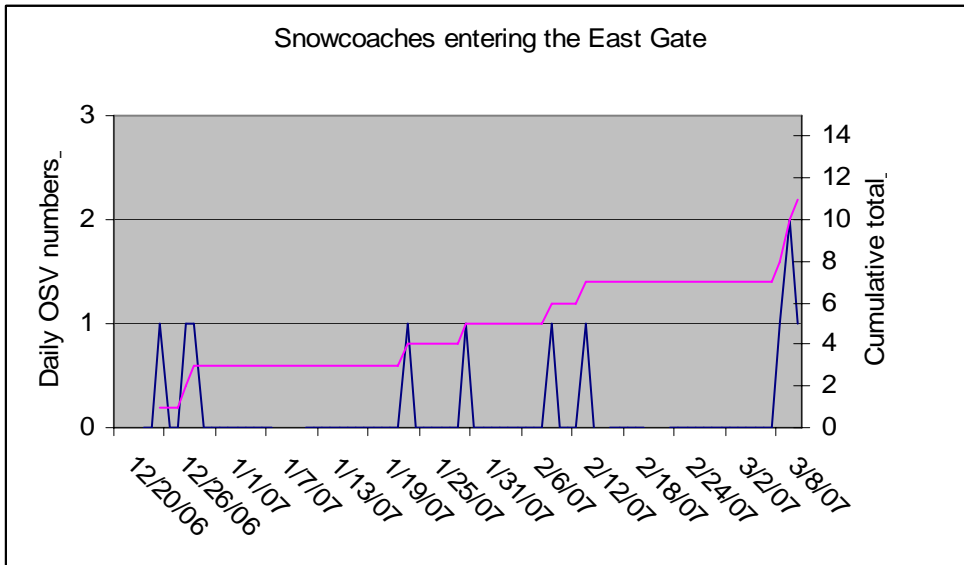
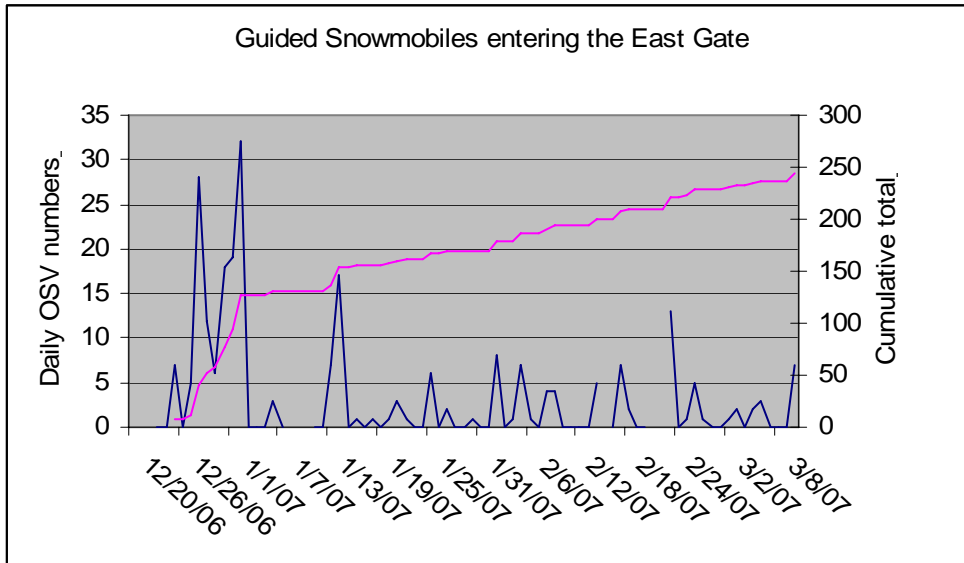


Appendix B: Daily and cumulative numbers of commercially guided snowmobiles and snow coaches entering various entrance stations of Yellowstone National Park during winter 2006-07. Daily totals are displayed on the left axis, while the winter's cumulative total is displayed on the right axis. Note that the scales of the Y axes vary among figures.

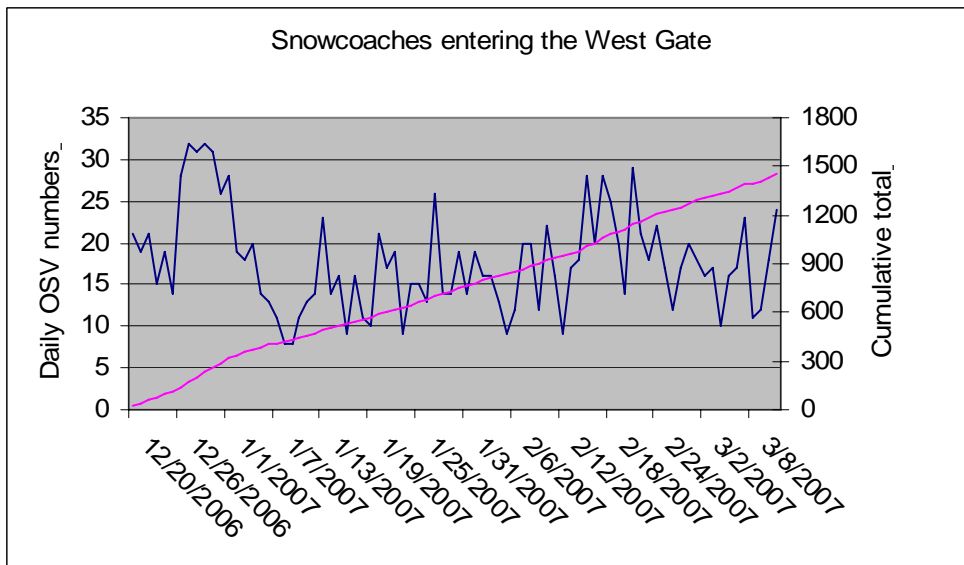
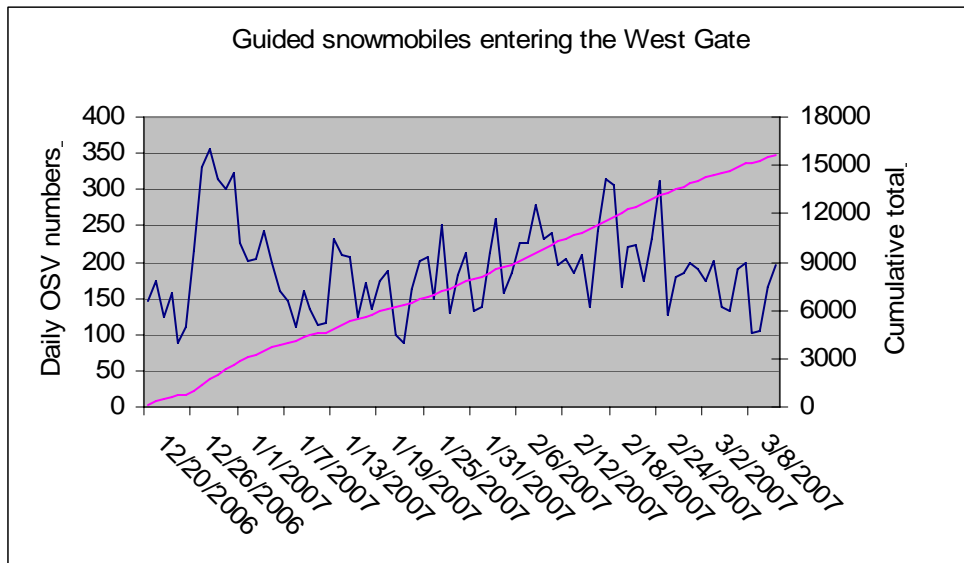
South Entrance Station



East Entrance Station



West Entrance Station



Appendix C. Summaries of observed wildlife groups and interactions by road segment during December 18, 2006, through March 29, 2007, Yellowstone National Park, Wyoming. Abbreviations are: OSV (over-snow vehicle), WV (wheeled vehicle) and P (pedestrian).

Road Segment	Species	Interactions	
Madison-Old Faithful	Bison	275 OSV, 45 WV, 5 P	
	Elk	72 OSV, 5 WV, 3 P	
	Swans	23 OSV, 1 WV	
	Coyote	10 OSV, 2 WV	
	Bald Eagle	21 OSV, 1 P	
	Golden Eagle	3 OSV	
	Madison-West Yellowstone	Bison	86 OSV, 17 WV, 4 P
Elk		170 OSV, 16 WV, 1 P	
Swans		116 OSV, 3 WV, 1 P	
Coyote		9 OSV, 1 WV	
Bald Eagle		28 OSV, 6 WV, 1 P	
Bobcat		2 OSV	
Raccoon		1 OSV	
Wolf		1 OSV	
Madison to Norris		Bison	40 OSV, 8 WV
		Elk	12 OSV
	Swans	19 OSV	
	Coyote	5 OSV	
	Bald Eagle	10 OSV, 1 WV	
	Golden Eagle	1 OSV	
Mammoth to Norris	Bison	55 OSV, 5 WV	
	Fox	1 OSV	
	Swans	2 OSV	
	Coyote	6 OSV	
	Bald Eagle	11 OSV, 1 WV	
	Golden Eagle	1 OSV	

Road Segment	Observations	% of Total Observations	Interactions	% of Total Interactions
Madison to West Yellowstone	684	41	463	42
Madison to Old Faithful	697	42	466	42
Mammoth to Norris	137	8	99	9
Norris to Madison	145	9	82	8

Appendix D. Comparison of human behavior during interactions with wildlife (i.e., bison, elk, trumpeter swans) among over-the-snow vehicles in commercially guided groups of snowmobiles, snow coaches and administrative groups (i.e., park and concessionaire staff) during December 18, 2006, through March 29, 2007, Yellowstone National Park, Wyoming. This data does not include wheeled vehicles or pedestrian-only interactions.

Only Snowmobiles Present

Elk n=164

Human Behavior	Commercially Guided Groups (n = 69)		Administrative Groups (n = 92)		Mixed (guided and admin present simultaneously)	
	No. Events	Proportion	No. Events	Proportion	No. Events	Proportion
None	51	73.9%	17	18.5%	0	
Stop	9	13.0%	73	79.3%	1	33.3%
Dismount	4	5.8%	0		1	33.3%
Approach	5	7.2%	0		1	33.3%
Impede-Hasten	0		2	2.2%	0	

Bison n=250

Human Behavior	Commercially Guided Groups (n = 133)		Administrative Groups (n = 109)		Mixed (guided and admin present simultaneously)	
	No. Events	Proportion	No. Events	Proportion	No. Events	Proportion
None	107	80.4%	65	59.6%	1	12.5%
Stop	13	9.7%	39	35.8%	4	50.0%
Dismount	9	6.8%	1	.9%	1	12.5%
Approach	2	1.5%	0		2	25%
Impede-Hasten	2	1.5%	4	3.7%	0	

Swans n=107

Human Behavior	Commercially Guided Groups (n = 62)		Administrative Groups (n = 42)		Mixed (guided and admin present simultaneously)	
	No. Events	Proportion	No. Events	Proportion	No. Events	Proportion
None	50	82.3%	18	42.9%	3	100%
Stop	7	9.7%	24	57.1%	0	
Dismount	3	4.8%	0		0	
Approach	2	3.2%	0		0	

Only Snow Coaches Present (all coaches are considered guided for analysis)

Elk $n=58$

Human Behavior	Number of Events	Proportion
None	39	67.2%
Stop	13	22.4%
Dismount	5	8.6%
Approach	1	1.7%

Bison $n=145$

Human Behavior	Number of Events	Proportion
None	112	77.2%
Stop	25	17.2%
Dismount	3	2.1%
Approach	1	0.7%
Impede-Hasten	4	2.8%

Swans $n=43$

Human Behavior	Number of Events	Proportion
None	29	67.4%
Stop	11	25.6%
Dismount	2	4.7%
Approach	1	2.3%

Mixed Groups (snowmobiles and snow coaches present simultaneously)

Elk $n=32$

Human Behavior	Number of Events	Proportion
None	4	12.5%
Stop	10	31.3%
Dismount	9	28.1%
Approach	9	28.1%

Bison n=57

Human Behavior	Number of Events	Proportion
None	15	26.3%
Stop	25	43.9%
Dismount	12	21.0%
Approach	5	8.8%

Swans n=9

Human Behavior	Number of Events	Proportion
None	1	11.1%
Stop	3	33.3%
Dismount	4	44.4%
Impede-Hasten	1	11.1%

Over-snow vehicle groups with pedestrians (skiers, snowshoers, etc)

Elk n=2

Bison n=4

Swans n=1

Bald Eagle n=1

Human Behavior	Mixed Snowmobile Groups	
	No. Events	Proportion
None	1	12.5%
Stop	2	25.0%
Approach	4	50.0%
Impede-Hasten	1	12.5%

Appendix E. Behavioral responses of wildlife species observed from December 18, 2006, through March 29, 2007, Yellowstone National Park, Wyoming.

Bison

Category of Response	No Events	Proportion
No Visible Response	471	87.2%
Look-Resume	48	8.9%
Travel	12	2.2%
Alarm-Attention	4	.74%
Flight	5	.93%

Elk

Category of Response	No Events	Proportion
No Visible Response	160	57.3%
Look-Resume	114	40.9%
Travel	3	1.1%
Alarm-Attention	2	.70%

Trumpeter Swans

Category of Response	No Events	Proportion
No Visible Response	143	86.7%
Look-Resume	9	5.4%
Travel	12	7.3%
Unknown	1	.6%

Coyotes

Category of Response	No Events	Proportion
No Visible Response	10	30.3%
Look-Resume	13	39.4%
Travel	5	15.2 %
Alarm-Attention	1	3.0%
Flight	4	12.1%

Bald Eagles

Category of Response	No Events	Proportion
No Visible Response	52	62.7%
Look-Resume	18	21.7%
Travel	11	13.2%
Flight	2	2.4%

Other species (wolf, golden eagle, raccoon, bobcat, fox)

Category of Response	No Events	Proportion
No Visible Response	5	50.0%
Look-Resume	2	20.0%
Travel	3	30.0%

Appendix F. Comparison of wildlife (i.e., bison, elk, swans) responses during interactions with over-the-snow vehicles in commercially guided groups (including snowmobiles and snow coaches), and administrative groups (i.e., park and concessionaire staff) during December 18, 2006, through March 29, 2007, Yellowstone National Park, Wyoming. This data does not include wheeled vehicles or pedestrian-only interactions.

Wildlife responses to groups of only snowmobiles

Elk n= 164

Wildlife Response	Commercially Guided Groups (n=69)		Administrative Groups (n=92)		Mixed (guided and admin present simultaneously)	
	No. Events	Proportion	No. Events	Proportion	No. Events	Proportion
None	38	55.1%	41	44.6%	3	100%
Look-Resume	31	44.9%	48	52.2%		
Travel			2	2.2%		
Alarm-Attention			1	1.0%		

Bison n=250

Wildlife Response	Commercially Guided Groups (n=133)		Administrative Groups (n=109)		Mixed (guided and admin present simultaneously)	
	No. Events	Proportion	No. Events	Proportion	No. Events	Proportion
None	120	90.2%	84	77.1%	6	75.0%
Look-Resume	9	6.7%	19	17.4%	2	25.0%
Travel	2	1.5%	5	4.6%		
Alarm-Attention	1	0.8%	1	0.9%		
Flight	1	0.8%				

Swans n=107

Wildlife Response	Commercially Guided Groups (n=62)		Administrative Groups (n=42)		Mixed (guided and admin present simultaneously)	
	No. Events	Proportion	No. Events	Proportion	No. Events	Proportion
None	58	93.5%	28	66.6%	3	100%

Look-Resume	1	1.6%	4	9.5%		
Travel	3	4.8%	9	21.4%		
Unknown			1	2.4%		

Wildlife responses to ‘mixed’ groups (snowmobiles and snow coaches present simultaneously)

Elk n=32

Wildlife Behavior	Number of Events	Proportion
None	16	50.0%
Look-Resume	14	43.8%
Travel	1	3.1%
Alarm-Attention	1	3.1%

Bison n=57

Wildlife Behavior	Number of Events	Proportion
None	49	85.9%
Look-Resume	4	7.0%
Travel	3	5.3%
Alarm-Attention	1	1.8%

Swans n=9

Wildlife Behavior	Number of Events	Proportion
None	8	88.9%
Look-Resume	1	11.1%

Wildlife responses to groups of only snow coaches

Elk $n=58$

Wildlife Response	Number of Events	Proportion
None	39	67.2%
Look-Resume	19	32.8%

Bison $n=145$

Wildlife Response	Number of Events	Proportion
None	134	92.4%
Look-Resume	10	6.9%
Flight	1	.7%

Swans $n=43$

Wildlife Response	Number of Events	Proportion
None	40	93.0%
Look-Resume	3	7.0%

Wildlife responses to groups of Over-snow vehicles and pedestrians (skiers, snowshoers, etc)

Elk $n=2$

Bison $n=4$

Swans $n=1$

Bald Eagle $n=1$

Wildlife Behavior	Number of Events	Proportion
None	8	100%

Appendix G. Encounters between over-snow vehicles and ungulates documented on groomed roads from December 18, 2006, through March 29, 2007, Yellowstone National Park, Wyoming.

Human Behavior	Groups of only snowmobiles		Groups of only snow coaches		Mixed groups	
	No. Events	Proportion	No. Events	Proportion	No. Events	Proportion
None	10	34.5%	3	33.3%	4	25.0%
Stop	12	41.4%	3	33.3%	5	31.3%
Dismount	1	3.4%			2	12.5%
Impede-Hasten	6	20.7%	3	33.3%	5	31.3%