Research Studies Related to Snowmobiling Impacts

WILDLIFE – Introduction and General Wildlife and Nature

A wide range of studies, dating back to the 1970s, have been done regarding the impacts of snowmobiles on wildlife. Generally, most studies have concluded that impacts are minimal or can at least be managed and that snowmobilers and wildlife can coexist very well and have done so for many years.

Even though many studies are twenty or thirty years old, their results are still applicable if not even substantially less (lower levels of impact) given the significant decrease in snowmobile sounds and exhaust emissions compared to 1970- and 1980-era snowmobiles. While most recent studies have been related to the Yellowstone National Park Winter Plan or to the growing ATV use (similar to the 'growing snowmobile use' that triggered many of the 1970s and 1980s era snowmobile studies), many have applicability and can be extrapolated for use in other areas. General snowmobile related findings include:

A University of Wisconsin study on the effects of snowmobile sound levels on deer and cottontail rabbits concluded that "only minor reactions were noted in the movements of cottontail rabbits and white-tailed deer to moderate and intensive snowmobiling activity" and that it had not been possible to determine sound levels at which there is a clear reaction on the part of the deer "because snowmobiles must be so close to deer to generate the higher levels that other factors such as visible presence…are likely to be more important." This study also compared the reaction of deer to the presence of cross-country skiers and found that when cross-country skiers replaced snowmobiles on the test trail systems, the deer moved away from the trail more frequently.

A study by the State of Maine concluded that, "Deer consistently bedded near snowmobile trails and fed along them even when those trails were used for snowmobiling several times daily. In addition, fresh deer tracks were repeatedly observed on snowmobile trails shortly after machines had passed by, indicating that deer were not driven from the vicinity of these trails." It also found that "the reaction of deer to a man walking differed markedly from their reaction to a man on a snowmobile. This decided tendency of deer to run with the approach of a human on foot, in contrast to their tendency to stay in sight when approached by a snowmobiler, suggests that deer responded to a machine and not to the person riding it."

A study conducted on the White Mountain National Forest in New Hampshire monitored snowmobile operations and deer movement and concluded that deer travel patterns were not affected by periodically heavy snowmobile use. In addition, continued use of established snowmobile trails was recommended.

The University of Minnesota study found no meaningful difference in deer's home range during periods of snowmobile use and non-use.

Addressing the subject of snowmobile operations in Yellowstone National Park, former Superintendent Jack Anderson commented, "We found that elk, bison, moose, even fawns, wouldn't move away unless a machine was stopped and a person started walking. As long as you stayed on a machine and the machine was running, they never paid any attention. If you stopped the machine, got off and started moving, that was a different story. The thing that seemed to be disturbing to them was a man walking on foot."

Voyageurs National Park reopened eleven bays located in the park to snowmobiling in 2001 as the result of a study that found there was no significant correlation between wolf activity and human use on these bays which had been closed to snowmobiling in 1992.

The Michigan DNR reported in 2005 that the gray wolf population in Michigan's Upper Peninsula (U.P.) rose from 360 to 400 this past year – hand-in-hand with the growth of snowmobiling in the U.P. – and that they were proposing to remove the wolf from the "endangered species" list. At the same time, the number of gray wolves in the Northern Rockies has surpassed 1,000 – just a decade after wolves were reintroduced to Yellowstone National Park – and concurrent with snowmobiling growth in the Rockies.

General and specific species-related wildlife studies related to snowmobiling or OHVs include:

General / Wildlife and Nature

1. **Wildlife Responses to Motorized Winter Recreation in Yellowstone – 2009 Annual Report**. McClure, C., Reinhart, D., White, P.J., Donovan, M. & Teets, B. (2009) National Park Service, Yellowstone Center for Resources. http://www.nps.gov/yell/parkmgmt/upload/Winter%202008-2009%20Wildlife%20Monitoring%20Report%20Draft.pdf

Executive Summary: Staff from the Yellowstone Center for Resources monitored wildlife responses to motorized winter recreation during December 10, 2008 through March 22, 2009. Oversnow vehicle traffic and general park visitation was lower this winter than the winter of 2007-2008 with a 28% drop in snowmobiles and a 10% drop in snowcoaches.

We used snowmobiles to conduct repeated surveys of wildlife responses to motorized winter vehicles and human activities along three groomed road segments in areas of both low and high intensity human and wildlife use. Our sampling unit was the interaction between oversnow 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 oversnow vehicles in response to observing wildlife groups were as follows: 55% demonstrated no visible reaction; 33% stopped; 6% dismounted their vehicles; 5% approached wildlife; and 1% impeded or hastened wildlife on the roadway. Seventy-five percent of the wildlife showed no visible response to oversnow vehicle interactions, 18% looked at the oversnow vehicles or humans and resumed their previous activity, 1% traveled, 5% displayed alarm or attention and less than 1% fled from the area.

2. **Wildlife Responses to Motorized Winter Recreation in Yellowstone – 2008 Annual Report**. McClure, C., Davis, T., Reinhart, D. & White. P.J. (2008) National Park Service, Yellowstone Center for Resources. http://www.nps.gov/yell/parkmgmt/upload/2008wildlife_final.pdf

Executive Summary: Staff from the Yellowstone Center for Resources monitored wildlife responses to motorized winter recreation during December 14, 2007 through March 24, 2008. Oversnow vehicle traffic by visitors was slightly lower than winter 2006-07. This primarily reflected a 7% drop in snowmobiles. However, the park saw a 9% increase in snowcoaches during 2007-08.

We used snowmobiles to conduct repeated surveys of wildlife responses to motorized winter vehicles and human activities along three groomed road segments in areas of both low and high intensity human and wildlife use. Our sampling unit was the interaction between oversnow 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 oversnow vehicles in response to observing wildlife groups were as follows: 52% demonstrated no visible reaction; 38% stopped; 4% dismounted their vehicles; 5% approached wildlife; and 1% impeded or hastened wildlife on the roadway. Seventy-two percent of the wildlife showed no visible response to oversnow vehicle interactions, 20% looked at the oversnow vehicles or humans and resumed their previous activity, 4% traveled, 4% displayed alarm or attention and less than 1% fled from the area.

3. **Wildlife Responses to Motorized Winter Recreation in Yellowstone – 2007 Annual Report**. Davis, T., White. P. J., Reinhart, D. & McClure, C. (2007) National Park Service, Yellowstone Center for Resources. http://www.nps.gov/yell/parkmgmt/upload/2007winusewildliferpt_final.pdf

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.

4. **Behavioral Responses of Wildlife to Snowmobiles and Coaches in Yellowstone.** White, P.J., Davis, T., Borkowski, J.J., Garrott, R.A., Reinhart, D.P., & McClure, D.C. (2006) Yellowstone National Park and Montana State University, Bozeman, Montana. http://www.nps.gov/yell/parkmgmt/upload/2006wildliferpt_final.pdf

Abstract: Managers of Yellowstone National Park are charged with protecting some of our nation's most important natural resources, while providing for their use and enjoyment by visitors. Over 100,000 visitors entered the park by over-snow, motorized means on snowmobiles (94%) or coaches (6%) during 2003-2006. Most vehicles toured the central portion of the park where bald eagles (Haliaeetus leucocephalus), bison (Bison bison), coyotes (Canis latrans), elk (Cervus elaphus), and trumpeter swans (Olor buccinator) wintered in areas close to roads. We sampled 5,688 interactions between groups of these species and groups of snowmobiles and coaches during 2003-2006 and used multinomial logits models, odds ratios, and predicted probabilities to identify conditions leading to behavioral responses. Bison responded less frequently (20%) to snowmobiles and coaches than swans (43%), elk (52%), coyotes (61%), or bald eagles (83%) due to fewer vigilance responses. However, the frequency of higher-intensity movement responses was similar among species (8-10%), with the exception of coyotes (24%). The likelihood of vigilance and movement responses by these species increased significantly if animals were on or near roads, animals groups were smaller, humans approached animals on foot, interaction time increased, or the numbers of snowmobiles and coaches in a group increased. There were thresholds on the odds of eliciting a response by wildlife for several of these covariates. We did not detect significant increases or decreases in the odds of movement responses for any wildlife species as cumulative over-snow vehicle traffic increased through the winter. However, the likelihood of a vigilance response by bison decreased within the winter having the largest visitation, suggesting some habituation to snowmobiles and coaches. In contrast, there was a significant increase in the odds of vigilance responses by elk as the cumulative visitation increased through the winter. Human disturbance did not appear to be a primary factor influencing the distribution and movements of the wildlife species we studied. The risk of vehicle-related mortality from snowmobiles was quite low and observed behavioral responses were apparently short-term changes that were later reversed. Bison, elk, and swans in Yellowstone used the same core winter ranges during the past three decades despite large winter-to-winter variability in cumulative exposure to OSVs. There was no evidence that snowmobile use during the past 35 years adversely affected the demography or population dynamics of bald eagles, bison, elk, or trumpeter swans (no data was available for coyotes). Thus, we suggest regulations restricting levels and travel routes of OSVs were effective at reducing disturbances to these wildlife species below a level that would cause measurable fitness effects. We recommend park managers consider maintaining OSV traffic levels at or below those observed during our study. Regardless, differing interpretations of the behavioral and physiological response data will continue to exist because of the diverse values and beliefs of the many constituencies of Yellowstone.

5. **Wildlife Responses to Motorized Winter Recreation in Yellowstone – 2005 Annual Report**. White, P.J., Davis, T., & Borkowski, J. (2005) National Park Service, Yellowstone Center for Resources & Montana State University. http://www.nps.gov/yell/parkmgmt/upload/winterrec05.pdf

Abstract: This study monitored the behavioral responses of bison (*Bison bison*), elk (*Cervus elaphus*), and trumpeter swans (*Olor buccinator*) to motorized winter recreation by repeatedly surveying seven groomed or

plowed road segments in Yellowstone National Park during December 2004 through March 20005. The study sampled >2,100 interactions between vehicles and wildlife groups and used multinominal logits models to identify conditions leading to behavioral responses. Responses by these wildlife species to over-snow vehicles were relatively infrequent, short in duration, and of minor to moderate intensity, with >81% categorized as no apparent response or look/resume activities, 9% attention/alarm, 7% travel, and 3% flight or defense. Analyses of similar data collected during 1999-2004 indicated the likelihood of active responses by wildlife increased significantly if (1) wildlife were on or near roads, (2) more vehicles were in a group, (3) wildlife groups were smaller, (4) ungulates were in meadows instead of forest or geothermal habitats, (5) interaction times increased, (6) wildlife were traveling instead of resting, and (7) humans dismounted vehicles and/or approached wildlife. The likelihood of an active response by bison or elk decreased as cumulative visitation increased, suggesting that these ungulates habituated somewhat to motorized recreation. There was no evidence of population-level effects to ungulates from motorized winter use because estimates of abundance either increased or remained relatively stable during three decades of motorized recreation prior to wolf colonization in 1998. Thus, **we suggest that the debate regarding the effects of motorized recreation on wildlife is largely a social issue as opposed to a wildlife management issue**. The likelihood of active responses by wildlife can be diminished by (1) restricting travel to predictable routes and times, (2) reducing the number of vehicles in groups, (3) reducing the number and length of stops to observe wildlife, (4) stopping vehicles at distances >100 meters, and (5) preventing human activities away from vehicles.

6. **Wildlife Responses to Motorized Winter Recreation in Yellowstone – 2004 Annual Report**. White, P.J., Davis, T., & Borkowski, J. (2004) National Park Service, Yellowstone Center for Resources & Montana State University. http://www.nps.gov/yell/parkmgmt/upload/wildlifewinteruse_2004_final.pdf

Executive Summary: Staff from the Yellowstone Center for Resources and Resource Management & Visitor Protection Office monitored the behavioral responses of wildlife to motorized winter recreation during December 12, 2003 through April 1, 2004, for comparison to data from previous and future winters. We used snowmobiles and wheeled vehicles to conduct repeated surveys of wildlife responses to motorized winter use vehicles and human activities along nine groomed or plowed road segments. Our sampling unit was the interaction between motorized winter use and an observed group of wildlife within 500 meters of the road. We focused our monitoring on the responses of bison, elk, and trumpeter swans to motorized winter use vehicles owing to the proximity and/or perceived sensitivity of these species to motorized vehicles during winter.

Snow pack during early winter (i.e., October and November of 2003) was less than the historic average since 1981. Snow pack was approximately average by late winter, however, with the exception of the northern range area where snow pack remained below average throughout the winter. There was relatively low motorized use by visitors during winter 2004, compared to previous winters. Approximately 16,000 "over-the-snow" vehicles (i.e., snowmobiles and snow coaches; OSVs) entered the park's west entrance during winter 2004, compared to >22,000 OSVs during winter 2003 (which was also a relatively low visitation winter owing to poor snow pack). This lower visitation resulted, in part, from court orders in December and February and the accompanying uncertainty imposed on motorized recreation in the park.

Similar to previous winters since 1999, the responses of most wildlife species to OSVs and associated humans during winter 2004 were typically minor, with 58% (n = 1,296) of the 2,239 total observed wildlife responses categorized as no apparent response, 18% (n = 410) look/resume, 11% (n = 252) attention/alarm, 9% (n = 196) travel, 4% (n = 82) flight, and <1% (n = 3) defense. Wildlife responses to motorized winter use were consistent across species (bison, elk, swans), but the magnitude of the responses varied considerably among species. The likelihood of observing an active response to snow coaches or increasing numbers of snowmobiles in a group was similar for bison and swans, but significantly higher for elk. The likelihood of a response by each species decreased as distance from the road increased. The estimated odds of observing an active response compared to no response by bison or elk were significantly higher for administrative traffic than for guided OSVs. Also, wheeled vehicles elicited substantially fewer active responses by bison or elk than either administrative or guided groups of OSVs.

Independent studies of the responses of wildlife to OSVs and associated humans in Yellowstone National Park (Hardy 2001, Jaffe et al. 2002, Davis et al. 2004) during 1999-2004 have consistently reported that behavioral responses were relatively infrequent, short in duration, and of low intensity. Also, bison and elk were less likely to respond on days with higher traffic, likely due to some sort of habituation to the relatively continuous traffic. Gross estimates of the additional energy costs of travel or flight responses provoked by OSVs were relatively moderate

for elk. Thus, animals exposed to OSVs likely do not incur a substantial energetic cost from such interactions, and these costs are likely easily compensated for without any significant demographic consequences. These findings are supported by trends in the abundance of bison and elk populations since the onset of motorized winter use in Yellowstone National Park, which provide no evidence of population-level effects to ungulates from motorized winter use because their abundances either increased or remained relatively stable prior to wolf restoration. Thus, any adverse effects of motorized winter use to ungulates have apparently been compensated for at the population level.

Bison were observed on groomed roads during 311 of 2,597 observations of bison groups from December 12, 2003, through April 1, 2004. Thus, the vast majority of observed bison groups were using areas off the groomed roads, as has also been noted in previous winters. We are currently collaborating with researchers from Montana State University (Robert Garrott and John Borkowski) and California State University-Monterey Bay (Fred Watson and Susan Alexander) to analyze bison distribution and use of groomed roads during 1997-2004. We have also developed conceptual models of bison movement through the park based on remotely sensed landscape features (e.g., vegetation, terrain, and geothermal maps), snow pack measurements and modeling, and bison distribution data. These models have been used to predict bison trail systems and movements based on environmental constraints, which we intend to compare with the existing groomed road system to evaluate how grooming has affected bison movements. Draft reports of these analyses should be available in autumn 2004 or winter 2005.

Monitoring results during the winters of 2003 and 2004 suggest that several aspects of human behavior associated with motorized winter use could be modified through adaptive management to lessen the frequency of possible disturbances to wildlife. We recommend that training for guides, park staff, and concessionaires include the following voluntary recommendations: 1) stop at distances >100 meters from groups of wildlife, when possible; 2) reduce the frequency of multiple groups of motorized vehicles stopping in the same area to observe wildlife (i.e., reduce group size of motorized vehicles); 3) reduce the number of stops to observe wildlife and human activities away from vehicles during these stops; and 4) reduce interaction time because the likelihood of an active response by wildlife increases with longer interaction times. This training is essential because recreationalists often perceive that it is acceptable to approach wildlife more closely than empirical data indicates wildlife will tolerate (Taylor and Knight 2003). Because bison and elk behaviorally respond to people deviating from known, predictable routes, management measures that encourage visitors to stay on roads and established trails should also reduce wildlife disturbance rates.

It is unlikely that significant changes in behavioral responses or population-level effects in response to OSVs will be detected in the near future owing to the dominating effects of winter severity, predator off-take (including restored wolves), and human removals on the behavior and demographics of these populations. Thus, we recommend some substantive changes in the focus of winter use monitoring for wildlife during winter 2005. First, we recommend focusing the behavioral sampling of wildlife responses to OSVs in the Madison-Firehole drainages, while ceasing such monitoring throughout the remainder of the park. This approach will enable us to maintain continuity in behavioral sampling in the area of most intensive OSV use, while providing us to with more logistical flexibility to begin focusing other issues of importance. Second, we recommend using field crews to sample and map bison travel vectors (i.e., trail systems) in the west-central portion of the park. These data can be used to validate the predictions of conceptual models of bison movement through the park based on remotely sensed landscape features (e.g., vegetation, terrain, and geothermal maps), snow pack measurements and modeling, and bison distribution data. If the models predict bison trail systems and movements accurately, then we can compare model predictions of bison movement based on based on environmental constraints with the existing groomed road system to evaluate how grooming has affected bison movements. Third, we recommend the collection of snow-urine samples from northern and central Yellowstone ungulates to assess nutrition using the methodology described by Pils (1997). This information will enable us to better assess energetic costs and physiological consequences of various environmental conditions, interactions with OSVs, and road grooming.

In collaboration with professors from Montana State University, we are currently analyzing the combined data set collected by various researchers during 1999-2004 regarding wildlife responses to motorized winter use in Yellowstone National Park. The objectives of these analyses are to evaluate potential indicator variables of wildlife responses to human winter use, identify key conditions leading to responses, quantify variations in the frequencies of responses, and estimate thresholds for the most important disturbance factors. When data is pooled from multiple winter seasons, we will: 1) improve the likelihood of detecting any potential effects that truly exist, but currently

cannot be detected from a single season's data; 2) strengthen the evidence for those effects already statistically significant; and 3) eliminate any spurious effects that may be marginally significant in any particular winter. Thus, we expect to have a more thorough and rigorous analysis of the behavioral responses of wildlife to OSVs completed by winter 2005.

7. **Wildlife Responses to Motorized Winter Recreation in Yellowstone – 2003 Annual Report**. Davis, T., White, P.J., Borkowski, J., Reinhart, D., McClure, C., Perotti, P., McEneaney, T., Plumb, G., Smith, D. & wallen, R. (2003) National Park Service, Yellowstone Center for Resources & Montana State University. http://www.nps.gov/yell/parkmgmt/upload/motorizedwinterrec03.pdf

Executive Summary: Staff from the Yellowstone Center for Resources and Resource Management & Visitor Protection Office monitored wildlife responses to motorized winter recreation during December 16, 2002 through April 18, 2003. The purpose of this monitoring was to collect baseline information on existing conditions for comparison to data collected after the implementation of changes in winter use management during winter 2004. Such comparisons will enable us to evaluate the effectiveness of changes in management at attaining desired conditions.

The winter of 2003 was relatively mild in terms of snow pack and temperatures. As a result, visitor over-the-snow vehicle traffic was relatively low in comparison to previous winters. We used snowmobiles and wheeled vehicles to conduct repeated surveys of wildlife responses to motorized winter use vehicles and human activities along eight groomed or plowed road segments in areas of both low and high intensity human and wildlife use. Our sampling unit was the interaction between motorized winter use and an observed group of wildlife within 500 meters of the road. We focused our efforts on monitoring the responses of bison, elk, and trumpeter swans to motorized winter use vehicles owing to the proximity and/or perceived sensitivity of these species to motorized recreation activities during winter.

Overall, the responses of wildlife to over-the-snow vehicles and associated humans was typically minor, with 61% of the observed responses by groups of bison, elk, and swans categorized as no apparent response, 23% look/resume, 5% attention/alarm, 8% travel, 2% flight, and 1% defense. Wildlife responses to motorized winter use were species dependent and the likelihood of observing an active response by bison and swans (but not for elk) increased as the numbers of snowmobiles in a group increased. Also, the likelihood of observing an active response by elk and swans (but not for bison) increased as the numbers of snow coaches in a group increased. The likelihood of a response by each species decreased as distance from the road increased.

Trends in the abundance of bison and elk populations since the onset of motorized winter use in Yellowstone National Park provide no evidence of population-level effects to ungulates from motorized winter use, with the abundance of bison and elk either increasing or remaining relatively stable prior to wolf restoration. Thus, any adverse effects of motorized winter use to ungulates have apparently been compensated for at the population level.

Based on monitoring results during winter 2003, we recommend that training for guides, park staff, and concessionaires include the following voluntary recommendations: 1) stop at distances >100 meters from groups of wildlife, when possible; 2) reduce the frequency of multiple groups of motorized vehicles stopping in the same area to observe wildlife; and 3) reduce the number of stops to observe wildlife and human activities away from vehicles during these stops. We are currently analyzing data collected during 1999-2003 to evaluate potential indicator variables of wildlife responses to human winter use, identify key conditions leading to responses, quantify variations in the frequencies of responses, and estimate thresholds for important disturbance factors. These analyses should help us refine our recommendations for adaptive management of motorized winter use to minimize the frequency of possible disturbances to wildlife.

The following paragraphs contain additional information our monitoring efforts during winter 2003. For a more detailed presentation, we suggest that the reader review Chapter I (Introduction) and Chapter III (Results). Additional information regarding our methods and discussion of our findings is provided in Chapter II (Methods) and Chapter IV (Discussion). Recommendations for adaptive management and improving the monitoring protocol during future winters are presented in Chapter V (Recommendations).

Synopsis of Findings:

In general, average snow water equivalents (i.e., the amount of water in the snow) per month were lower than the overall monthly averages since 1981. For example, the cumulative snow water equivalent value of 4,999 centimeters at the Madison Plateau SNOTEL site during winter 2003 was lower than totals obtained during 28 of the past 36 winters at this site. Similarly, ambient temperatures during winter 2003 were relatively moderate for ungulates. Only one day had a minimum temperature below the approximate effective critical temperature for bison (i.e., -34F), and <12% of total days were less than the approximate effective critical temperature for elk (i.e., 0F).

The number of snowmobiles entering the West Entrance Station exceeded 550 machines, which is the daily snowmobile entry limit for the winters of 2004 and 2005, on only one day. The numbers of snowmobiles entering the South and East Entrance Stations during winter 2003 did not exceed the daily snowmobile entry limits for each station during the winters of 2004 and 2005 (i.e., South = 250 snowmobiles; East = 100 snowmobiles). The cumulative total of over-the-snow vehicles entering the West Entrance Station surpassed 7,500 vehicles on January 20th during winter 2003. In contrast, this threshold was reached on December 31st during the winters of 1999 and 2000.

During daylight hours, observers traveled until a wildlife group (i.e., ≥1 animal) was detected within 500 meters of the road. The observers remained in a position along the road to observe the group until ≥1 motorized winter vehicle (i.e., snowmobile, snow coach, wheeled vehicle) entered a zone within 500 meters of the group. The observers categorized the motorized 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. The observers categorized the highest level of human activity (i.e., most potential for disturbance) and predominant response behavior of the majority of the animals in the group during interactions.
Winter use crews conducted 332 surveys of road segments, covering 11,182 kilometers. Observers recorded 4,269 groups of wildlife during these surveys, including 908 groups of elk, 2,294 groups of bison, 447 groups of swans, and 620 groups of other species (e.g., bald eagles, coyotes, wolves). Observers recorded human behaviors and the responses of wildlife to motorized winter vehicles during 3,020 interactions. No groups of wildlife were observed during 30 surveys of road segments.

The behavior of over-the-snow vehicles and associated humans in response to wildlife groups was typically minor, with 59% of the 1,315 total observed human behaviors to groups of bison, elk, and swans categorized as no visible reaction to wildlife, 5% stop/resume, 13% stop and observe for an extended period, 13% dismount over-the-snow vehicles, 8% approach wildlife, 1% impede and/or hasten wildlife, and 1% undetermined. Qualitative comparisons suggest that the behaviors of visitors were similar between low and high intensity use areas, and those associated with snowmobiles or snow coaches. There appeared to be a tendency for visitors in commercially guided snowmobile groups to approach wildlife more frequently than visitors in unguided snowmobile groups. This apparent difference may be misleading or nonexistent, however, owing to the relatively small sample of guided groups compared to unguided groups. Additional data from one or more winter seasons will be necessary to establish the reliability of these apparent differences.

Bison rarely responded to human activity along roads (22% of interactions), whereas elk and swans responded more often (≤58% of interactions). Behavioral responses of wildlife decreased as distance from motorized winter use corridors increased. The estimated odds of observing no response relative to either a look and resume or active response by bison, elk, and swans was significantly higher for each 100 meter increase in distance from the road. Also, mean distances of bison and elk groups from groomed road segments during winter 2003 did not indicate avoidance of the road as motorized use increased (as indicated by daily over-the-snow vehicle traffic entering the West Entrance Station). In combination with the relatively minor and infrequent responses by wildlife to over-the-snow vehicle traffic, these results suggest that wildlife habituated to motorized winter use.

Wildlife responses varied by species among commercially guided, unguided, and administrative groups during winter 2003. For example, the estimated odds of observing an active response relative to no response by bison were significantly higher for a commercially guided group than for an unguided group (under identical conditions). Conversely, the estimated odds of observing a look and resume response or an active response relative to no response by elk was significantly lower for a commercially guided group than for an unguided group. There were no statistically significant results among comparisons of swan responses to commercially guided, unguided, and administrative groups. We suspect that these somewhat inexplicable variations in associations among wildlife

responses and guide status results from the relatively low sample of guided groups (<10% of cases) compared to unguided groups. Thus, these apparent differences must be viewed cautiously because they may be misleading or nonexistent. By collecting data over several winter seasons, we can reexamine this issue with an increased sample size to establish the reliability of these apparent differences.

Statistical analyses by Dr. Borkowski indicated that several other variables likely influence the odds of a response by bison, elk, and/or swans to motorized winter use. These variables include group size, habitat type, precipitation, visibility, wildlife activity (e.g., standing v. bedded), ambient temperature, interaction time, and daily numbers of motorized vehicles entering the south and west gates. For example, for each 10-animal increase in the size of a wildlife group during winter 2003, the estimated odds of observing no response relative to a look and resume response were significantly higher for both bison and elk. By collecting data over several winter seasons, the influence of these variables on wildlife responses can be reexamined with an increased sample size, thereby providing better inference.

Bison were observed on groomed roads during 159 of 1,668 observations of bison groups from December 27, 2002, through March 10, 2003. Thus, the vast majority of observed bison groups were using areas off the groomed roads. One hundred and twenty of the bison groups observed on groomed roads were traveling, whereas 36 groups were stationary and 3 groups were resting. The estimated odds of observing an active response relative to no response was 20 times greater when bison were on the road than when they were off the road. Bison use of groomed roads occurred throughout the daylight survey hours, with no apparent peak time of road use. Elk groups were observed using groomed roads less than bison.

A total of 95 interaction events between ungulates and over-the-snow vehicles and associated humans were documented when animal groups were on the groomed roads, including 75 groups of snowmobiles and 20 groups of snow coaches. Thirteen percent of these snowmobile groups impeded or hastened wildlife movement. Twenty-five percent of these snow coach groups impeded or hastened wildlife movement. Wildlife were observed on the plowed road from Mammoth to the Northeast Entrance on 35 occasions during our surveys, including 14 bison groups, 16 coyote groups, and 5 elk groups. Wildlife were not trapped by, or forced to jump over, snow berms along the sides of the road during any of these observations.

Counts of trumpeter swans on the north and west shores of Yellowstone Lake and along the Yellowstone River peaked in late November at 496 swans, and decreased relatively consistently through late February as open water sections of the Yellowstone River diminished. Conversely, counts of trumpeter swans along the Madison and Firehole Rivers increased during late December, peaked at 47 swans in mid-January, and remained relatively high through early February. As the winter progressed, and open water areas in the park diminished, the proportion of the swan population counted within Yellowstone National Park decreased compared to areas outside the park. Thus, relatively fewer swans were exposed to motorized winter use in the park.

The collection of fecal samples and measurement of fecal glucocorticoid levels via radioimmunoassay has been shown to be an effective, non-invasive method to measure physiological stress in elk. We collaborated with Dr. Robert Garrott, Montana State University, to collect fecal samples (105 total) at approximately 2-week intervals throughout the winter from 35 radiocollared adult female elk in the west-central portion of the park. We have contracted with Drs. Robert Garrott and Scott Creel, Montana State University, to extract the fecal samples and determine nanograms of corticosterone excreted per gram of dry feces using the double-antibody [125I] corticosterone radioimmunoassays. These analyses should be completed during 2004. The results of the analyses will be compared to similar samples collected during winters of 1999 and 2000 to evaluate the potential for chronic stress of ungulates in areas with relatively intensive motorized winter use.

8. **Wildlife Road Survey and Human Interactions On and Off Road: Final Report**. Jaffe, R., Elwood, D., Dimmick, A., Davis, T, & McClure, C. (2003) Yellowstone National Park – West District Resource Management.

Introduction: Studies were conducted in Yellowstone National Park to examine the effects of winter recreation on wildlife by Aune (1981) and Hardy (2001), and the effects of road grooming on bison by Bjornlie and Garrott (2001). Monitoring wintering wildlife distribution and wildlife-human interactions along the road corridor between West Yellowstone and Old Faithful was initiated during the 2001-2002 winter as part of the effort to reduce

resource impacts and improve visitor safety and enjoyment in Yellowstone National Park. Methods from Hardy (2001) were expanded so this year's monitoring could be compared to results from her study.

Three biological technicians were hired for winter monitoring efforts beginning on December 11. The first three weeks were used for training, protocol testing, and project development. A total of 170 road surveys were conducted on 74 days, December 27 through March 10, with an average duration of 2.4 hours and 3,498 wildlife groups documented, and a total of 510 site-specific human-wildlife interaction events were recorded during the study. Staff logged over 9,000 miles on two snowmobiles. The two primary objectives of these surveys were to (1) document seasonal and diurnal wildlife distribution and activity, and (2) document human behavior in relation to wildlife and wildlife responses to human behavior associated with snowmobile and snowcoach use.

Results: The total number of animals counted during road surveys was 25,173. Bison, elk, swans, bald eagles, and coyotes were the most numerous species counted and are summarized below. Less common species sighted during surveys, which included moose, mule deer, muskrat, wolf, golden eagle, and double-crested cormorant, were excluded from the summary tables.

Eighty-seven percent (n=21,936) of the total number of animals observed during road surveys has no visible response to over-snow vehicles (OSVs). Of the 13% (n=3,263) of total animals counted that exhibited an observable response, 68% looked directly at the people viewing them and resumed their activity. Thirty-two percent of the responses were more active, including walk/swim away, rise from bed, attention/alarm, flight, agitate (buck, kick, bison tail-raise), jump snow berm, and charge. Of the 17,209 animals counted within 100m of the road, 17% (n=2,966) showed an observable response to the presence of OSVs that stopped, while 3% (n=297) of 7,924 animals counted further than 100m from the road showed a visible response

9. **Record of the Snowmobile Effects on Wildlife: Monitoring Protocols Workshop, Volume One.** Graves, T. & Reams, V. (2001) National Park Service – Biological Resource Management Division.

Abstract: This workshop included experts from federal agencies, state agencies, and universities and was held in Denver, Colorado on April 10-12, 2001 to summarize the state-of-science on monitoring the effects of snowmobiles on wildlife in national parks and surrounding lands. Volume 1 summarizes: 1) the presentations made during the plenary session of the workshop, 2) results of the electronic survey, 3) discussions and conclusions of the work groups, and 4) research recommendations. Discussion and Conclusions from this workshop include:

Primary Issues and Species: The primary issues raised in this study naturally pertained to wildlife impacts. The large majority of these issues related to immediate individual-level effects such as increased energy expenditure or behavioral changes. Concerns about snowmobile impacts on denning animals were also a significant issue. However, many of the wildlife issues raised dealt with larger-scale, complex processes, such as the indirect effects snowmobile use might have through its effects on predators or moving populations of animals into different territories.

The primary species of concern were carnivores, especially lynx, wolverines, and wolves. It is important to remember that respondents to this research were drawn from across the United States, and generally responded pertaining to the species with which they work. Therefore, the relative importance of each guild and species is certainly influenced by the people who chose to participate.

Conclusions about monitoring: The wide range of information needs identified by experts in the field present a significant challenge to those attempting to develop a uniform package of possible monitoring techniques. Information needs to appear to be guild or species-specific.

Respondents generally feel that population-level effects are most important or useful to study, followed by individual behavioral effects. The primary exception to this is for threatened or endangered species; respondents apparently believe that identifying any adverse individual level effects would be sufficient grounds for making management decisions. Unfortunately, it appears that most of the limited evidence available to date pertains to individual effects; a significant need therefore exists for basic research and monitoring of population-level effects.

Need for Monitoring or Need for Basic Research: Experts in the field of wildlife (and wildlife reactions to disturbance) are uncomfortable passing judgments on whether snowmobiles adversely (or, for that matter, positively) affect wildlife. Even under circumstance with the best available information, the question of when an

impact becomes serious enough to warrant taking action is a subjective value judgment, and many respondents recognized this. But the majority felt that insufficient data exist to even begin to understand the issue. Only for ungulates are some scientists willing to say data are adequate, but even for these commonly studied species, most respondents have serious concerns.

This raises the question about whether monitoring is the place to focus agency efforts. Clearly, more basic research is needed. It is difficult to know what the best monitoring protocols would be when it is not clear about what effects should be monitored. Nevertheless, the NPS is under a mandate to develop monitoring protocols, and we feel it is important to begin monitoring, however basic, as early as possible. Too often monitoring is left until problems become severe; at that point it is quite difficult to discern the extent to which conditions have changed in the absence of baseline data. Therefore, we encourage researchers and managers to move forward with the development of monitoring protocols, and to continue to refine them as more information becomes warranted.

10. **Review of Research Related to the Environmental Impact Statement for the Yellowstone and Grand Teton National Parks and the John D. Rockefeller, Jr. Memorial Parkway.** (2000) University of Wyoming, Institute of Environment and Natural Resources; p 3-17. http://wyotrails.state.wy.us/pdf/review.pdf

Executive Summary: Wildlife and Winter Recreation in Yellowstone National Park Studies – Unlike most of the reports reviewed in this document, the major report on wildlife issues does not represent a collection and analysis of data, but rather it is an extensive review of current literature (Oliff et al, 1999) on the effects of winter recreation on wildlife in the Greater Yellowstone Area. The Kurz report (1998) on bison in the Hayden Valley of Yellowstone, however, does follow the format of the other reports, that is, in the collection and presentation of data. In general, both reports offer valuable insights into the impact of winter use on the wildlife of Yellowstone. In the development of park management policies, however, it would be helpful either to conduct or to examine further studies, with more data on specific management questions. For example, it would be useful to identify, over time, critical habitat for the various sensitive species. And given the fact that wildlife may be particularly sensitive to weather and climate conditions--which change over the course of time--, on-going monitoring would be extremely useful.

11. **Effects of Winter Recreation on Wildlife of the Greater Yellowstone Area: A Literature Review and Assessment.** Olliff, T., Legg, K. & Kaeding, B. (1999) Greater Yellowstone Coordinating Committee, Yellowstone National Park. 303 p. http://atfiles.org/files/pdf/wildlife-winter-yellowstone.pdf or http://www.nps.gov/yell/parkmgmt/upload/wildlifewint.pdf

Summary: This publication is a compilation of papers submitted by resource managers and biologists in the Greater Yellowstone Area from the Forest Service, Park Service, the states of Montana, Idaho, and Wyoming, and private organizations. The chapters cover bighorn sheep, bison, elk, gray wolves, grizzly bears, lynx, mid-sized carnivores, moose, mountain goats, subnivean fauna, bald eagles, trumpeter swans, and vegetation. The purpose of this document is to provide guidelines for managing winter recreational use in the context of preserving wildlife populations. Several topics are discussed, including the current population status and trend of the individual species, relevant life history data, information on winter habitat use, summaries of studies on the influence of human activities on individual species in the winter, and the potential effects of specific winter recreational uses on those species.

12. **Winter Recreation Effects on Wildlife.** Caslick, J. & E. (1997) Natural Resources YCR, Yellowstone National Park.

Abstract: Numerous studies have concluded that wildlife is a major component of the Yellowstone experience, and a major economic "draw" to the area. As increasing pressures for development of visitor facilities and new modes of transportation evolve, early consideration of their potential effects on wildlife (including individual animals, animal populations, and associated ecological processes) become ever more important, if wildlife resources are to continue to be a major feature of Yellowstone. The purpose of this report is to briefly summarize and evaluate the published research on winter recreation impacts on wildlife, particularly as they apply to Yellowstone, and to provide recommendations. This may have immediate application in decision-making during the trade-off processes that inevitably must occur when balancing resource conservation with visitor enjoyment.

13. **A partial literature review of the effects of various human activities on wildlife**. Hamilton, N. (1997). Bureau of Land Management. A compilation of selected older studies. http://nohvcclibrary.forestry.uga.edu/SCANNED%20FILES/W-0017-review%20of%20effects%20of%20human%20activities%20on%20wildlife.pdf

14. **Wildlife and recreationists: Coexistence through management and research.** Knight, R. L., & Gutzwiuer, K. J. (1995) Island Press Covelo, CA.

Abstract: Wildlife recreationists define and clarify the issues surrounding the conflict of outdoor recreationists and wildlife. It is a synthesis of what is known concerning wildlife and recreation and addresses both research needs and management options to minimize conflicts.

15. **Impacts of winter recreationist on wildlife in a portion of Yellowstone National Park, Wyoming.** Aune, K. E. (1981) M.S. Thesis, Montana State University, Bozeman.: 111pp.

Abstract: General responses of wildlife to winter recreationists in Yellowstone National Park were attention or alarm, flight, and rarely aggression. Responses varied with the species involved, nature of the disturbance, and time of season. Winter recreation activity was not a major factor influencing wildlife distributions, movements, or population sizes, although minor displacement of wildlife from areas adjacent to trails was observed. Management recommendations are presented.

16. **Impacts of snowmobiles on wildlife.** Bury, R. L. (1978) Transactions of the North American Wildlife and Natural Resources Conference.

Abstract: The major effects of snowmobiles on wildlife appear to be in changes of the animals' daily routine, rather than direct mortality. This seems to be the case with regard to elk, rabbits, and small subnivean animals. Other animals such as deer seem to be more tolerant of snowmobiles. In general, snowmobiles created little effect on large animals, moderate effects were observed on medium-sized animals, and small animals over wintering in sub-snow environments were drastically effected.

17. **Snowmobiles, animals, and man: Interactions and management issues**. McCool, S. F. (1978) Paper presented at the Transactions of the North American Wildlife and Natural Resources Conference.

Abstract: Decisions regarding the opening, closing, or restricting of lands to snowmobile and other off-road vehicle use appears to be more a function of intuitive managerial expertise and judgment and political pressure than a direct result of systematic problem-driven research. Existing research on snowmobile-wildlife impacts has been unable to produce a consensus on the impacts of the activity on a wildlife population. The snowmobile problem results from human behavior and the way humans use snowmobiles. Understanding why humans use snowmobiles, perhaps even to the point of finding effective and acceptable recreational experiences.

18. **Human-wildlife interactions in the Gallatin Range, Yellowstone National Park.** Chester, J. M. (1976) Montana State University, Bozeman.

Abstract: The relationships between the intensity and kinds of human use and the distribution, movements, and behavior of seven species of wildlife in the backcountry areas of the Gallatin Range in Yellowstone National Park were investigated in 1973 and 1974. Except for minor shifts in elk distribution around campsites, variation in the intensity of human use did not appear to be responsible for shifts in wildlife distribution. Wildlife encounters most commonly occurred at distances between 100 and 300 feet, Encounter distances were shortest for mule deer and moose and greatest for bears.

Except for deer and coyotes, which were usually alert or running, all species were most commonly feeding when first observed. In response to knowledge of human presence, the moose was most likely to stand its ground, while bears were the least likely. Wildlife belligerency toward humans was rare. When it did occur, bear and moose were usually involved. Groups of four or more persons experienced lower observation frequencies than smaller groups. Parties of two or less were most likely to encounter grizzly bears. The use of noise did not appear to affect the frequency of wildlife observations or encounters.

19. **Snowmobile tracks and animal mobility.** Hubbe, M. (1973)

Abstract: Impact of snowmobile tracks on animal mobility was studied in Maine in January 1973. The supporting strength of snow and the resistance of snow to impact on/off snowmobile tracks were compared. It was found that the depth an animal sinks in powder snow is proportional to weight and inversely proportional to foot area. Evidence shows an animals ability to walk on crust is inversely related to the kinetic energy of its footfall and proportional to foot diameter. Snowmobile tracks were helpful.

20. **Wildlife-snowmobile interaction project: Preliminary report covering period November.** Huff, D. E. (1972) University of Minnesota and Minnesota Department of Natural Resources Cooperating.

Abstract: There is a strong relationship between numbers of tracks and specific cover types during the winter at Sherburne National Wildlife Refuge; in the most heavily used cover type, oak woods, significantly fewer tracks crossed the snowmobile trail than the snowshoe trail. Major cover types should be considered before constructing snowmobile trails in areas established for wildlife.

21. **Ecological Effects of Snowmobiles.** Neumann, P.W. & Merriam, H.G. – Department of Biology, Carleton University, Ottawa, Canada. (1972) The Canadian Field-Naturalist, Vol. 86, 207-212.

Abstract: Ecological impact of snowmobiles was studied in the Ottawa area. Snow structural changes by snowmobiles had significant effects on temperature gradients, water holding capacity, and melting rate. Snowshoe hare and red fox mobility and distribution also were affected. Snowmobile damage to hardwood saplings and planted pines was significant. Browsing was unaffected except on damaged saplings.