THE ECOLOGY OF BISON MOVEMENTS AND DISTRIBUTION IN AND BEYOND YELLOWSTONE NATIONAL PARK

A Critical Review
With Implications for Winter Use and Transboundary Population Management

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The history and enormity of issues leading to this study have touched the professional or personal lives of a broad spectrum of Americans, including federal and state civil servants and citizens who care passionately about the integrity of Yellowstone National Park, bison conservation, or protection of livestock against reinfection with a zoonotic organism nearing eradication in the industry. Given the strong polarization among interests involved in these environmental conflicts, the authors feel privileged to have been welcomed by key informants to engage in exploration of their knowledge and insights, and in many cases to have been provided with unpublished data contributing to our assessment and recommendations. Foremost among those we wish to acknowledge as contributing to the assessment is Dr. Mary Meagher, whose passionate concerns for the conservation of Yellowstone bison and the integrity of the Yellowstone Park ecosystem have been uncompromising. We encourage her to continue analyzing the as yet unrealized potential of a data set spanning more than 30 years, complimented by experience in the Yellowstone ecosystem exceeding the duration of most professional careers in wildlife management. In contrast, Rick Wallen, the current bison biologist with the National Park Service, is just beginning to develop a research and management program. We thank Rick for contributing information and his insights to the assessment and hope in return that the report contributes to the development of his program. We are grateful to both Rick Wallen and Dr. Doug Smith for the experience and insights we gained while riding the Mary Mountain Trail with them in October 2004. Finally, we wish to acknowledge the enormous contribution to the project by Traci Weller of Bozeman, Montana. Traci organized and scheduled the interviews and workshops, recorded the dialogue and prepared transcripts. Her competency and humor sustained us through the arduous interview schedule.

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APPENDIX I

KEY INFORMANT INTERVIEWS
JULY 15 – AUGUST 13, 2004

Aune, Keith	Montana Fish, Wildlife & Parks	Chief of research and technical services	July 22, 2004 August 10, 2004
Backus, Alison	Montana State University - Natural History Media	Masters Candidate	August 2, 2004
Bjornlie, Dan	Wyoming Fish and Game	Trophy game division, Lander	August 12, 2004
Brewster, Wayne	Yellowstone Center for Resources, Yellowstone National Park	Deputy Director	July 26, 2004
Cain, Steven	Grand Teton National Park	Supervisory Wildlife Biologist	August 11, 2004
Caron, Rick	Yellowstone National Park	Chief Maintenance	July 29, 2004
OTHER ROAD CREW	Yellowstone National Park	12 maintenance equipment operators	July 29, 2004
Clark, Tim	Yale University	Professor	August 11, 2004
Garrott, Robert	Montana State University	Professor	August 2, 2004
Gogan, Pete	Montana State University; USGS Northern Rocky Mountain Science Center	Adjunct Associate Professor; Wildlife Research Biologist	July 21, 2004
Gross, John	National Park Service	Ecologist	July 21, 2004
Irby, Lynn	Montana State University	Professor, retired	August 13,2004
Jerde, Chris	University of Alberta	PhD candidate	June 24 and July 27, 2004
Johnson, Ann	Yellowstone Center for Resources, Yellowstone National Park	Chief Archaeologist	July 28, 2004
McClure, Craig	Yellowstone National Park	Resource Manager	August 9, 2004
McNulty, Dan	University of Minnesota	Wolf and bison ecologist	August 5, 2004
Meagher, Mary	Yellowstone National Park	Bison biologist, retired	July 15, 16, and 27, 2004
Miles, Wes	Yellowstone National Park	Norris District Ranger	August 9, 2004
Olenicki, Tom	Montana State University	PhD candidate	August, 13, 2004
Olexa, Ed	USGS Northern Rocky Mountain Science Center	Wildlife Biologist	July 21, 2004
Olliff, Tom	Yellowstone Center for Resources, Yellowstone National Park	Natural Resources Branch Chief	August 3, 2004
Plumb, Glenn	Yellowstone Center for Resources, Yellowstone National Park	Supervisory Wildlife Biologist	August 4, 2004; July 23, 2004
Reinhart, Dan	Yellowstone National Park	Resource Manager	August 3, 2004
Renkin, Roy	Yellowstone Center for Resources, Yellowstone National Park	Vegetation and Fire Ecologist	August 4, 2004
Roffe, Tom	United States Fish and Wildlife Service	Veterinarian	July 22, 2004
Ross, Dave	Yellowstone National Park	West Yellowstone District Ranger	August 6, 2004
Sacklin, John	Planning and Compliance, Yellowstone National Park	Chief of Planning	July 23, 2004
Schneider, Kevin	Planning and Compliance, Yellowstone National Park	Planner	July 23, 2004
Smith, Doug	Yellowstone Center for Resources, Yellowstone National Park	Yellowstone Wolf Project leader	July 26, 2004

Taper, Mark	Montana State University	Associate Professor	July 27, 2004
Wallen, Rick	Yellowstone Center for Resources, Yellowstone National Park	Yellowstone Bison Project leader	July 23, 2004
Watson, Fred	California State University, Monterey		
White, PJ	Yellowstone Center for Resources, Yellowstone National Park	Yellowstone Ungulate Project leader	July 28, 2004
Young, Dennis	Yellowstone National Park	Madsion District Ranger	August 9, 2004

APPENDIX II

GROUP MODELING WORKSHOPS

Yellowstone Center For Resources

Workshop 1: October 20, 2004, Mammoth, Wyoming

Participants: Wayne Brewster, Lynn Irby, Dan McNulty, Tom Olenicki, Tom Oliff , Glenn Plumb, Dan Reinhart, Roy Renkin, Bob Seibert, Doug Smith, Rick Wallen, PJ White

Workshop 2: October 30, 2004, Emigrant, Montana

Participants: Kevin Schneider, Rick Wallen
Regrets: Glenn Plumb

Workshop 3: February 25-26 , 2005, Lake Louise, Alberta

Participants: Glenn Plumb, Rick Wallen

Montana Workshop, October 21, 2004, MFWP Office, Bozeman, Montana

Participants:
Montana Fish Wildlife and Parks: Kurt Ault, Kieth Aune
USDA/APHIS: Ryan Clark
USFWS: Tom Roffe
Regrets: Jack Rhyan

Wyoming Workshop, October 25, 2004, WGF Office, Jackson Wyoming

Participants:
National Parks Service, GTNP: Steven Cain, Sarah Dewey
Wyoming Game and Fish Department: Dan Bjornlie
Wildlife Conservation Society: Joel Berger
Regrets: Sue Consolo-Murphy, Tim Clark

Meagher Research Group Workshop, October 27, 2004, Emigrant, Montana

Participants: Mary Meagher, Mark Taper, Anne Johnson
Regrets: D. J. Schubert, Chris Jerde

USGS Workshop, October 28, 2004, Montana State University, Bozeman, Montana

Participants:
USGS: Peter Gogan
University of Colorado: Mike Coughenhauer
Regrets: John Gross, Ed Olexa

APPENDIX III

ENVIRONMENTAL NON-GOVERNMENT ORGANIZATIONS WORKSHOP

October 29, 2004

Yellowstone Inn and Conference Center
1515 West Park
Livingston, MT. 59047
10:00 a.m. – 5:00 p.m.

American Buffalo Foundation
Joe Gutkoski, Secretary
Bozeman, MT

American Wildlands (did not attend)
Rob Ament, Executive Director
Bozeman, MT

Barb Abramo
West Yellowstone, MT

Bear Creek Council (did not attend)
David Keltner, Chair
Gardiner, MT

Buffalo Field Campaign
Mike Mease
West Yellowstone, MT

Defenders of Wildlife (did not attend)
Minnette Johnson
Missoula, MT

Fund for Animals (did not attend)
Andrea Lococo, Rocky Mountain Coordinator
Jackson, WY

The Fund for Animals (did not attend)
D.J. Schubert, Ranch Manager/Wildlife Biologist
Murchison, TX

Gallatin Wildlife Association
Glenn Hockett, President
Bozeman, MT

Greater Yellowstone Coalition
Amy McNamara, National Parks Director
Bozeman, MT

Greater Yellowstone Wildlife Alliance
William C. Patric
Bozeman, Montana

George Nell
Gardiner, MT

HBNA (Horse Butte Neighborhood Association)
Karrie Taggart
Horse Butte Neighbors of Buffalo
West Yellowstone, MT

Horse Butte Neighbors of Buffalo
Liz Kearney, Newsletter Editor
West Yellowstone, MT

Humane Society of the United States
Northern Rockies Regional Office
Dave Pauli, Director
Billings, MT

Intertribal Bison Cooperative (did not attend)
Fred DuBray
Rapid City, SD

Jackson Hole Conservation Alliance
Dr. Franz Camenzind
Jackson Hole, WY

Dr. Mary Meagher
Cinnebar Basin, MT

Montana Conservation Voters
Jeanne-Marie Souvigney, Program Director
Livingston, MT

Montana Wildlife Federation (National Wildlife Federation) (did not attend)
Craig Sharpe, Executive Director
Helena, MT

National Parks Conservation Association
Tony Jewett, Senior Director
Helena, MT

National Parks Conservation Association
Patricia "Patti" Borneman, Program Coordinator
Northern Rockies Region
Helena, MT

Natural Resources Defense Council (did not attend)
Charles M. Clusen
Director, National Parks Project
Natural Resources Defense Council
Washington, DC

The Nature Conservancy
Laura Hubbard, Project Manager
Montana Field Office
Helena, MT

Rocky Mountain Elk Foundation (did not attend)
Peter J. Dart, President and CEO
The Rocky Mountain Elk Foundation
Missoula, MT

Sierra Club (did not attend)
Kathryn Hohmann
Bozeman, Montana

Society for Range Management
Jeff Mosley, SRM 2004 Board of Directors
Dept. of Animal and Range Science
Montana State University
Bozeman, MT

Society for Range Management
International Mountain Section
Jim Knight, PhD
Dept. of Animal and Range Science
Montana State University
Bozeman, MT

Wildlife Conservation Society (did not attend)
Craig Groves
Bozeman, MT

Wilderness Society, Northern Rockies Chapter (did not attend)
Bob Ekey
Bozeman, MT

Wyoming Wildlife Federation (did not attend)
Cathy Purves
Western Wyoming Field Director
Lander, WY

Facilitator: Dennis Phillippi, Bozeman Montana
Coordinator: Traci Weller, Bozeman MT
Investigators: C. Gates, B. Stelfox, T. Muhly, Calgary AB

APPENDIX IV

BISON WINTER ROAD USE MONITORING STUDIES

Three major studies regarding bison use of groomed roads and interactions with Over Snow Vehicles (OSV) have been conducted in Yellowstone National Park (YNP). The first (Kurz et al. 2000, Reinertson et al. 2002) was initiated in winter 1997-1998 and was conducted during four subsequent winters. The purpose was to assess the level and frequency of groomed road use by bison and generate a data set on bison use of groomed roads to serve as a basis for comparison with future monitoring efforts. Four types of data were collected: ground survey observations, automated point photos, groomer surveys and aerial surveys (Reinertson et al. 2002). Random crepuscular and daytime ground surveys of bison were conducted along three road sections in YNP, the road from Pelican Valley to Canyon, the road from Gibbon Canyon to Golden Gate and roads in the Madison-Firehole area. The Pelican Valley to Canyon section was monitored all five years of the study, the Gibbon Canyon to Golden Gate section was monitored the final four years of the study and the Madison area was monitored the final 2 years. Two-person teams recorded all bison observations along the road section, including data on group size, sex/age composition, location (UTM), group behaviour (foraging, resting, traveling), snow depth, habitat, time of day, winter weather conditions, distance from road, type of road use (i.e. crossing or linear use), direction of travel if on road, and location of entry and exit from road. Point photo data was collected at eight locations, Swan Lake, Roaring Mountain, Norris Junction, Gibbon Meadows, Otter Creek, Mary Mountain Trailhead, the North Geologic overlook and Buffalo Ford. Photographs were taken every 90 minutes with a view of the road. Snow and weather conditions were also recorded at each photo station. During grooming, groomer operators recorded all bison observations, including date, time and section of groomed road where sighting occurred, and reaction of the bison to the groomer. Aerial surveys and radio-telemetry of bison were conducted to monitor large-scale movements and distribution of the population within the study area.

A concurrent study was conducted by Bjornlie and Garrott (2001) in the Madison-Firehole area of YNP, during the winters of 1997-1998 and 1998-1999. Road sections between Old Faithful, Madison Junction, West Yellowstone and Norris were surveyed and data from trail monitors was gathered to study bison movements and use of winter roads. Three-person crews traveled one of 6 survey routes each day, attempting to locate all bison along the route. The location, age and sex composition, and behaviour (traveling, foraging or resting) of bison were recorded in addition to the number of bison traveling along the road for > 50 m. Trail monitors were located at the Mary Mountain trail and Gneiss Creek trail. SWE data were collected from the Canyon SNOTEL station to correlate snowpack conditions with bison distribution.

A third study (Davis et al. 2004, White et al. 2004) was initiated in winter 2002-2003 to collect data on interactions between wildlife, including bison, and OSV's on groomed roads and also examined whether responses of wildlife to snowmobiles and snow coaches differed, and whether levels of human activity and behavioural responses of wildlife

differed between commercially guided and unguided groups of snowmobiles. The study was repeated in 2003-2004 for comparison (White et al. 2004) and is expected to continue into the future. Data were collected on number and type of OSV's entering each park gate, and SWE data was collected from SNOTEL stations in YNP. Three, two-person crews used snowmobiles or wheeled vehicles to conduct repeated surveys of wildlife distribution and responses to motorized vehicles along eight road sections (Madison to Old Faithful, Canyon Village to Lake Butte, Madison to West Yellowstone, Mammoth to Lamar Valley, Norris to Madison, Mammoth to Norris, Fishing Bridge to West Thumb, Canyon Village to Norris, Fishing Bridge to Sylvan Pass). Surveys were conducted during daylight hours only, at all times of the week and sections were surveyed without replacement. Observers traveled along a road segment until they located a wildlife group, at which time they stopped and observed the wildlife until a motorized vehicle (OSV on groomed roads and wheeled vehicle along plowed roads) entered the area (within 500 m). Observers then began recording the interaction between the motorized vehicle user and wildlife. For each observation of a bison group along a survey route the time of observation, habitat type (aquatic, burned forest, unburned forest, wet meadow, dry meadow, geothermal), group size and composition, and activity of the group (standing, traveling, resting) was recorded. Categories for measuring motorized vehicle user responses to wildlife were: no visible interaction, stop their vehicles, dismount vehicle, approach wildlife or impede and/or hasten wildlife. Categories for measuring wildlife responses to OSV users were: no visible reaction, look at vehicles or activity then resume behaviour, travel away from activity, attention/alarm behaviour, flight from activity or defense behaviour.

Road Use Patterns by Bison

Most bison observed were not on roads; 7.9% (519) of bison groups were observed on the road along the Pelican Valley to Canyon road section, 7.2% (251) of bison groups were on the road along the Gibbon Canyon to Golden Gate road section and 12.8% (118) of bison groups were on the road along the Madison road section (Reinertson et al. 2002). When bison were observed on roads, 95% were traveling linearly along the road (Kurz et al. 2000). Photographs recorded bison on the road 14.4% of the time and 9.75% of groomer observations were of bison on the road.

Kurz et al. (2000) reported the percent of bison observed on roads for each road section and total number of bison groups observed on each road section (Table 1). The highest percent of bison observed on roads occurred along the Gibbon Canyon and Elk Park to Gibbon Meadows sub-sections of the Gibbon Canyon to Golden Gate road, and along the Mud Volcano to Buffalo Ford and Hayden Valley (north of Mud Volcano to Mary Mountain trailhead) sub-sections of the Pelican Valley to Canyon road. Bison were most likely to travel on groomed roads from Gibbon Canyon to Gibbon meadows and from Buffalo Ford to the Mary Mountain trailhead. In the case of the former road section, the high percentage of bison found on roads may be due to restriction of bison to narrow valleys, which also contain roads, because of steep topography along the movement corridor between foraging areas (Kurz et al. 2000). The latter road section may have been relatively heavily used because of frequent traveling back and forth along the road between feeding areas (Kurz et al. 2000).

Davis et al. (2004) and White et al. (2004) monitored wildlife/OSV interactions between December and April. In 2002-2003 they conducted 332 surveys totaling 11,182 km while observing 4,269 groups of wildlife (2,294 groups of bison) and 3,020 interactions. In 2003-2004, 402 surveys were conducted totaling 11,389 km with 4,940 wildlife observations (2,597 bison) and 3,174 interactions. Road segments were categorized into low and high use based on frequency of interactions per kilometer surveyed (Davis et al. 2004). The number of bison groups and bison/OSV interactions observed along each road section is indicated in Table 2 for 2002-2003 and Table x for 2003-2004. Overall, bison were observed on groomed roads during 159 of 1,668 observations (9.5%) in 2002-2003 and 311 of 2,597 observations (12.0%) in 2003-2004. Bjornlie and Garrott (2001) recorded 19% of bison travel was on roads. Unfortunately, these studies do not indicate the percentage of sightings of bison on roads by road section therefore it is difficult to compare patterns of road use with Kurz et al. (2000); however, it is clear that bison more frequently used corridors between Madison and Old Faithful and Canyon to Lake Butte (i.e. the road through Hayden Valley) with relatively high frequency. The sections most used by bison are also the sections where interactions between bison and OSV's are most frequent.

The pattern of road use by bison was not consistent among winters. In 1997-1998, bison were observed on roads 8% of the time in December and January, 25% of the time in February and 38% of the time in March (Kurz et al. 2000). In 1998-1999, bison were observed on roads 8% of the time in December, 15% of the time in January, 23% of the time in February and 35% of the time in March (Kurz et al. 2000). In 1999-2000, bison were observed on the road 12% of the time in December, 33% of the time in January, 10% of the time in February and 36% of the time in March (Kurz et al. 2000); similar patterns were observed the following two winters (Reinetrson et al. 2002). Snow depths also varied, increasing monthly as winter progressed (Kurz et al. 2000). Bjornlie and Garrott (2001) found that bison use of roads peaked in late fall and early spring, and was lowest during the OSV season. It appears bison travel along roads more frequently in late winter/early spring, perhaps in relation to snow depth and spring greenup. However, all movement (on roads and trails) increased during late winter (Bjornlie and Garrott 2001). In March, roads are plowed, which may affect bison use of roads (Kurz et al. 2000); additionally peak movement in the spring coincided with meltoff and greenup at lower elevations, which may also affect bison movements. Increased travel by bison along linear corridors during early spring could also be due to an increase in effort to find forage once snowpack begins to melt (Bjornlie and Garrott 2001).

A greater number of bison traveled along roads during an above-average SWE winter (1998-1999) more than a below average SWE winter (1997-1998). SWE was a significant predictor of road use by bison (Bjornlie and Garrott 2001). Greater use of roads by bison, both annually and seasonally, as snow depth and/or SWE increases suggests a correlation between snow conditions and bison use of roads. However, all of these studies were short term and the majority were conducted during below average to average SWE winters. It is impossible to determine from these studies whether snow conditions are a causative mechanism for road use.

Interactions Between Bison and OSV's

Of all the recorded interactions between OSV's and wildlife, 48% (2,984) involved groups of snowmobiles, 12% (722) involved snowcoaches and 40% (2453) involved wheeled vehicles (Davis et al. 2004, White et al. 2004). In 2002-2003, 13% of snowmobile groups impeded or hastened wildlife movement and 25% of snow coach groups impeded or hastened wildlife movement (Davis et al. 2004) Although snowcoaches appear to have a greater impact on wildlife, they make up a smaller percentage of OSV interactions with wildlife. Additionally, there was a notable discrepancy in the type of OSV causing impede/hasten interactions in wildlife. In 2003, snow coaches and snowmobiles accounted for 68% and 32%, respectively, of impede/hasten interactions compared to 2004, when snow coaches and snowmobiles accounted for 22% and 78%, respectively, of impede/hasten interactions.

In 2002-2003 the majority of OSV users had no reaction to wildlife (59%), 18% stopped and observed wildlife, 13% dismounted, 8% approached and only 1% impeded and/or hastened wildlife (Davis et al. 2004). The majority of bison groups (78%) had no response to OSV's, only 9% of groups showed alarm behaviour, moved away from the OSV users or showed defense behaviour. The likelihood of observing an active response in bison increased as snowmobile group size increased and odds of observing an active response in bison were significantly higher for commercially guided groups than unguided groups, although sample size of guided groups was very small (< 10% of interactions). Guided groups appeared more likely to approach wildlife than unguided groups (Davis et al. 2004). In the subsequent winter, a similar percentage of people had no visible reaction to wildlife (White et al. 2004). More OSV users stopped to observe animals in 2004, but the numbers of users that dismounted the OSV and approached wildlife decreased. Wildlife was impeded and/or hastened by OSV users more often in 2004 (6%) compared to 2003 (1%). The responses of most wildlife species to OSV users was minor; 58% of wildlife responses were categorized as no apparent response, 18% as look/resume, 11% as attention/alarm, 9% as travel, 4% as flight, and <1% as defense. In bison, 84% of interactions were 'no apparent response' or 'look-and-resume'.

Active responses in bison caused by bison/OSV interactions varied depending on vehicle type, location of bison, composition of bison group and composition of OSV group. The odds of observing an active response in bison were 20 times greater when bison were on the road than when they were off road (Davis et al. 2004). Active responses were also more likely as the number of juveniles in a bison group increased, but decreased as the number of adult males in the group increased (White et al. 2004). The odds of observing an active response by bison were greater as snowmobile group size increased and were greater if a snow coach was in the group (White et al. 2004). Odds of observing an active response was greater when the bison group was traveling rather than resting and as interaction time increased (up to 20 minutes; White et al. 2004). Bjornlie and Garrott (2001) found that when traveling on roads, 53% of bison groups encountering OSV's had negative interactions, of which 68% of those interactions involved running from 50 m to 4 km.

Administrative OSV users (e.g. park staff) were more likely to stop and view wildlife but guided groups were more likely to approach wildlife when stopped. In 2003-2004,

70% of guided groups passed wildlife without stopping, compared to 45% of administrative groups. Of those that stopped, 7% of guided groups approached wildlife whereas 1% of administrative groups approached wildlife.
Groomers are more likely to cause active responses than other OSV types (snowcoaches and snowmobiles). Over half (51%) of bison encounters with road groomers resulted in bison running (Kurz et al 2000). Grooming typically occurred between 3 pm to 2 am yet no bison sightings were recorded after 10 pm (Kurz et al. 2000) suggesting bison rarely travel at night. Bjornlie and Garrott (2001) also found little evidence of bison traveling along roads at night in the Madison-Firehole area. Because bison appear to rarely travel at night (Kurz et al. 2000, Bjornlie and Garrott 2001), grooming could be conducted later at night (after 10 pm) to mitigate impacts of groomers on bison. Bison response to OSV use is likely minor as there was no evidence of population level effects of OSV use on bison (Davis et al. 2004, White et al. 2004).

Literature Cited

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Reinertson, E., D. Reinhart, and G. Kurz. 2002. Winter bison monitoring: 2002 annual report. Yellowstone Center for Resources. Yellowstone National Park, Mammoth Hot Springs, Wyoming, USA.

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Appendix IV, Table 1**.** Percentage of bison observations and number of bison groups observed on roads for each road section surveyed. Data from Kurz et al. (2000) conducted in winters of 1997-1998, 1998-1999 and 1999-2000.

Road Segment	Road Sub-section	Percent of Bison Observations on Roads	Total Number of Bison Groups Observed
Pelican Valley to Canyon	Mary Bay to Fishing Bridge Junction	12	31
	Fishing Bridge Junction to Cascade Picnic area	18	50
	Mud Volcano to Buffalo Ford	28	76
	Hayden Valley (north of Mud Volcano to Mary Mountain trailhead)	26	68
	Otter Creek to Canyon Junction	13	37
Gibbon Canyon to Golden Gate	Golden Gate to Indian Creek	8	7
	Roaring Mountain	8	7
	Frying Pan Spring to Bijah Spring	11	9
	Ranger Museum	12	10
	Elk Park to Gibbon Meadows	27	23
	Gibbon Canyon	34	29

Appendix IV, Table 2. Bison observations and interactions with OSV's in winter of 2002-2003. Data table from Davis et al. (2004).

Road Segment	Total km surveyed	Bison Groups Observed	Groups Observed per km surveyed	Interactions Observed	Interactions Observed per km surveyed
Madison to Old Faithful	1451	675	0.47	599	0.41
Madison to West Yellowstone	1305	232	0.18	228	0.17
Canyon to Norris	590	20	0.03	16	0.03
Madison to Norris	998	113	0.11	85	0.09
Mammoth to Norris	655	74	0.11	50	0.08
Mammoth to Lamar Valley	3570	621	0.17	389	0.11
Canyon to Lake Butte	1506	498	0.33	300	0.20
West Thumb to Fishing Bridge	1134	55	0.05	41	0.04

Appendix IV, Table 3. Bison observations and interactions with OSV's in winter of 2003-2004. Data table from White et al. (2004).

Road Segment	Total km surveyed	Bison Groups Observed	Groups Observed per km surveyed	Interactions Observed	Interactions Observed per km surveyed
Madison to Old Faithful	1569	1350	0.86	981	0.63
Madison to West Yellowstone	1415	1118	0.79	887	0.63
Canyon to Norris	ND	ND	ND	ND	ND
Madison to Norris	578	199	0.34	127	0.22
Mammoth to Norris	710	145	0.20	97	0.14
Mammoth to Lamar Valley	2354	942	0.40	742	0.32
Canyon to Lake Butte	2073	1055	0.51	294	0.14
West Thumb to Fishing Bridge	1798	106	0.06	31	0.02
West Thumb to South Entrance	256	9	0.04	3	0.01
West Thumb to Old Faithtful	636	16	0.03	12	0.02