Affected Environment

CHAPTER 3: AFFECTED ENVIRONMENT

The "Affected Environment" describes the current condition of the resources and values of Yellowstone National Park (Yellowstone or the park) that would be affected by the implementation of the proposed winter use alternatives. The resource value topics presented in this chapter, and the organization of the topics, correspond to the resource impact discussions contained in "Chapter 4: Environmental Consequences" immediately following this chapter.

WILDLIFE AND WILDLIFE HABITAT, INCLUDING RARE, UNIQUE, THREATENED, OR ENDANGERED SPECIES, AND SPECIES OF CONCERN

Yellowstone provides winter habitat for many terrestrial wildlife species, including bison, elk, mule deer, moose, bighorn sheep, mountain lions, lynx, bobcats, martens, fishers, river otters, wolverines, coyotes, gray wolves, red foxes, and snowshoe hares. Avian species that overwinter in Yellowstone include trumpeter swans, bald eagles, common ravens, gray jays, Clark's nutcrackers, great gray owls, and a variety of waterfowl, raptors, and passerine bird species (Olliff et al. 1999). Species such as grizzly and black bears hibernate during winter months, and are rarely encountered by oversnow vehicles (OSVs). Winter conditions, increased energy demands, and decreased mobility due to snow result in stress to wildlife that are active during the winter months.

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In spite of challenges faced by wildlife in the winter, many species of wildlife that spend the winter in the park would be adversely impacted to a negligible to minor level by OSV use. Some of these species have winter ranges primarily outside of park boundaries, or in areas of the park not subject to OSV use. They are rarely exposed to OSVs, are unlikely to suffer higher than minor adverse impacts by exposure to OSVS, and/or are not federally listed or of special concern in the park. These species are dismissed from further discussion in chapter 1. Species that were carried through for analysis include bison, elk, lynx, wolverines, gray wolves, trumpeter swans, and bald eagles.

The park and other researchers have conducted a variety of monitoring projects and other studies on wildlife in the park in the winter. Some of these have focused on interaction with winter recreation; others have been aimed at better understanding the existence and ecology of different species. For example, the park conducted annual winter wildlife monitoring observation studies along motorized OSV routes from the winter of 1999 to the winter of 2009 that focused on interaction of wildlife and OSVs. Wildlife observed were primarily bison, elk, trumpeter swans, and bald eagles, with rare sightings of gray wolves. In addition, a previous study looked at the interaction of elk and cross-country skiers (Cassirer et al. 1992). Several studies also investigated the relationship between groomed roads and bison movement (Bjornlie 2000; Bjornlie and Garrott 2001; Bruggeman et al. 2006; Bruggeman et al. 2009a; White et al. 2009).

Other species included in this analysis, particularly lynx and wolverines, are secretive, live in forested or mountainous areas with reduced visibility, and/or actively avoid encounters with humans. Because of this, there is limited information on lynx or wolverine ecology, or on the impacts of OSV use and human presence on lynx or wolverine behavior, movements, distribution, or population. Recently, two studies were started to better understand the existence and ecology of wolverines in the greater Yellowstone area. Due to the limited availability of information on lynx and wolverines in Yellowstone, lynx and wolverine behavioral, displacement, and population-level responses to OSVs are based on research observations in available literature regarding the amount of human disturbance, roads, and motorized vehicle use tolerated in lynx and wolverine habitats. Human-caused disturbances in the park due to winter use include OSV traffic, aircraft, non-motorized foot traffic and skiing, and other noise-related disturbances. The following overview is supplemented by the Scientific Assessment of Yellowstone National Park Winter Use Report.

RECENT RESEARCH AND MONITORING

From 1999 to 2009, researchers have monitored the behavioral responses of individual bison, trumpeter swans, bald eagles, and elk (and, more rarely, coyotes, wolves and golden eagles) to OSVs passing by or stopping on groomed roads. In addition, responses to related activities by OSV users, such as dismounting snowmobiles or exiting snowcoaches, were also monitored. Several recent publications have been based, in part, on data from this monitoring (White et al. 2009; Borkowski et al. 2006; Bruggeman et al. 2007; Bruggeman et al. 2006). Four of these studies (Borkowski et al. 2006; Bruggeman et al. 2007; Bruggeman et al. 2006; White et al. 2009) were part of a collaboration between the National Park Service (NPS) and Montana State University-Bozeman investigating the effects of winter recreation on Yellowstone's wildlife. Borkowski et al. (2006) included observations of 6,508 encounters between OSVs and OSV users and wildlife between 1999 and 2004, and White et al. (2009) included 5,688 observations of wildlife/OSV user groups and OSV user encounters between 2002 and 2006. These studies examined the effect of groups of snowmobiles or snowcoaches on the wildlife, rather than the effect of individual OSVs.

In evaluating the effects of winter recreation on wildlife, understanding whether individual animals have habituated to human disturbance, as opposed to simply becoming tolerant of disturbance, is important (Bejder et al. 2009; Cyr and Romero 2009). Habituation is the process by which animals learn to minimize their response to a potential disturbance through repeated neutral or non-threatening exposures to the stimulus. Habituation may result in energy savings to animals not inclined to flee from neutral stimuli, but may also increase vulnerability to disease, natural predators, or increased mortality risks from vehicle collisions (Boyle and Samson 1985; Bejder et al. 2009). Habituation should not be confused with tolerance, which is defined as the acceptance of disturbance. An animal may tolerate disturbance stimuli for a variety of ecological reasons separate from the behavioral process of habituation. For example, individuals may tolerate disturbance if they cannot afford energetically to respond, need to remain in an area to avoid predation risks or competition, or if there are no suitable habitats nearby in which to move (Gill et al. 2001; Frid and Dill 2002; Bejder et al. 2009).

It is difficult to generalize about patterns of wildlife habituation to human disturbance because, in many cases, responses are specific to certain species (Belanger and Bedard 1990) and individualistic (Runyan and Blumstein 2004; Ellenberg et al. 2009). Further, many factors condition an animal's responses to disturbance, often obscuring the distinction between habituation and tolerance. An animal's decision to move from a disturbed area to another area is based on a number of factors including the quality of the site occupied, distance to and quality of other sites, relative risk of predation or competition, dominance rank, and investment a given individual has made in its current site (Gill et al. 2001). Animals with no suitable habitat nearby or within traveling distance may be constrained from movement despite the disturbance (Frid and Dill 2002).

Studies conducted at the park indicate that animals infrequently demonstrated active responses to OSV and associated human presence (table 11). Based on these findings it would appear that bison, elk, swans, and eagles have become desensitized to OSV use and other human disturbance in the park during winter to some extent (Borkowski et al. 2006; White et al. 2009). Bison have been documented to be least likely to react to OSV-related disturbances during winters with greatest visitation, possibly suggesting habituation to high-intensity winter use (White et al. 2009). In contrast, elk did not appear to habituate to the repeated presence of skiers (Cassirer et al. 1992). Although these conclusions suggest the potential for a response to OSV use, there is uncertainty as to the effect over time of multiple disturbance events on individual animals.

TABLE 11: OBSERVED RESPONSES OF WILDLIFE TO OSV USE

	Bison		Elk		Trumpeter Swans	Bald Eagles
Observed Response	Borkowski et al. 2006	White et al. 2009	Borkowski et al. 2006	White et al. 2009	White et al. 2009	White et al. 2009
No Apparent Response	81%	80%	48%	48%	57%	17%
Look-Resume	8%	9%	32%	27%	21%	64%
Alert	2%	3%	12%	17%	12%	9%
Travel	7%	5%	6%	5%	9%	4%
Flight	1%	2%	2%	2%	1%	6%
Defensive	<1%	<1%	<1%	<1%	0%	0%

Studies suggest that most of the individual wildlife observed in Yellowstone, including bison, elk, trumpeter swans, bald eagles, and coyotes, respond to OSV activities by reacting to the potential threat, generally observed as vigilant behavior by the animal (ears up, head raised, ceasing a previous activity such as grazing, without additional alert behavior) (McClure et al. 2009; White et al. 2009). If the animal perceives the disturbance as a more serious threat it may demonstrate an active response including travel away from the threat (walking), flight (running), or defense/attack directed at the threat (charging) (Borkowski et al. 2006; White et al. 2009). In most cases, more active responses require greater energy, reducing the amount of energy available to an animal for winter survival (Parker et al. 1984; Cassirer et al. 1992).

Collectively, all species observed in Yellowstone exhibited non-travel responses (no response, look-resume, alert response) to OSV use at least 90 percent of the time (table 11). All species demonstrated active responses (travel, flight, defensive) less than 10 percent of the time. Defensive responses (charging) to OSV-related human activities were rare (Borkowski et al. 2006; McClure et al. 2009; White et al. 2009).

White et al. (2009) assessed the relationship between wildlife behavioral responses and factors including wildlife group size or distance from road, interaction time, group size of snowmobiles or snowcoaches, type of habitat, and cumulative winter OSV traffic. For bison, elk, swans, and bald eagles, odds of a movement response (travel, flight) decreased with increasing distance of the animals from the road. As the number of individual animals in a group increased, the odds of a movement response generally decreased for bison, swans and elk in thermal habitat, whereas the odds of a movement response increased with larger group size for elk in wetland or unburned forest habitat. The odds of a movement response by wildlife increased with larger OSV group size, longer interaction time, direct approaches by OSV users, or specific habitat-species combinations (White et al. 2009).

Apparent habituation could also mean an animal is under physiological stress and would, under healthy circumstances, respond to the threat. A method used to determine the impact of OSVs on wildlife is to measure the level of stress hormones or glucocorticoids (GC) levels in blood or feces of the animal. However, GC levels do not allow researchers to differentiate between stressors (e.g., predator pressure, extreme weather, OSV

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presence), and vary with such factors as the time of year and reproductive and nutritional status of the animal. GC levels of bison, elk, and wolves during the winters of 1999 and 2000 provide an example of the difficulty in interpreting GC levels. The analysis by Creel and others (2002) from one winter (1999) showed that GC levels in elk were significantly higher during the snowmobile season than during wheeled vehicle season, after controlling for the effects of age and snow depth (Creel et al. 2002). However, Hardy (2001) found that data from winter 2000 showed no obvious trends between daily OSV traffic and GC levels in elk. Hardy (2001) did not detect any significant links between OSV usage and bison GC levels during these two winters (winter 1999 and winter 2000). The disparities in the data interpretation demonstrate the difficulties in interpreting GC data, because many factors are not stress related, including age, seasonal patterns in GC secretion, sex, body condition, diet, social ranking and reproductive status (Hardy 2001; Borkowski et al. 2006). Also, this study took place prior to OSV guiding requirements and the introduction of wolves in Yellowstone in 1996, both of which may affect GC levels.

In addition to wildlife monitoring, researchers and NPS staff monitored population and demographic trends for bison, elk, trumpeter swans, and bald eagles in relation to varying levels of OSV use in the park (Fuller et al. 2007; Wagner 2006; Bruggeman et al. 2007; Geremia et al. 2009; Proffitt et al. 2009, 2010; White et al. 2009). The data from these studies provides no evidence that OSV use has adversely affected the demography or population dynamics of the wildlife studied compared to other, more important factors. Some of these other factors include bison management and large-scale culling, a decline in cutthroat trout in Yellowstone Lake for eagles, the reintroduction of wolves, vegetation succession following the 1988 fires, early flooding and nest predation on swans, and annual variation in snow pack and winter weather (Garrott et al. 2009; Baril et al. 2011; also see the Scientific Assessment of Yellowstone National Park Winter Use).

Unless behavioral observational studies are combined with more costly studies that would include tagging individuals, using Global Positioning System (GPS) to track movements, and measuring stress hormone levels in the animals, along with individual mortality and reproductive data, it is difficult to conclude what effect, if any, OSV use has on individuals or populations by observational studies alone. As discussed in the following section, data collected thus far do not indicate that OSV use in the park has population-level effects for any of the species studies to date (White et al. 2009; Plumb et al. 2009).

BISON (BISON BISON)

Yellowstone is the only area in the United States continually occupied by wild, free-ranging bison (IUCN 2010; Plumb and Sucec 2006).

Yellowstone is the only area in the United States continually occupied by wild, free-ranging bison (Gates et al. 2010; Plumb and Sucec 2006). Bison are gregarious, social animals and travel together in herds of females and calves. A healthy bull bison stands 6 feet at the withers and weighs about 2,000 pounds (one ton). Females are slightly smaller than males. Both sexes have horns, a large head, and a heavily muscled neck. Bison forage on sedges and grasses, and during Yellowstone's winters generally split into smaller groups and travel to lower elevations with less snow cover, including open meadows and geothermal areas. Geothermal areas are important to the winter survival of bison in central Yellowstone, providing snow-free or low-snow cover areas where bison can forage and conserve the energy needed to travel in deep snowpack (Gates et al. 2005; Garrott et al. 2009).

The Yellowstone bison population is subdivided into the central and northern breeding herds, though individuals intermix between herds at various times of year (Meagher 1973; Geremia et al. 2011; Halbert et al. 2012). The ranges for both bison and elk are shown in figure 4. The northern breeding herd congregates in the Lamar Valley and on adjacent plateaus (Specimen Ridge, Mirror Plateau) for the breeding season during July 15 through August 15. During the remainder of the year, these bison use grasslands, wet meadows, and sage-steppe habitats in the Yellowstone River drainage, which extends 100 kilometers (approximately 62 miles) between Cooke City and the Paradise Valley north of Gardiner, Montana (Houston 1982; Barmore 2003). The northern range is drier and warmer than the rest of the park, with average snow-water equivalents (water content of snow pack) ranging from 30 to 2 centimeters (11.8 to 0.8 inches) in the higher and lower elevation portions of the range, respectively (Watson et al. 2009). The central breeding herd occupies the central plateau of Yellowstone National Park, extending from the Pelican and Hayden valleys with a maximum elevation of 2,400 meters in the east to the lower elevation and thermally influenced Madison headwaters area in the west. Winters are often severe, with snow water equivalents averaging 35 centimeters (13.8 inches) and temperatures reaching -42 degrees Celsius (-43.65 Fahrenheit) (Watson et al. 2009). This area contains a high proportion of moist meadows composed of grasses, sedges, and willows, with upland grasses in drier areas. Central herd bison congregate in the Hayden Valley for breeding. Most of these bison move between the Madison, Firehole, Hayden, and Pelican valleys during the rest of the year. However, some animals travel to the northern portion of the park and mix with the northern herd before returning to the Hayden Valley for the subsequent breeding season (Geremia et al. 2011).

Winter is a difficult time for many species. Based on data from 1996 through 1997, winterkill (starvation) during severe winters is assumed to be approximately 10 percent of the early winter bison population (NPS 2000e). Under natural conditions, old, young, sick, and disabled bison are the most vulnerable during major episodes of winter stress, low forage availability, and higher bison densities. Their carcasses are scavenged by many species, including mammals, birds, and insects, and play an important role in park ecology (NPS 1998b). Bison carcasses are especially important as a high-quality food source for species of concern including grizzly bears, bald eagles, and gray wolves (Swensen et al. 1986; Green et al. 1997; Smith et al. 1998).

Historical and Current Park Management of Bison

Bison management practices in the greater Yellowstone area have progressed through several phases since the park’s inception, including protection, intensive husbandry, herd reductions, minimal human intervention, and hunting or culling when animals leave the park boundaries (Gates et al. 2005; NPS 2008a). This long and complex history is summarized in the Gates et al. report (2005), available at http://www.nps.gov/yell/naturescience/gatesbison.htm.

Bison

Long-term data indicate that the population of bison in the park increased from a low of only 23 animals in 1901 to a high of 5,000 animals in 2005, with the bison population fluctuating between 2,000 and 5,000 animals since 1980 (White et al. 2011). An aerial survey of Yellowstone bison in the summer of 2011 counted about 3,700 animals (NPS 2011). Bison herd numbers have increased following a large drop in population during winter 2008 due to management removals at the Montana border to prevent bison from leaving Yellowstone.

FIGURE 4: RANGES FOR BISON

After cessation of culling in the park's interior in 1968, the bison population generally increased, with minor fluctuations, to a high of 5,000 animals in winter 2005. Most of this increase in population coincided with a substantial increase in OSV recreation, with winter visitors increasing from 5,000 to nearly 100,000 people during this same period (Gates et al. 2005). The number of OSV riders in the west-central region of the park, where bison are common, also increased during this time. Thus, in general the number of bison-OSV interactions has increased steadily since the introduction of OSVs in the park, despite high levels of OSVs pre-management, and there appears to be few population-level impacts on bison. In recent years, use numbers of OSVs have decreased, and since 2004, the number of winter visitors has fallen to between 50,000 and 60,000 people (NPS 2008a).

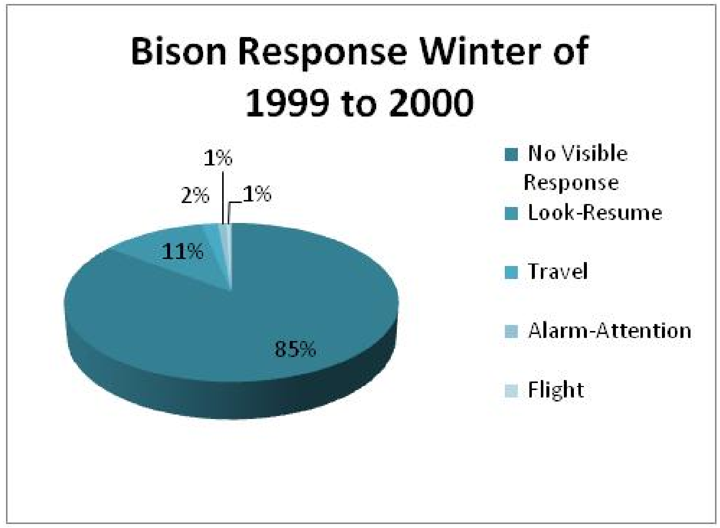
Management removals at (or near) the park boundary along with predation and winterkill (starvation) have been the primary causes of bison mortality in the park. The risk of brucellosis (a contagious bacterial disease associated with spontaneous abortion) transmission from bison to cattle, and the economic cost associated with this risk, prompted the development of various bison management plans over the last 20 years. Starting in the mid-1980s, federal and state agencies negotiated a series of management agreements to manage bison outside the park, the most recent being the Interagency Bison Management Plan (IBMP) in 2000, with subsequent adjustments during 2005 through 2012. Management measures from the 2000 IBMP included hazing bison back into the park, capture, brucellosis testing, removal of bison that repeatedly leave the park, and the culling of bison by agency personnel. An adaptive adjustment to the IBMP in 2005 also includes a measure for hunting bison outside the park. The IBMP is designed to conserve a wild and free-ranging bison population, while reducing the risk of brucellosis transmission to cattle. New policies allow untested females or mixed groups of bison to migrate onto and occupy Horse Butte peninsula and nearby areas each winter and spring. Controls include hazing bison back into the park during mid-May, lethal removal, and retaining animals in facilities for brucellosis testing and eventual release or culling. If populations drop below 2,300 bison, the agencies increase implementation of non-lethal measures and if populations drop below 2,100 bison, agencies cease lethal management and hunting and shift to non-lethal management measures.

Behavioral Reponses of Bison to Winter Visitors

Bison

Before the implementation of mandatory guiding, conflicts between OSV users and wildlife were common (Dimmick 2003). Rangers were frequently dispatched to the scene of wildlife/visitor conflicts to direct traffic and ensure the safety of both visitors and wildlife. OSV users cited for off-road violations often stated that they were attempting to evade or go around bison (Dimmick 2002, 2003; NPS 2008a).

Implementation of mandatory guiding has substantially reduced wildlife-visitor conflicts. Trained guides are knowledgeable about where wildlife is likely to occur and how to avoid harassing behavior. Guides enforce park rules including speed limits and restrictions on off-road travel (Taber 2006; NPS 2008a). Because guides are trained, in part by the NPS, they are able to instruct visitors to observe wildlife in a way that minimizes more energetic behavioral responses, for instance, by limiting interaction time and maintaining an appropriate distance from wildlife groups (NPS 2008a).



Source: McClure et al. 2009

Studies have examined the reactions of bison to OSV users in the park over recent years. White et al. (2009) and Borkowski et al. (2006) reported that OSV use caused active movement responses in less than 10 percent of individual bison observed; 80 percent showed no apparent response. Behavioral monitoring from the winter of 1999 to the winter of 2009 indicates that bison demonstrated no visible response to OSVs 85 percent of the time, with active responses, including travel, alarm-attention, and travel/flight/alarm-attention, observed during more than 3 percent of interactions. "Look-resume" vigilance responses composed the remaining 11 percent of visible responses (McClure et al. 2009). This indicates that the vast majority of bison in winter 2009 appeared undisturbed by OSV users, with minimal energetic responses. One aspect of behavioral response that does not seem to have been measured, however, is the effect, if any, to an individual animal of repeated disturbance-based responses over the course of a day. More plainly, there do not appear to be studies where species responses were examined to determine if there is a limit to disturbance where the response of an individual changes over the course of a day (e.g., for animal A (responses 1–6 travel, then responses 7–11 look-resume)). It is unclear the value of this type of information in that it may be difficult to draw conclusions due to the variability in individual response.

Few studies have looked specifically at the population-level effects of winter use on distribution patterns of elk, bison, and wolves (Messer et al. 2009; Smith et al. 2007; Bruggeman et al. 2009a). White et al. (2009) report that human disturbance associated with OSVs did not appear to be a primary factor influencing the distribution or movement of bison, and concluded that individual responses that resulted in flight or other active behavior were apparently short-term behavioral responses and did not have lasting influence on the pattern of bison distribution. The data suggests that individual bison are sometimes affected by winter use in the park as indicated by movement responses 8 percent to 10 percent of the time, and look-resume response behavior. Based on monitoring, these individual-level disturbances have not affected the abundance, distribution, or movement of bison compared to other factors such as brucellosis risk management (Bruggeman et al. 2006; Borkowski et al. 2006; White et al. 2009; Plumb et al. 2009).

Bison Use of Groomed Roads on Bison Range Expansion and Population Growth

Historically, the bison winter range included the Lamar Valley, Pelican Valley, Hayden Valley, and Firehole River drainage (Meagher 1970, 1973). Over time, bison use of the northern and western regions of the range gradually increased, roughly correlating with the start of OSV use and trail grooming in 1971. In 1980, bison were first observed using a packed road surface to travel west of Pelican Valley (Meagher 1998). Since then, bison were often observed traveling along groomed road corridors, and air surveys observed bison using road corridors in traveling out of the park (Meagher 1998). Bison use of the Madison headwaters region between Old Faithful, West Yellowstone, and Mammoth occurs where road grooming and OSV travel by winter visitors is concentrated.

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Meagher (1998) suggested that groomed roads directly contributed to an increased bison population and observed changes in bison range distribution by providing energy-efficient travel corridors. The study also suggests that bison selectively choose to travel on groomed roads because the roads are packed and easier to travel on, and that bison traveling on roads save energy. It was hypothesized that this has resulted in bison population growing to higher levels and at a faster rate than they would have in the absence of groomed roads, thus altering bison distribution in Yellowstone. The study contends that road use by bison is particularly important during stress-induced, exploratory dispersal. Based on research observation, the availability of groomed routes may influence whether bison travel and may direct bison movements by providing an energy efficient route of travel (Meagher 1989, 1993, 1998. (See discussions of Meagher's research in NPS 2000b: 143-147, 2003d: 117-120, 2004a: 80-81.)

Recent publications, however, assert that road grooming is less important to bison population dynamics than other natural factors (Gates et al. 2005; Bruggeman et al. 2009b). These scientists found no correlation between the presence of groomed trails and increased bison movements (Cheville et al. 1998; Wagner 2006). Instead, the publications attribute bison population growth to a natural increase in population following the cessation of active herd reductions by the NPS in the 1960s. As population density increased, nutritional intake and foraging efficiency for individual bison were reduced and bison began to move to lower elevation winter ranges inside and outside the north and west boundaries of the park (Taper et al. 2000). In other words, increases in bison abundance were followed by range expansion, often triggered by severe snow events (Gates et al. 2005). The requirement for additional winter habitat due to higher population density and the ability of bison to travel through deep snow, resulted in necessary range expansion, in search of new foraging areas and migration westward to the Madison headwaters (Bjornlie and Garrott 2001; Gates et al. 2005; Bruggeman et al. 2009a, 2009b; Plumb et al. 2009). Also, winter bison movements from the central to northern parts of the park may have started in the 1980s (Coughenour 2005; Fuller et al. 2007), but these movements became more common and included greater numbers of bison after 1996 (NPS 2008a).

While Meagher (1993, 1998, 2001) and Coughenour (2005) suggest that over time, OSVs and groomed trail corridors may have made small contributions to the western migration trends of the central herd bison, most researchers conclude that the changes in bison movement and range over the last 20 years are primarily in response to population-level dynamics (Gates et al. 2005; Fuller et al. 2007; Coughenour 2005; Taper et al. 2000; Plumb et al. 2009). These changes have resulted in movement from the central interior portions of Yellowstone to the northern and western portions of the park, regardless of winter use occurring in Yellowstone's central region (Gates et al. 2005; Fuller et al. 2007; Coughenour 2005; NPS 2008a).

In summary, the best available evidence regarding road grooming and bison distribution suggests the following.

- First, observed changes in bison distribution were likely consequences of natural population growth and range expansion that would have occurred regardless of the presence of snow-packed roads (Bjornlie and Garrott 2001; Coughenour 2005; Gates et al. 2005; Bruggeman et al. 2009a).
- Second, road grooming did not change the population growth rates of bison relative to what may have been realized in the absence of road grooming (Gates et al. 2005; Bruggeman et al. 2006; Fuller 2006; Wagner 2006).
- Third, there is no evidence that bison preferentially used groomed roads during winter (Bjornlie and Garrott 2001; Bruggeman et al. 2006).

- Fourth, road segments used for travel corridors appeared to be overlaid on what were likely natural travel pathways, including narrow canyons and stream corridors (Gates et al. 2005; Bruggeman et al. 2009b).

- Fifth, bison use of travel corridors that include certain road segments would likely persist whether or not the roads were groomed (Gates et al. 2005; Bruggeman et al. 2009a).

Data on the bison population and their movements in the Yellowstone area prior to extensive hunting by humans and in the absence of OSVs are unavailable. Therefore, the vast majority of detailed information on bison was collected during the recent population expansion and in the presence of road grooming. Because bison now migrate to lower elevation ranges for forage during winter, bison movement and population data in the absence of OSVs are impossible to determine after the fact, and in the absence of a control population, what precise impact, if any, road grooming and winter use has on bison winter range expansion and population growth (Bruggeman et al. 2007, 2009a).

ELK (*CERVUS ELAPHUS*)

Elk were nearly extirpated from North America by the early 1900s, due to human hunting, competition with domestic grazing animals, and habitat shift and loss (Clark 1999). Most of the surviving elk in North America found refuge in the greater Yellowstone area due, in part, to strict hunting regulations and enforcement in the park after 1886. Elk herd summer ranges are found throughout Yellowstone (Clark 1999).

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Historic and Current Park Management of Elk

More than 10,000 elk from seven to eight different herds likely spend summer in Yellowstone, but this number decreases to a few thousand during winter. Elk choose habitat based on the preferred mix of topography, weather, vegetation, and factors that reduce their vulnerability to predation. Grasses are the primary forage, followed by forb species and conifers (Clark 1999). Their summer range is extensive and is based primarily on vegetation productivity. Winter range is limited to lower elevation and snow depth and is much smaller.

Elk

Elk play an important role in the ecology of the Yellowstone area. Winter-death carcasses, young calves, and adults are an important food source for many key park species including bald eagles, wolverines, wolves, coyotes, and grizzly bears. Elk make up more than 90 percent of the diet of gray wolves. Newborn or young elk are often killed and consumed by grizzly bears (Swensen et al. 1986; Smith et al. 1998; Barber et al. 2005). Browsing by elk and the nitrogen deposits in elk droppings can affect vegetation productivity, location, and diversity, and soil fertility. Changes in elk abundance and distribution can alter plant and animal ecology, composition, and structure in Yellowstone.

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Elk in the non-migratory Madison headwaters herd are exposed to high levels of OSV use. From 1968 to 2004, when winter visitors to the park expanded from just 5,000 to over 100,000, the Madison headwaters elk herd population remained around 500 animals (Garrott et al. 2009). Before the introduction of wolves to the park, female elk had a 90 percent annual survival rate, with healthy recruitment and high birth and survival rates of calves (Garrott et al. 2003).

Elk are not observed to use groomed roads as travel corridors to the same extent as bison. However, as discussed previously, individual elk can occasionally be visibly bothered by OSV travel, demonstrated by increased attention/alert or active movement/fleeing (Hardy 2001; Bjornlie 2000). Studies reported in Borkowski et al. (2006) and White et al. (2009) indicate that 48 percent of individual elk had no apparent response to OSV use, 27 to 32 percent exhibited a “look-resume” response, 12 to 17 percent “alert,” 5 to 6 percent “travel,” and 2 percent “flight.” Most interactions between OSV users and elk occur in along the groomed road corridor used by OSVs in the upper Madison River drainage between West Yellowstone, Montana and Old Faithful.

There is some evidence that elk were displaced approximately 60 meters (197 feet) from roads with mostly unguided OSV-use during observations from winter 1998 to winter 2001 (Hardy 2001; NPS 2008a). Observations of behavioral responses and apparent avoidance of humans in the vicinity of the roads were short-term changes and did not have a lasting influence on species distribution patterns. Later studies found that the use of guides may help reduce interactions that result in energetically costly movement responses by wildlife (e.g., flight) because guides are trained to limit their groups’ interaction time with animals, prevent wildlife harassment and chasing, and control the distance at which their groups approach animals (NPS 2008a).

CANADA LYNX (*LYNX CANADENSIS*)

Canada lynx once ranged throughout the boreal forests of North America from Alaska to Canada and into the northern United States. Below the Canadian border, lynx are listed as a threatened species in 14 states that support boreal forest types and have verified records of lynx occurrence: Colorado, Idaho, Maine, Michigan, Minnesota, Montana, New Hampshire, New York, Oregon, Utah, Vermont, Washington, Wisconsin, and Wyoming (Yellowstone) (USFWS 2005). Based on declining populations and continuing threats from logging, recreation and development to their remaining habitat, Canada lynx were listed as threatened in the lower 48 states in March 2000 (USFWS 2005).

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Lynx are rarely found in Yellowstone and accurate historical population records are limited. Potential habitat for lynx is shown in figure 5. A total of 73 lynx sightings or tracks were reported in Yellowstone from 1887 to 1993, but the reliability of many reports is questionable and cannot be verified (Yellowstone National Park files; Consolo-Murphy and Meagher 1995). A survey conducted from 2001 to 2004 for lynx in Yellowstone National Park found DNA and track evidence for three lynx, a female and two kittens, all east of Yellowstone Lake (Murphy et al. 2005). This area also contained the highest indices of abundance for snowshoe hare and red squirrel, which form a large percentage of lynx diets (Koehler and Aubry 1994; Sunquist and Sunquist 2002). The authors note that lynx in other areas of the park could have escaped detection, but state that based on their data, they believe lynx are primarily found in the eastern portions of the park. Lynx are also occasionally seen in other areas of the park, such as Indian Creek (just south of Mammoth) and in the Beryl Springs area (between Norris and Madison). Both times, the lynx were traveling near a road that was groomed for OSV travel.

Data on lynx-human encounters suggest that lynx are generally intolerant of continued human presence, human scent, disturbance, and agricultural or housing development (Brand and Keith 1979; Fortin and Huot 1995; Staples 1995; Aubry et al. 1999). Mowat et al. (1999) states that based on their observations and research, lynx in Canada and Alaska likely tolerate moderate levels of snowmobile traffic throughout their winter ranges, readily cross highways, and appear comfortable near roads. However, Apps (1999) reports that lynx in the southern parts of their range, including the lower 48 states, are generally more sensitive to road fragmentation of habitat due to the relative scarcity of prime habitat and reduced prey availability compared to that available to lynx the boreal forests of Canada and Alaska. Although some research suggests that lynx tolerate moderate levels of snowmobile traffic, there is debate about whether this tolerance is due to a level of comfort with human disturbances or a lack of suitable alternative habitats. Observations in Washington found that logging and U.S. Forest Service (USFS) roads that were little used in the summer but frequently used by snowmobiles in the winter and roads less than 15 meters (49 feet) wide did not appear to affect lynx movements or habitat use (Koehler and Brittel 1990; McKelvey et al. 1999). While these little-used roads do not appear to affect lynx, research in the southern Canadian Rockies indicates that wider, more heavily used paved roads may influence lynx spatial organization, and lynx appear to avoid crossing highways (Apps 1999). Thus, lynx movements in the lower 48 states may be restricted by roads and highways due to direct avoidance of roads and habitat alteration and fragmentation. Ruediger (1996 unpublished report) found that traffic volumes were also a factor and volumes must generally exceed 2,000 to 3,000 vehicles a day in order for lynx to be affected. Many lynx are reported to have been killed by automobiles in other parts of the country and in Canada (Brocke et al. 1992; Weaver 1993; Staples 1995; Gibeau and Heuer 1996; Halfpenny et al. 1999; Murphy et al. 2006). There have been no reported lynx strikes in the greater Yellowstone area (Murphy et al. 2006). Thus, wide paved roads and those with higher traffic volume appear to have the most influence on lynx movements and habitat use.

Groomed trails alone also may affect lynx dispersion and predator-prey dynamics in lynx habitat. Groomed trails may facilitate access to lynx habitat by competing predators such as coyotes. Bunnell et al. (2006) used observations of coyote tracks from two field studies and found a strong association between coyote movements and OSV routes in deep snow areas. In contrast, Kolbe et al. (2007) found that coyote trails were generally associated with firmer snow conditions but not necessarily with compacted OSV trails. They also found snowshoe hare to be a rare component of the coyote winter diet. Both authors found that lynx show a greater preference for higher elevations than coyotes. Areas of higher elevations, except the Sylvan Pass area, are areas where OSV use does not occur.

FIGURE 5: LYNX HABITAT IN YELLOWSTONE NATIONAL PARK

Due to lynx range distribution, there have been fewer studies on lynx inhabiting the lower 48 states and in the southern part of their range, than on lynx in the boreal forests of Canada and Alaska. Studies conducted on the Rocky Mountain lynx populations have found that lynx may avoid crossing highways, avoid areas of human presence, and may use roads as territory boundaries (Apps 1999). Lynx do not appear to avoid crossing logging roads, or roads with lower levels of vehicle use (Koehler and Brittel 1990, McKelvey et al. 1999). Lynx may also be affected by human facilitation of access to their habitat by competing predators (or predators that may prey upon lynx) (Koehler and Aubry 1994). Lynx habitat in Yellowstone is likely limited to the eastern portion of the park, crossed by only one lightly used OSV snow road (with fewer than 10 OSVs per day, on average). The presence of kittens and the two recent sightings of lynx next to roads groomed for OSV use in other areas of the park indicate that lynx are likely traveling in and out of this area, particularly during breeding and dispersal. Traveling lynx would likely encounter groomed winter trails, and OSVs and humans traveling these trails both within and outside the park. Their movements and ability to disperse could be adversely affected by OSV-associated noise and human presence on these groomed snow roads. Groomed roads make up very little of the total land area in Yellowstone and not all summer use roads are plowed or groomed in Yellowstone in the winter, so the amount of exposure to groomed trails would be small. Because of the secretive nature of lynx, their rarity, and their use of heavily forested habitat, few ecological studies have been conducted on lynx, and even fewer researchers have looked into the effects of winter recreation on this species. Therefore, it is difficult to determine how OSV use in Yellowstone would affect lynx habitat use, behavior, or distribution. Most of the park does not contain suitable habitat for lynx, and thus the majority of lynx that would encounter heavily used groomed trails and OSVs would be traveling from one area of prime habitat to another for dispersal or breeding purposes. These travels are important to lynx ecology for genetic dispersion and habitat use. Lynx are mobile in the winter, and there is a potential for this species to encounter groomed roads and/or OSVs during their travels. However, evidence suggests that lynx travel through Yellowstone, rather than inhabit the park permanently.

WOLVERINE (*GULO GULO*)

The wolverine is a rare and sparsely distributed member of the weasel family that inhabits remote areas of the circumpolar boreal forests. Even though wolverines only weigh from 6 to 18 kilograms, they are fierce predators and are able to successfully hunt large ungulates, including adult elk. Wolverines have rarely been studied by scientists (with a total of only about 25 publications worldwide) due in part to their scarcity, elusive behavior, and large home range size, as well as the inaccessible, rugged terrain they inhabit. As of 2001, there were six studies published on North American wolverines, with only two in the United States (Heinemeyer et al. 2001). Until recently, wolverine populations in the lower 48 states were thought to be limited to the northern Cascade region of Washington and the Northern Rocky Mountain region in Idaho, Montana, and Wyoming. However, scientists have now documented wolverines in California's Sierra Nevada Mountains and in Colorado's southern Rocky Mountains (USFWS 2010c). Due in part to the limited amount of information on wolverines, especially those living in the lower 48 states, and the recently observed populations in Colorado and California, the U.S. Fish and Wildlife Service (USFWS) initiated a status review of the North American wolverine population to determine whether this population should be listed as threatened or endangered under the Endangered Species Act (ESA). In December 2010, the USFWS ruled the wolverine occurring in the contiguous United States was a distinct population segment that warranted being added to the Lists of Endangered and Threatened Wildlife and Plants (USDOI 2010). However, this listing was precluded by higher priority actions and, instead, the contiguous U.S. distinct population segment of the wolverine was added to the candidate species list, or is currently proposed for

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listing. The USFWS considers the current range of the species to include portions of Washington, Idaho, Montana, Wyoming, Colorado, Utah, Oregon, and California.

Wolverines rely on carrion as a food source but are also known to prey on large ungulates (Magoun and Valkenburg 1983), snowshoe hare, and ground squirrel in areas of Alaska and the Yukon (Gardner 1985; Banci 1987). In the Yellowstone area, researchers found that wolverines primarily fed on ungulate carcasses, including elk, moose, and deer (Packila et al. 2007a). During winter, wolverines generally scavenge carcasses of adults, whereas in the spring they take young or newborn calves. They consume Marmots and ungulates during late spring and summer. These prey items are supplemented with small mammals and birds. Some researchers suggest that year-round food supply is an important consideration for den location (Banci and Harestad 1990). Sylvan Pass is the closest known location of a wolverine to an OSV corridor and contains suitable denning habitat. Wolverine tracks were seen on Sylvan Pass during the winter of 2009 (Sacklin pers. comm. 2010).

Wolverine distribution and population characteristics in Yellowstone National Park and neighboring wilderness areas along the park's east, northeast, and south boundaries were investigated during 2005 to 2009 by capturing and monitoring radio-marked individuals, and conducting surveys for their tracks during winter. Four wolverines were captured during intensive trapping efforts. Two wolverines were trapped and radio collared in the winter of 2006, one near Sylvan Pass. The closest preferred denning habitat to an OSV corridor in this area occurs at the pass itself (Landa et al. 1998; Banci and Harestad 1990). In the winter of 2007, researchers trapped two young wolverines, both north of Yellowstone. One additional wolverine was captured during winter 2008, and none were captured during winter 2009. One wolverine’s home range was in the southeast corner of the park, and another overlapped this same area, with its home range also extending southwest of park boundaries. The two other wolverine home ranges were respectively north and south of park boundaries (Murphy et al. 2011).

The Greater Yellowstone Wolverine Program, established by the Wildlife Conservation Society, has conducted extensive research on wolverines in the greater Yellowstone area. During extensive trapping efforts from 2001 to 2007, 28 wolverines were captured and fitted with GPS collars, none of which were found in Yellowstone. Preliminary research results show that, of the collared wolverines, male wolverines had an average home range size of 1,160 square kilometers (448 square miles), and female wolverines had an average home range size of 453 square kilometers (175 square miles). Of the 28 wolverines captured and collared, 17 were females. Females give birth in mid-February to only 1 kit every 2.5 years. Seven females denned up and gave birth to young, with 6 using designated wilderness areas; one den (not in designated wilderness) was in Yellowstone. One female’s natal den was in an area that was occasionally subject to snowmobile activity. Dens were at high elevation (7,200 to 9,300 feet), and usually found within areas of avalanche debris, at subalpine sites near timberline, and among boulder talus. The birthing dens were occupied until late April. Young wolverines dispersed from their mother’s home range when they were about a year old. Over three winters, eight wolverines (five females, three males) were captured and fitted with collars that recorded continuous activity levels during the winter. Male activity peaked in the morning and evening, whereas non-reproductive female activity peaked during morning. The reproductive female showed little activity for two weeks following the birth of her kit. The wolverines inhabited areas with varying levels of OSV use (McCue et al. 2007). Yellowstone OSV use peaks in the morning, early afternoon, and late afternoon, likely corresponding with active periods for wolverines.

The Wildlife Conservation Society also conducted research on wolverine road crossing patterns and occurrence in the greater Yellowstone area, focusing on a crossing near the Henry Lakes Range at Earthquake Lake (US287) and Raynolds Pass (ID/MT87) west of Yellowstone National Park. The results demonstrate that wolverines cross roads to navigate their home ranges, and that linkage of home ranges via road crossing (and very likely snowmobile trail crossing) is critical to the maintenance of the greater Yellowstone area wolverine population (Packila et al. 2007b unpublished).

Wolverines tend to avoid humans. Human disturbance in the vicinity of a natal den may cause the wolverine to abandon her den for a less desirable den site, possibly resulting in reduced reproductive success (Banci 1994). This behavior has been observed in wolverines subject to human disturbance in both Norway (Myrberget 1968) and Finland (Pulliainen 1968). Wolverines also appear to avoid areas of human activity for den choice, including areas of OSV use, because aerial surveys in the greater Yellowstone area in 2001 noted few wolverine tracks or foraging evidence in areas of heavy snowmobile use (Heinemeyer et al. 2001). The effects of OSV use in the park and the greater Yellowstone area on individual behavior and overall population are unknown, due to lack of long-term data and difficulty in observing or tracking individuals because they avoid humans and because of low population numbers.

TRUMPETER SWAN (*CYGNUS BUCCINATOR*)

Hunted to near extinction in the early 1900s, trumpeter swans benefited from protections through the passage of the Migratory Bird Treaty Act in 1918 (MBTA) that helped reduce illegal hunting of trumpeter swans; however, habitat changes and hunting continued to reduce swan numbers. The tri-state area (Wyoming, Idaho, and Montana) flock of trumpeter swans was petitioned for listing under the ESA in 2003, but the USFWS did not find enough evidence for listing. Currently, the greater Yellowstone area population of swans is again under review for listing due to recent declines in the region (USFWS 2010d).

During the breeding season, two nesting pairs of resident swans were found, but neither successfully produced young. Only two nesting pairs were observed over the past three seasons. Since 2001, there were at most four annual nesting attempts by trumpeter swan pairs in the park.

The park has both a resident population and a migratory winter population. Migrants that visit Yellowstone in the winter are a combination of swans from the Yellowstone/greater Yellowstone area and swans from Canada (primarily Grande Prairie, Alberta; Proffitt et al. 2009). The resident population in the park is less than 10 swans, with fall migratory populations numbering as high as 500 (Baril et al. 2010). Resident trumpeter swans display strong site fidelity to breeding areas and nest sites, and winter habitat is generally associated with areas of ice-free, open water (Baril et al. 2010). The winter habitat of swans and eagles is shown in figure 6.

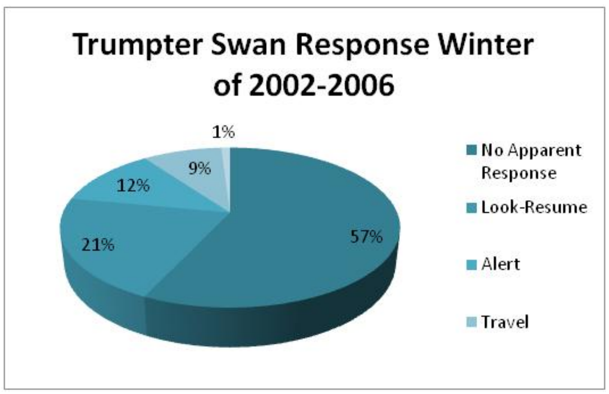
The resident Yellowstone trumpeter swan population is considered at risk, due to decreasing numbers of swans and cygnets from 1961 to present. Surveys in 2011 counted 167 swans in Yellowstone, the Paradise Valley, and on Hebgen Lake during midwinter, and 9 adults and no cygnets in autumn. The estimated abundance of resident trumpeter swans in Yellowstone National Park decreased from a high of 59 individuals in 1968 to 3 individuals in 2010 (Baril et al. 2010). There was some evidence that this decrease in abundance became more dramatic after supplemental feeding of swans outside the park (Centennial Valley, Montana) was terminated in the winter of 1992-1993 (Proffitt et al. 2009). There was little evidence that numbers of migrants affected the abundance of the resident population, but growth rates were lower following severe winters, wetter springs, and warmer summers (Proffitt et al. 2009). During 1987 through 2007, the proportion of adults breeding annually ranged from 0.27 to 0.67, an average of 6.1 pairs nested in Yellowstone National Park, and an average of 2.7 cygnets survived until September (Proffitt et al. 2010). This overall low productivity of trumpeter swans suggests that the decrease in resident swan abundance will likely continue unless swans dispersing from other areas immigrate to Yellowstone National Park. Trumpeter swan presence may be limited to ephemeral residents and wintering aggregations of migrants from outside the park (Proffitt et al. 2009, 2010).

The resident Yellowstone trumpeter swan population is considered at risk, due to decreasing numbers of swans and cygnets from 1961 to present.

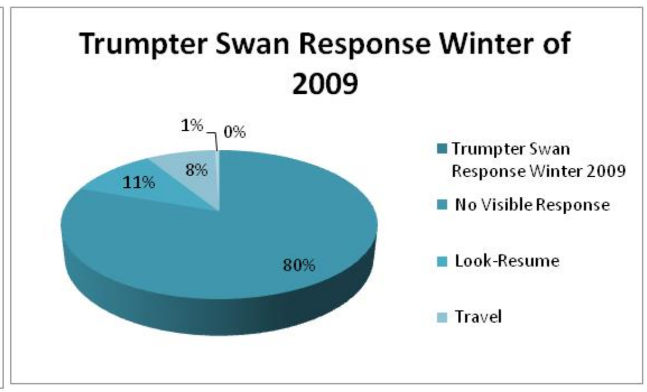
FIGURE 6: EAGLE AND SWAN WINTER HABITAT

There was no swan reproduction in Yellowstone National Park during 2011. Only two nesting pairs were observed over the past four seasons. Since 2001, there were at most four annual nesting attempts by trumpeter swan pairs in the park. More than 53 percent of nest attempts failed to raise any young, which researchers attribute to predation and early season flooding (Proffitt et al. 2010). Overall, the attempts of resident swans to nest in the park have declined since 1987, but numbers have fallen even more steeply over the last decade (Baril and Smith 2009).

Swans have also been the subject of study regarding reactions to OSV presence, with results indicating that human disturbance did not appear to be a primary factor influencing the distribution or movement of swans. White et al. (2009) report on the results of winter monitoring that occurred in the park from 2002 to 2006. Trumpeter swan responses to OSVs were characterized as 57 percent "no apparent response," 21 percent "look-resume," 12 percent "alert," 9 percent "travel," and 1 percent "flight." In 2009 winter wildlife monitoring (McClure et al. 2009), 80 percent of trumpeter swans had no reaction to OSVs, 11 percent responded with "look-resume," 8 percent "travel," and 0.5 percent "alarm-attention." No swans had a flight response. As with other species, the odds of a reaction increased with variables including time of interaction, distance to road, and human behavior (McClure et al. 2009). Because nesting pairs may be extremely sensitive to human disturbance, park researchers recommend that nesting areas remain closed from April 30 to August 15 in order to allow time for cygnets to mature. This does not overlap with the winter-use season.



Source: McClure et al. 2009



Source: White et al. 2009

It is also unlikely that poor production across the greater Yellowstone area has resulted from OSV use in the park. Swans generally return to their breeding territories between February and late May, with young hatching in late June when OSV is no longer a presence in greater Yellowstone area parks (Stalmaster and Kaiser 1998; Steidl and Anthony 2000; Gonzalez et al. 2006; Olliff et al. 1999) (NPS 2008a). A site along the Madison River, less than 100 meters (328 feet) from the park's heavily used west entrance road, has been a traditional swan nesting area for decades, and at least 23 cygnets have fledged from this site since 1983, making it one of the more productive nesting areas in the park. Researchers attribute the overall decline in the greater Yellowstone area to drought and wetland loss, low immigration rates, predation, and competition with other migrants, particularly snow geese (Baril and Smith 2009).

BALD EAGLE (*HALIAEETUS LEUCOCEPHALUS*)

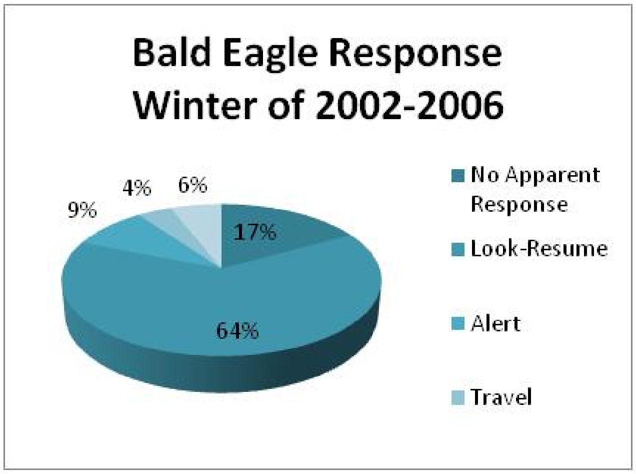
Since their federal listing as an endangered species in 1967, bald eagle populations in the lower 48 states have increased dramatically, with nesting territories recorded in nearly every state. As a result, this species was removed from the Endangered Species List in August 2007, but protection for bald eagles remains in place under the Bald and Golden Eagle Protection Act and the MBTA.

The park has a substantial resident population of eagles that may migrate short distances in winter to be near open water. This population expands seasonally with the addition of migratory eagles.

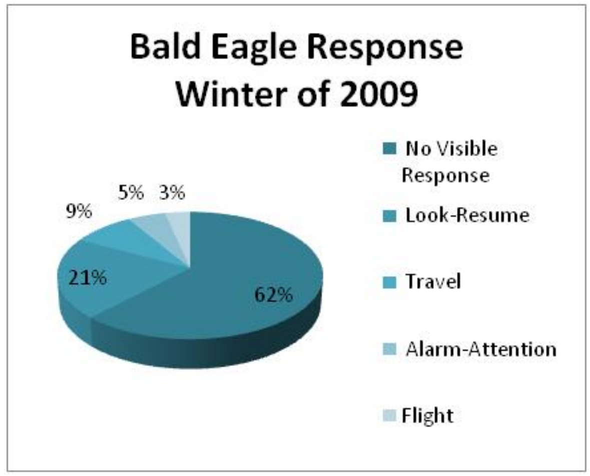
The park has a substantial resident population of eagles that may migrate short distances in winter to be near open water. This population expands seasonally with the addition of migratory eagles. Bald eagles are found in Yellowstone throughout the year, nesting in large trees generally near open water (Stangl 1999; Swensen et al. 1986; Alt 1980). Bald eagle winter habitat is usually near areas of unfrozen rivers or lakes, which provide access to freshwater fish. Winter habitat for eagles is shown in figure 6. Bald eagles also feed on carrion, upland small species, and waterfowl. Nest building occurs between October and April, with actual nesting beginning in mid-February. Incubation occurs for 35 days, with hatching taking place in late March. Bald eagle surveys in 2011 found 25 occupied territories and 13 young were fledged from 10 successful nests (59 percent nest success). The numbers of nesting and fledging bald eagles in the park increased incrementally from 1987 to 2005, but were not significantly correlated with cumulative winter visitation (White et al. 2009; also see the Scientific Assessment of Yellowstone National Park Winter Use). The overall bald eagle population remains stable in Yellowstone National Park, but decreased reproductive success has been observed for eagles nesting in the Yellowstone Lake area in recent years, possibly due to reductions in cutthroat trout abundance, human disturbance, climate change, or other unidentified reasons. For the Yellowstone Lake population, nest success was only 44 percent compared with 75 percent in all other areas of Yellowstone. Similarly, productivity was just 0.56 at Yellowstone Lake, but 1.00 elsewhere. Thus, bald eagle populations may gradually decline (Baril et al. 2010).

Eagle Nesting in Yellowstone

Based on wildlife monitoring the NPS performed in the park from winter 2002 to winter 2006 (White et al. 2009), bald eagle responses to OSVs and human activity were categorized as 17 percent "no response," 64 percent "look-resume," 9 percent "attention-alarm," 4 percent "travel," and 6 percent "flight." Annual monitoring reports from 2009 (McClure et al. 2009) recorded 58 total interactions between winter recreationists and eagles. Of these, 62 percent initiated no response from the eagles, 21 percent resulted in "look-resume," 9 percent in "travel," 5 percent in "alarm-attention," and 3 percent in "flight." The combined percentage of travel and flight, the most active responses, was lower (12 percent) than that recorded in 2008 (16 percent), while the percentage of no response increased from 59 percent in 2008 to 62 percent in 2009 (McClure et al. 2009).



Source: McClure et al. 2009



Source: White et al. 2009

White et al. (2009) concluded that human disturbance did not appear to be a primary factor influencing the distribution of movement of bald eagles and that individual responses that resulted in flight or other active behavior were apparently short term and without lasting influence on species distribution patterns. A pair of bald eagles nesting near the west entrance road, where OSV traffic routinely passed within 55 meters (180 feet) of the nest, successfully fledged young in 2001. Buffer areas of 400 to 800 meters (0.25 to 0.50 miles) have been recommended where watercraft or vehicles are not permitted to stop (Stalmaster and Kaiser 1998; Grubb et al. 2002; Gonzalez et al. 2006). Grand Teton maintains a 0.5-mile closure around all bald eagle nests from February 15 to August 15. In Yellowstone, this type of closure is difficult, because roads are often sited in steep canyons along the river courses where bald eagles nest and feed. Thus, Yellowstone manages bald eagle nest sites on a case-by-case basis. Additionally, during OSV use season, the park enforces a 400-meter (0.25 mile) no-stop buffer for all eagle nests.

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About one month of the eagle breeding and nesting period coincides with the OSV use season in the park, during which time nests are being prepared and eggs laid and incubated. The presence of OSVs during this month creates a small risk that birds displaced by noise or disruption might have less foraging time and be less successful in raising offspring due to increased energy expenditure for flight, decreased pair bonding and reduced nest building time, and possible poor incubation by disturbed eagles. There is no overlap or potential for disturbance from OSV use after chicks have hatched. Nesting success and numbers of fledgling bald eagles in Yellowstone increased during a period of intense OSV use (1987 to 2005) and were not correlated with cumulative OSV traffic.

GRAY WOLF (*CANIS LUPUS*)

Historically found throughout North America, gray wolves were extirpated from the Yellowstone area by the mid-1930s by hunters and trappers. Listed as endangered under the ESA in 1974, wolves were reintroduced into the park between 1995 and 1997. Wolves in the Yellowstone area are classified as a non-essential, experimental population by the USFWS and per the ESA 10(j) and are managed in Yellowstone as a threatened population. Recently wolves have been delisted in Idaho and Montana, and Wyoming, and the U.S. Department of Interior reached an agreement in August 2011 on how to end federal protections for wolves in the state of Wyoming (USFWS 2011).

During winter foraging, gray wolves typically frequent ungulate winter ranges, including the Yellowstone northern range, Hayden and Pelican valleys, Madison headwaters, upper Gallatin drainage, the North Fork of Shoshone basin, and the Clark's Fork River (Green et al. 1997).

Wolves in the Yellowstone region primarily prey on elk, which made up 83 percent of their diet in 2009 (Smith et al. 2010). Moose, deer, pronghorn, and bison make up the bulk of the remainder of their diet (Phillips and Smith 1997; Smith et al. 2010). Wolves hunt ungulates year-round and feed on ungulate carcasses when available (Becker et al. 2009; Metz et al. 2012). During winter foraging, wolves typically frequent ungulate winter ranges, including the Yellowstone northern range, Hayden and Pelican valleys, Madison headwaters, upper Gallatin drainage, the North Fork of Shoshone Basin, and the Clark's Fork River (Green et al. 1997, Kaufmann et al. 2007, Smith et al. 2009). Figure 7 shows the ranges of Yellowstone wolf packs.

Until 2003, wolf numbers in the park increased following reintroduction. Between 2003 and 2012, density-dependent natural factors, such as fighting between and within wolf packs resulting in wolf mortality, food stress, and mange, caused declines. In December 2011, researchers observed 98 wolves in the park in 10 packs with 7 breeding pairs. This is a decline of 23 percent from 124 wolves in 2008. Pack size ranged from 3 (Agate pack) to 19 (Mollie's pack). The number of pups per pack in early winter ranged from 0 to 7 (NPS 2011e).

Winter researchers monitoring wildlife behavioral responses to OSVs have observed wolves only rarely in 6 years of monitoring, with a total of just 14 sightings as of 2009 that involved OSV-wolf interactions (less than 1 percent of total wildlife-OSV observations), with the majority of wolf responses consisting of look-resume or no visible response (McClure et al. 2009). Wolf tracks were frequently seen on the roads by winter wildlife monitoring crews, and wolves have been documented traveling and making nocturnal kills during winter in developed areas of the park. After reintroduction, wolves quickly became a showcase animal in the Lamar Valley, readily visible from the wheeled vehicle route, and attracting visitors just for the purpose of wolf watching. Wolf distribution does not appear to be affected by human recreation in the park (Smith et al. 2005), but no studies have looked specifically at the population-level effects of winter use on distribution patterns, or at associated behavioral implications. Wolves den in April, after the winter use season has ended (Smith et al. 2010).

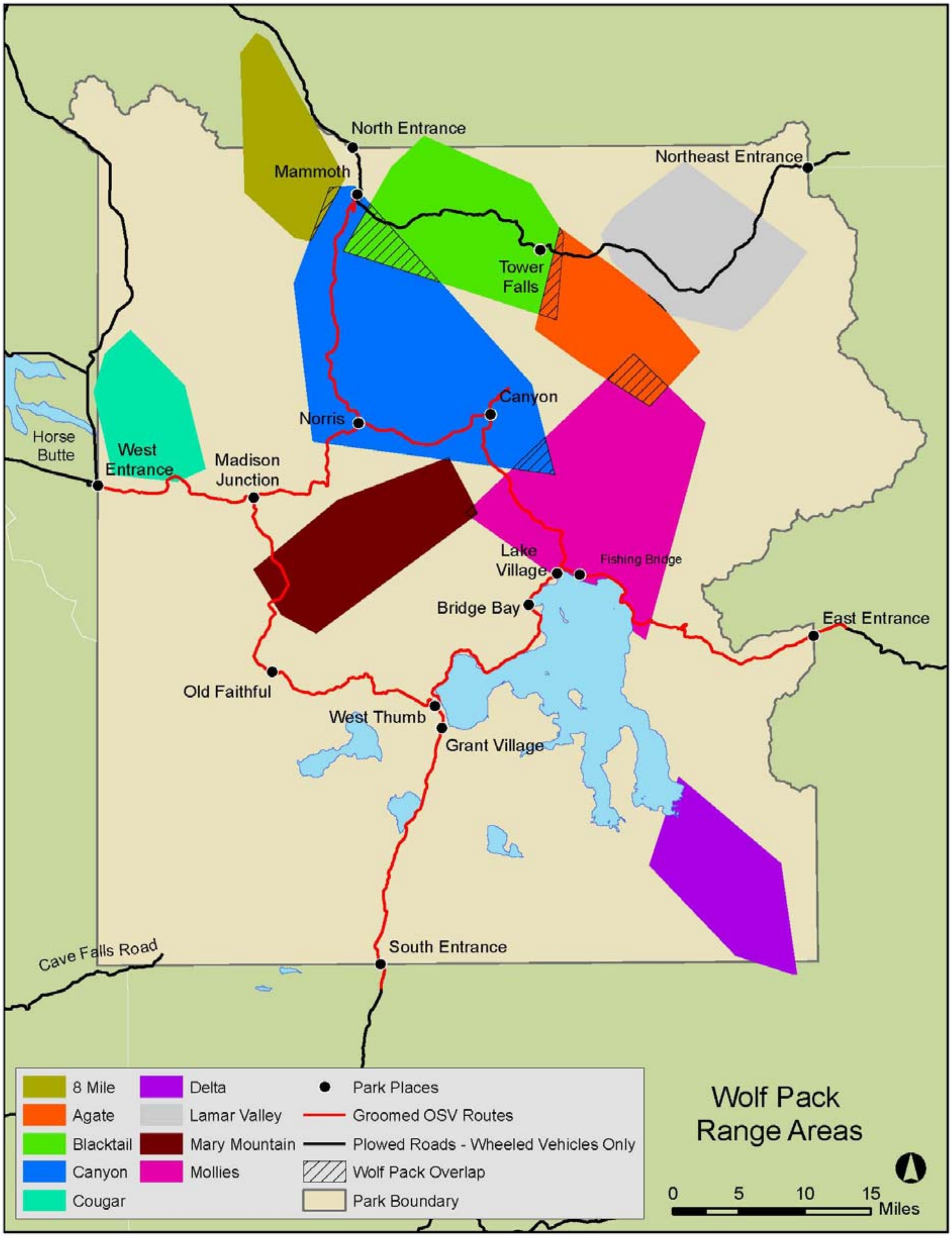

FIGURE 7: WOLF PACK RANGES IN YELLOWSTONE NATIONAL PARK

Creel et al. (2002), reporting on studies of wolves in Yellowstone, Voyagers, and Isle Royale national parks in 1999 and 2000, found that increased stress hormone levels, and therefore physiological stress, were correlated to OSV usage on short and annual scales. Several other researchers have found that prolonged GC elevation typically results in reduced survival and reproduction among both humans and captive animals (Munck et al. 1984; Sapolsky 1994). Creel et al. (2002) state that despite higher stress hormone levels, they found "no evidence that current levels of snowmobile activity are affecting the population dynamics of [wolves] in these locations." However, their research did detect "a clear physiological stress response induced by the current level of snowmobile activity" in the population of elk and wolves they sampled during their research. It should be noted that OSV use has dropped by about two-thirds since these studies were completed (Sacklin pers. comm. 2010). Therefore, these results represent a higher level of OSV use than that occurring in recent years.

Avoidance of roads by wolves may adversely affect their hunting success. Data from one study of wolf hunting success in the Gallatin Range indicate that wolves are more likely to successfully bring down an elk in areas that are flat, open, and near roads (Creel and Winnie 2005). Such data suggest that avoidance of such areas by wolves during the day due to OSV use may limit their hunting success; however, this is a specific result from one study and results may vary depending on geographic location.

Habituation by wolves may occur if they are fed or exposed to human food or trash or human activity. Wolves in Yellowstone have an ample prey base for food supply, and wolves in and around Yellowstone rarely pose a threat to humans or demonstrate begging behaviors. Wolves frequenting areas of human use or development or wolves that are observed approaching people are hazed by the park staff, generally with bean-bag bullets (Smith et al. 2010).

Wolves in Yellowstone have an ample prey base for food supply, and wolves in and around Yellowstone rarely pose a threat to humans or demonstrate begging behaviors.

Hazing generally has good success in eliminating unwanted behaviors or in moving wolves out of an area. But if wolves demonstrate threatening behavior or begging behaviors that indicate they are conditioned to expect handouts from people, hazing may not be successful or park managers may decide the threat posed by the wolf (or wolves) is too high, and the wolf (or wolves) must be removed (Smith et al. 2010). Guiding requirements, education on proper storage of food and behavior around wildlife, and limits on the total number of visitors per day decrease the development of habituation in park wolves due to winter use. Humans who feed or encourage wolves to approach, or who leave food scraps in places accessible to wolves, may cause wolves to become habituated, but in recent years, OSV associated visitors have not been cited as a problem. Wolves may habituate regardless of human behavior, due to frequent exposure to non-threatening humans. It appears that wolves generally avoid encounters with OSV users, and may preferentially choose to travel on OSV roads during times of low human activity (Smith et al. 2008, 2009, 2010).

AIR QUALITY

Air quality is protected under several provisions of the Clean Air Act (CAA), including the Prevention of Significant Deterioration (PSD) program and the National Ambient Air Quality Standards (NAAQS). These regulatory requirements, as they relate to Yellowstone, are described in greater detail below.

PREVENTION OF SIGNIFICANT DETERIORATION

The CAA established the PSD program to protect air quality in relatively clean areas. One purpose of the PSD program is to protect public health and welfare, including natural resources, from adverse effects that might occur even though NAAQS are not violated. Another purpose is to preserve, protect, and enhance the air quality in national parks, national wilderness areas, national monuments, national seashores, and other areas of special national or regional natural, recreational, scenic, or historic value (42 USC 7401 et seq.). The PSD program applies to new major sources and major modifications to existing sources. A key component of the PSD program is the establishment of the maximum allowable increase in pollutant concentrations above a baseline level (or "increment") that a new or modified source can create without degrading air quality.[1] The baseline concentration is defined for each pollutant and, in general, is the ambient concentration existing at the time that the first complete PSD permit application affecting the area is submitted. Significant deterioration is said to occur when the amount of new pollution would exceed the applicable PSD increment (EPA 2009d). In Yellowstone, the baseline year for evaluating PSD increment consumption is 1979.[2]

In addition to PSD increment limitations, the PSD program provides special protection for designated Class I areas. Yellowstone National Park is classified as a Class I area under the CAA PSD program, meaning it is afforded the greatest degree of air quality protection. Even if the PSD increment is not exceeded, no PSD permit can be issued if the Class I area federal land manager (in this case NPS) determines that the source of the emission will adversely affect the Class I area's air quality related values (AQRVs). The AQRVs of the park are those resources that are potentially sensitive to air pollution and include visibility, water quality, soils, vegetation, and wildlife (NPS 2007a). If the PSD increment is exceeded, but the federal land manager certifies that the source will not adversely affect the Class I area's AQRVs, a PSD permit can still be issued (NPS 2011a). The Federal Land Managers' Air Quality Related Values Work Group (FLAG) was formed to provide a consistent and objective approach to determining if a proposed emission source would have an adverse impact on AQRVs in a Class I area. The FLAG 2010 Phase I report describes the methodology and impact criteria for assessing AQRVs, including visibility (NPS 2010b).

CAA—Clean Air Act

PSD—Prevention of Significant Deterioration

NAAQS—National Ambient Air Quality Standards

AQRV—air quality related value

FLAG—Federal Land Managers' Air Quality Related Values Work Group

NATIONAL AMBIENT AIR QUALITY STANDARDS

NAAQS requirements were established to protect human health and the environment and to serve as ceilings for acceptable maximum air quality concentrations (Hawkins and Ternes 2004). The NAAQS consist of numerical standards for air pollution, which are broken into "primary" and "secondary" standards for six major air pollutants described below. Primary standards protect public health (including sensitive populations such as asthmatics, children, and the elderly) and represent levels at which there are no known major effects on human health. Secondary standards are intended to protect the nation's welfare, and account for air pollutant effects on soil, water, visibility, materials, vegetation, and other aspects of the environment (EPA 2010j). These standards are detailed in table 12, along with the averaging time period used to assess each standard and the statistical form of the standard used to determine compliance. Units of measure for the standards are parts per million (ppm – parts per 1,000,000) by volume, parts per billion (ppb – parts per 1,000,000,000) by volume, milligrams per cubic meter of air (mg/m^3), and micrograms per cubic meter of air ($\mu g/m^3$) (EPA 2010j).

[1] http://www.epa.gov/nsr/psd.html.

[2] http://www.nature.nps.gov/air/Pubs/pdf/yell/Snowmobile_Report.pdf.

- Carbon monoxide (CO)—Carbon monoxide is a colorless, odorless gas (EPA 2010a) produced by the incomplete burning of carbon in fuels (EPA 2009a). It is toxic to mammals because of its strong tendency to combine with hemoglobin to form carboxyhemoglobin, which reduces the oxygen-carrying capacity of the blood. Because the hemoglobin that has combined with CO is no longer available to carry oxygen, delivery of oxygen to the body's organs and tissues is inhibited, resulting in adverse health effects (Ayres and Kornreich 2004). Health effects may include impairment of visual perception, manual dexterity, learning ability, and performance of complex tasks; headaches and fatigue; or respiratory failure and death (EPA 2009b, 2010a).
- Nitrogen dioxide (NO_2)—Nitrogen dioxide has a strong, harsh odor and is a liquid below 70°F, becoming a reddish-brown gas at temperatures above 70°F (21.1°C). Nitrogen oxides (NO_x) are released into the air from the exhaust of motor vehicles; the burning of coal, oil, or natural gas; and during other industrial and manufacturing processes. In addition, NO_2 reacts with sunlight leading to the formation of ozone and smog conditions in the air (ATSDR 2002). Evidence suggests that short-term exposure to NO_2 may result in adverse respiratory effects including airway inflammation in healthy people and increased respiratory symptoms in people with asthma. Emissions control measures leading to reductions in NO_2 can generally be expected to reduce population exposures to all gaseous nitrogen oxides, which may have the co-benefit of reducing the formation of ozone and fine particles both of which pose significant health threats (EPA 2009c).
- Ozone (O_3)—Ozone is a colorless and odorless (in low concentrations) gas that is found in both the upper atmosphere (10 to 30 miles above the earth's surface) and at ground level. It is not usually emitted directly into the air, but at ground level is created by a chemical reaction between oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight (EPA 2010b). Inhaling ground-level ozone can result in a number of health effects: induction of respiratory symptoms including coughing, throat irritation, pain and discomfort in the chest, chest tightness, and shortness of breath; decreased lung function; and inflammation of airways. Exposure occurs when people inhale ambient air containing ozone, and people with the greatest exposure are those heavily exercising outdoors for long periods of time when ozone concentrations are high (EPA 2010c).
- Particulate matter (PM)—Particle pollution, or PM, is the term for a mixture of solid particles and liquid droplets found in the air (EPA 2010d). Particles that are less than 2.5 micrometers in diameter are known as "fine particles" ($PM_{2.5}$); those larger than 2.5 micrometers, but less than 10 micrometers, are known as "inhalable coarse particles" (PM_{10}) (EPA 2010d). Particulate pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles (EPA 2010e) from sources such as power plants, vehicles, construction activity, fires, and windblown dust. PM can either be emitted directly from such sources or formed in the atmosphere through secondary reactions or condensation (EPA 2010d). Health effects from PM emissions include reduced lung function, the development or aggravation of respiratory problems, irregular heartbeat, non-fatal heart attacks, and premature death in people with heart or lung disease (EPA 2010f).
- Sulfur dioxide (SO_2)—Sulfur dioxide is one of a group of highly reactive gases known as "oxides of sulfur" (EPA 2010g). Sulfur dioxide in the air results primarily from activities associated with the burning of fossil fuels such as at power plants (ATSDR 1998) and other industrial facilities (EPA 2010g). Current scientific evidence links short-term exposures to SO_2, ranging from 5 minutes to 24 hours, with a variety of adverse respiratory effects including bronchoconstriction (tightening of the airway muscles in the lungs) and increased asthma symptoms (EPA 2009a). Annual ambient SO_2 concentrations have decreased by more than 70 percent since 1980 (EPA 2010h).

- Lead—Lead is a naturally occurring, bluish-gray metal found in small amounts in the earth's crust, but it can also be found in all parts of the environment. Much of it comes from human activities including burning fossil fuels, mining, and manufacturing (ATSDR 2007). The largest source of lead in the atmosphere has been from leaded gasoline combustion, but with the phaseout of lead in gasoline, air lead levels have decreased considerably. Lead is a toxic element, causing a variety of effects at low dose levels. Brain damage, kidney damage, and gastrointestinal distress in humans are seen from acute (short-term) exposure to high levels of lead in humans. Chronic (long-term) exposure to lead results in effects on blood, the central nervous system, blood pressure, kidneys, and vitamin D metabolism in humans (EPA 2010i).

Areas that have never been designated as nonattainment area for a pollutant and NAAQS are considered attainment areas. Areas that do not meet the NAAQS are classified as nonattainment areas for that pollutant. Former nonattainment areas currently meeting the NAAQS are designated as maintenance areas.

Yellowstone is in five counties—Park and Teton counties, Wyoming; Fremont County, Idaho; and Gallatin and Park counties, Montana. All are currently in attainment of the NAAQS (EPA 2010k). However, air pollutant emissions within a 186-mile (300-kilometer) radius of Yellowstone have the potential to affect air quality sensitive resources in the park. There are several counties within a 186-mile (300-kilometer) radius of the park currently designated in non-attainment for PM_{10}, SO_2, and/or lead NAAQS established by the EPA (EPA 2010k; NPS 2004b):

- Lewis and Clark County, Montana, in non-attainment for SO_2 and lead;
- Yellowstone County in non-attainment for SO_2; and
- Missoula (MT), Silver Bow (MT), Yellowstone (MT), Rosebud (MT), Power (ID), Bannock (ID), and Sheridan (WY) counties in non-attainment for PM_{10}.

Pursuant to the CAA provisions, Wyoming and Montana have adopted air quality standards that are more stringent for some pollutants than provided in the NAAQS (see table 12). Idaho adopted NAAQS as the state standard. While it is clear that the CAA delegates jurisdiction for enforcement of air quality standards to conforming states, it is equally clear that the act gives federal land managers the affirmative responsibility to protect air quality and AQRVs (including visibility). The federal land manager, in this case the NPS, has the authority and jurisdiction to administer some provisions of the CAA, particularly the non-degradation standard for Class I air, and to manage activities within its jurisdiction that either affect, or have the potential to affect, air quality or associated values.

AIR QUALITY AT YELLOWSTONE NATIONAL PARK

The climate in Yellowstone is characterized by cold winters and mild to warm summers. During the winter months, the average daytime temperature ranges from 0°F (17.8°C) to 20°F (-6.7°C). Subzero overnight temperatures are common during the winter. The prevailing winds during the winter months are generally from the west and west-southwest (NPS 2009a; WRCC 2002). Annual snowfall averages near 150 inches; however, it is not uncommon for higher elevations to get twice that amount. In general, Yellowstone weather is unpredictable at all times of the year (ALL Trips n.d.; NPS 2010f). Air pollutant emissions can be transported long distances, eventually affecting air quality sensitive resources in parks hundreds of kilometers downwind of sources (NPS 2004b). The Wyoming Department of Environmental Quality is the governing authority for regulating air pollution from stationary sources in Wyoming. Because there is little industrial activity and a relatively low population in northwestern Wyoming, overall air quality in the park is good (NPS 1998a). Regional sources of air pollutants that could affect Yellowstone include electric utility power plants, oil and gas processing, coal bed methane wells, industrial fossil-fuel combustion, and agriculture. Local sources of air pollution include automobiles, snowmobiles, and wildland fires (NPS 2007a). As previously described, several counties within a 186-mile radius of the park are designated in non-attainment for PM_{10}, SO_2, and/or lead NAAQS as a result of various local and regional sources of air pollutants.

TABLE 12: NATIONAL AND STATE AMBIENT AIR QUALITY STANDARDS

Pollutant	Primary/ Secondary (for NAAQS)	Averaging Time	National and Idaho	Montana	Wyoming	Form (for NAAQS)
Carbon Monoxide	Primary	8-hour	9 ppm	Same as NAAQS	Same as NAAQS	Not to be exceeded more than once per year
		1-hour	35 ppm	23 ppm	Same as NAAQS	
Lead	Primary and Secondary	Rolling 3-month average	0.15 $\mu g/m^3$	—	0.15 $\mu g/m^3$	Not to be exceeded
	N/A	Quarterly	—	1.5 $\mu g/m^3$	—	Not to be exceeded
Nitrogen Dioxide	Primary	1-hour	100 ppb	300 ppb*	—	98th percentile, averaged over 3 years
	Primary and Secondary	Annual	53 ppb	50 ppb	50 ppb	Annual mean
PM_{10}	Primary and Secondary	24-hour	150 $\mu g/m^3$	Same as NAAQS	Same as NAAQS	Not to be exceeded more than once per year on average over 3 years
		Annual	—	50 $\mu g/m^3$	50 $\mu g/m^3$	Annual arithmetic mean
$PM_{2.5}$	Primary and Secondary	Annual	15.0 $\mu g/m^3$	—	Same as NAAQS	Annual mean, averaged over 3 years
		24-hour	35 $\mu g/m^3$	—	Same as NAAQS	98th percentile, averaged over 3 years
Ozone	Primary and Secondary	8-hour	0.075 ppm	—	0.08 ppm	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
	N/A	1-hour	—	0.10 ppm	—	Not to be exceeded more than once per year
Sulfur Dioxide	Primary	1-hour	75 ppb	500 ppb	—	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
	N/A	24-hour	—	0.1 ppm	0.1 ppm	Not to be exceeded more than once per year (state)
	N/A	Annual	—	0.02 ppm	0.02 ppm	Arithmetic average over any four consecutive quarters (state)
	Secondary	3-hour	0.5 ppm	—	0.5 ppm	Not to be exceeded more than once per year

*Form differs from NAAQS; not be exceeded more than once over 12 consecutive months.

Sources: EPA 2012b; MTDEQ 2011; Wyoming DEQ 2010.

AIR QUALITY RELATED VALUES

As previously described, the AQRVs of Yellowstone include visibility, water quality, soils, vegetation, and wildlife. Although visibility in the park is still superior to that in many parts of the country, visibility in the park is often impaired by haze (light-scattering pollutants). The Environmental Protection Agency's (EPA's) regional haze regulations require states to establish goals for each Class I air quality area to improve visibility on the haziest days and ensure that no degradation occurs on the clearest days (NPS 2007a).

Secondary pollutants such as sulfates and nitrates, produced by industrial sources and automobile emissions, can result in the deterioration of visibility in park units and contribute to acid deposition, which leads to impacts in forests. Acid deposition, commonly referred to as acid rain, occurs when acidic materials are transferred from the atmosphere to the Earth in either wet (rain, sleet, snow, fog) or dry (gases, particles) form. The main chemical precursors leading to acidic conditions are atmospheric concentrations of SO_2 and NO_x. When these two compounds react with water, oxygen, carbon dioxide, and sunlight in the atmosphere, the result is sulfuric acid (H_2SO_4) and nitric acid (HNO_3), the primary agents of acid deposition (Ecological Society of America 2000). Although there are currently no standards for levels of sulfates or nitrates in ambient air, these pollutants may present a concern for ecosystem health in park units.

Certain headwater lakes in the park are potentially sensitive to atmospheric deposition (deposited material) of sulfur and nitrogen compounds because of their low acid neutralizing capacity. Their snowmelt-dominated hydrology makes them vulnerable to episodic acidification in the spring, and possibly chronic acidification. In addition, high-elevation soils may be poorly buffered and sensitive to acidification (NPS 2006b, 2007a).

Soils and vegetation in the park may be sensitive to nutrient enrichment from nitrogen deposition as well. In some parts of the country, including other high-elevation ecosystems in the Rocky Mountains, nitrogen deposition has altered soil nutrient cycling and vegetation species composition. Native plants that have evolved under nitrogen-poor conditions have been replaced by invasive species that are able to take advantage of increased nitrogen levels (NPS 2007a).

Wildlife is considered an AQRV at Yellowstone; however, there is currently no information indicating that wildlife species in the park are being affected by air pollutants (NPS 2006b).

Effects of OSVs on Air Quality Related Values

Atmospheric and snowpack concentrations of OSV emitted pollutants have decreased in response to best available technology (BAT) implementation, and current emission levels from OSVs likely do not compromise ecosystem health in a measurable way. For a detailed review addressing the potential effects of OSV emissions on nitrate deposition, biota, soils, the snowpack, runoff and surface waterbodies, refer to the Scientific Assessment of Yellowstone National Park Winter Use.

AIR QUALITY CONDITIONS AND TRENDS

The NPS measures progress toward improving park air quality by examining trends for key air quality indicators, such as visibility, which affects how well and how far visitors can see; atmospheric deposition, which affects ecological health through acidification and fertilization of soil and surface waters; and ozone, which affects human health and native vegetation. The NPS monitors one or more of these indicators in 57 park units, including Yellowstone National Park, and there is sufficient data to assess conditions and trends in all of these parks. In addition, many state and local air quality monitoring stations are near enough to parks that the data they collect are considered reasonably representative of park air quality. Air quality trends provide one measure of performance and progress. In general, air quality that is improving, or showing no degrading trend, may be considered a sign of success. In accordance with the Government Performance and Results Act, the NPS has established performance goals based on air quality trends and reports annually on progress toward these goals (NPS 2009b). For fiscal year 2011, Yellowstone's goal was for air quality to remain stable or improve (NPS 2011d).

In addition to determining the trends in air quality, the NPS is interested in assessing the condition of the air resources in NPS units, including Yellowstone. To assess conditions, the NPS Air Resources Division (ARD) uses all available monitoring data collected from NPS, EPA, state, tribal, and local monitors over a 5-year period to derive estimates of the air quality parameters at all NPS units in the continental United States. NPS ARD uses this data to develop an index for each type of air quality data collected (visibility, ozone concentrations, and wet deposition) that assigns air quality to one of three condition categories (NPS 2011g): air quality is a significant concern, air quality is in moderate condition, or air quality is in good condition.

Based on this air quality rating guidance published by ARD (NPS 2011g), the year-round air quality condition at Yellowstone is rated as a "significant concern" for nitrogen wet deposition (deposited nitrogen to the earth's surface through precipitation). It is rated a "moderate condition" for ozone, visibility, and sulfur wet deposition (deposited sulfur through precipitation) (table 13). However, it should be noted that the "significant concern" condition for nitrogen wet deposition is due to regional sources and is not related to OSVs (refer to the Scientific Assessment of Yellowstone National Park Winter Use). A NPS review of air quality trends from 1998 to 2008 shows no statistically significant change in nitrogen or sulfur wet deposition or visibility on hazy days. Visibility on clear days improved over this time period (statistically significant trend) and vegetation ozone exposure decreased (although not statistically significant).

The stations where these trends are measured are not specifically related to winter OSV use; however, monitoring these key indicators provides a general overview of year-round air quality conditions and trends at the park, which is valuable when assessing air quality as it relates to winter use.

General Air Quality Trends Related to OSV Use

By the late 1990s, an average of 795 snowmobiles entered the park each day, resulting in high levels of pollution from CO, PM, and hydrocarbons. All snowmobiles at that time were two-stroke machines, which result in greater emissions of CO and PM than current four-stroke machines. The 2000 Winter Use Plan FEIS proposed banning snowmobiles and only allowing cleaner and quieter snowcoaches (four-stroke snowmobiles were not available at the time). Subsequent winter use plans proposed addressing impacts to air quality (among other issues) using a combination of new technologies, limits on vehicle numbers, and mandatory use of guides (NPS 2010c). All plans proposed allowing a combination of snowmobiles and snowcoaches. Snowmobile numbers decreased from plan to plan and snowcoach numbers remaining consistent.

TABLE 13: CONDITION OF AIR RESOURCES AT YELLOWSTONE NATIONAL PARK

Air Quality Resource	Condition Rating Criteria	Condition (2006-2010)[1]	1998-2008 Trend[2]
Visibility	Current Group 50 minus estimated Group 50 Natural (deciviews)[3] > 8 = Significant Concern 2-8 = Moderate < 2 = Good	Moderate (3.1 deciviews)	Improving on clear days (statistically significant ($p \leq 0.05$)), no significant trend on hazy days
Nitrogen Wet Deposition	Wet Deposition of N or S (kg/ha/yr)[4] > 1 = Significant Concern < 1 = Moderate	Significant Concern (1.9 kg/ha/yr)	No statistically significant trend
Sulfur Wet Deposition		Moderate (0.8 kg/ha/yr)	No statistically significant trend
Ozone	Vegetation ozone exposure (W126)[5] > 13 ppm-hrs Significant Concern 7-13 ppm-hrs Moderate < 7 ppm-hrs Good	Moderate (10.5 ppm-hrs)	Possibly improving, but not significant (($0.05 < p \leq 0.15$)

[1] Based on NPS ARD 2006–2010 5-year average estimates (NPS ARD 2012a, 2012b, 2012c) Criteria provided in NPS ARD 2011.

[2] NPS ARD 2010.

[3] Group 50 is defined as the mean of the visibility observations falling within the range from the 40th through the 60th percentiles. The metric compares actual visibility with estimated natural visibility.

[4] The criteria shown are the more stringent criteria that NPS applies to parks in certain ecosystems in the west that are considered nitrogen or sulfur sensitive, including Yellowstone. A threshold for the “good” condition has not been determined for nitrogen and sulfur wet deposition in Yellowstone. Natural wet deposition in the west has been estimated at 0.13 kg/ha/yr (NPS 2011).

[5] Some types of vegetation are more sensitive to ozone than humans are. The W126 measures cumulative ozone exposure over the growing season. The NPS has rating criteria for human health based 8-hour ozone standard and Yellowstone would be in the “moderate” category based on the human health ratings (65.9 ppm 4th highest 8-hour ozone concentration for 2006-2010).

Despite numerous legal challenges, the implementation of snowmobile BAT requirements and entrance limits have been an important consequence of winter use planning. The implementation of BAT requirements and the reduction in the number of OSVs entering the park dramatically reduced CO, PM, and hydrocarbon emissions. Maximum 8-hour CO concentrations at Old Faithful have declined from 1.2 ppm in 2002/2003 to 0.4 ppm in 2007/2008. The 98th percentile $PM_{2.5}$ concentrations at Old Faithful have decreased from 21 $\mu g/m^3$ in 2002/2003 to 5.8 $\mu g/m^3$ in 2007/2008 (Ray 2008). In addition to BAT requirements and lower snowmobile numbers, improvements in air quality have been assisted by commercial guiding (guides help ensure the use of BAT and guides encourage users to keep idling to a minimum) and changes in entrance station procedures to prevent idling groups of snowmobiles.

The substantial CO and PM emissions reductions from requiring four-stroke snowmobiles have come with one important tradeoff—an increase in NO_x emissions. Four-stroke snowmobiles have higher NO_x emissions than two-stroke snowmobiles. Diesel snowcoaches have higher NO_x emissions than gasoline snowcoaches. Preliminary monitoring results for the 2009/2010 season indicate that NO_2 concentrations at the west entrance are slightly below 50 percent of the recently established 1-hour NO_2 standard of 0.100 ppm. The available monitoring data supports the conclusion that the park is compliance with the NAAQS for NO_2. There is an insufficient record of NO_2 monitoring data to draw firm conclusions about NO_2 concentration trends in the park at this time. The NPS will continue NO_2 monitoring to better understand any trends in concentrations and the relationship between NO_2 concentrations and specific OSV types.

Additional monitoring will be needed to further characterize existing NO_2 concentrations in the park and ensure compliance with the standard.

AIR QUALITY MONITORING IN YELLOWSTONE NATIONAL PARK

Wet Deposition—The process by which aerosol particles collect or deposit themselves on solid surfaces, decreasing the concentration of the particles in the air. Acid rain is one form of wet deposition.

Air quality monitoring has occurred at Yellowstone since 1980 when the park initiated wet deposition monitoring as part of the National Atmosphere Deposition Program/National Trends Network. The site for wet deposition monitoring is at Tower Ranger Station. Dry deposition has been estimated for Yellowstone since 1996 as part of the Clean Air Status and Trends Networks (NPS 2006c). Additional air quality monitoring at the park includes the following:

- Air Atlas—Air Atlas is a geographical information system (GIS) database of air quality estimates for 270 parks that are part of the NPS Inventory and Monitoring Program. These estimates are often used when on-site monitoring data is not available (NPS 2006c).
- Night Skies—Air pollution and poor quality outdoor lighting degrade night skies. Optical monitoring to collect baseline data on night sky brightness at the park was conducted in 2005. Optical measurements can produce not only a measure of night sky brightness and identification of light pollution sources, but also a measure of the effect of the atmosphere on light scattering caused by fine particulates and other air pollutants, as well as moisture (NPS 2006b, 2006c).
- Mercury Monitoring—Mercury in rainfall is monitored in the park as part of the Mercury Deposition Network, which was initiated in 2002 at Yellowstone. The monitoring site is at Tower Ranger Station. Both distant industrial sources and local geothermal sources contribute to mercury deposition in the park (NPS 2006c, 2007a).
- Ozone Monitoring—Ozone has been monitored with a continuous analyzer in the park since 1987. Data indicate that ozone concentrations and doses are not currently at levels known to cause injury to natural resources like vegetation, although no systematic surveys to assess vegetation injury have been performed in the park (NPS 2007a).
- Visibility Monitoring—As part of the Interagency Monitoring of Protected Visual Environments network, visual air quality in the park has been monitored since 1981 using a variety of methods, including an aerosol sampler, a transmissometer, a nephelometer, an automatic 35-mm camera, a digital camera, and a time-lapse video camera (NPS 2007a).

There are several air monitors within and in the immediate vicinity of Yellowstone. One network air quality station is near Yellowstone Lake maintenance facility on the north end of the lake, approximately ½ mile away from a moderately used OSV route (Site ID 560391011) (EPA 2009e; Ray 2008). The lake station measures ozone, meteorology, sulfate, nitrate, nitric acid, sulfur dioxide, and PM as part of the Clean Air Status and Trends Networks and Interagency Monitoring of Protected Visual Environments monitoring network. Another air quality station, near the Tower Ranger Station (near a wheeled vehicle road and 15 miles from the nearest OSV route), measures wet deposition for mercury, sulfates, nitrates, and ammonium as part of the National Atmosphere Deposition Program/National Trends Network national deposition monitoring network (Ray 2008). Results for ozone monitoring at the Lake station are summarized in table 14, which presents a trend of general fluctuation in airborne concentrations of ozone that have remained below the current 8-hour NAAQS of 0.075 ppm and the Montana 1-hour standard of 0.1 ppm.

TABLE 14: RESULTS OF OZONE MONITORING AT YELLOWSTONE NATIONAL PARK, 1998–2008

Site ID	Location	County	Year	4th Highest 1-hour Max (ppm)[1]	4th Highest 8-hour Max (ppm)[2]
560391011	Yellowstone National Park	Teton County, Wyoming	1998	0.070	0.066
			1999	0.078	0.071
			2000	0.073	0.065
			2001	0.076	0.066
			2002	0.073	0.066
			2003	0.071	0.065
			2004	0.065	0.060
			2005	0.068	0.060
			2006	0.074	0.069
			2007	0.073	0.065
			2008	0.070	0.065
			2009	N/A	0.063
			2010	0.070	0.066
			2011	0.070	0.066

Source: EPA 2012a.

[1] The Montana air quality standard for one-hour ozone concentrations is 0.1 ppm (not be exceeded more than once per year). With some limited exceptions, the 1-hour ozone NAAQS has been revoked.

[2] The NAAQS for ozone is 0.075 ppm and is based on the annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years

The EPA has data for $PM_{2.5}$ from 2003 to 2008 from one location in the park near the west entrance (Site ID 300310013) and PM_{10} monitoring from 1998 to 2006 from one location in West Yellowstone, Montana (Site ID 300310012), outside the park boundary in the community of West Yellowstone. The monitoring site at the west entrance was established in 1998 to measure CO, and continuous $PM_{2.5}$ monitoring was added in 2003. The west entrance was moved about 0.25 mile further into the park in spring 2008, and the air quality monitoring station was similarly relocated (MTDEQ n.d.). Results for $PM_{2.5}$ and PM_{10} monitoring for the two stations are summarized in table 15, which presents a trend of general decline since 1998 in PM_{10} that has remained well below the current 24-hour standard of 150 $\mu g/m^3$. Results for $PM_{2.5}$ monitoring at the west entrance present a trend of considerable fluctuation since 2003; however, concentrations have remained well below the current 24-hour and annual standards of 35 $\mu g/m^3$ and 15 $\mu g/m^3$, respectively (EPA 2009e).

Since 2003, ambient monitoring has been used in the winter to determine CO and $PM_{2.5}$ concentrations at two locations in the park, one at Old Faithful (Site ID 5§.0391012) and another at the west entrance (Site ID 300310013), as part of the adaptive management program on the use of OSVs. CO and $PM_{2.5}$ are also monitored outside the park in the town of West Yellowstone, Montana, in cooperation with the park (Ray 2010a). Results for CO and $PM_{2.5}$ monitoring at the three stations are summarized in tables 16 and 17.

As part of the adaptive management program on the use of OSVs. CO and $PM_{2.5}$ are also monitored outside the park in the town of West Yellowstone, Montana, in cooperation with the park (Ray 2010a).

TABLE 15: RESULTS OF $PM_{2.5}$ AND PM_{10} MONITORING AT YELLOWSTONE NATIONAL PARK

Site ID	Location	Year	$PM_{2.5}$ (µg/m^3)		PM_{10} (µg/m^3)	
			Daily Value [a]	Annual Mean [b]	Daily Value [a]	Annual Mean [b]
300310012	Firehole, West Yellowstone [c]	1998	—	—	45	19
		1999	—	—	48	18
		2000	—	—	39	18
		2001	—	—	42	18
		2002	—	—	30	15
		2003	—	—	40	17
		2004	—	—	32	15
		2005	—	—	32	15
		2006	—	—	21	9
300310013	Yellowstone National Park, West Entrance [d]	2003	4.1	2.47	—	—
		2004	10.2	4.68	—	—
		2005	6.8	3.67	—	—
		2006	10.3	4.26	—	—
		2007	10.4	5.00	—	—
		2008	4.7	3.80	—	—

Source: EPA 2009e.

[a] Fourth highest 24-hour maximum.

[b] Fourth highest 24-hour maximum.

[c] Outside the park boundary, in the town of West Yellowstone. Data not available after 2006.

[d] Data for monitor 300310013 not available for after 2008

— = Data not available.

TABLE 16: RESULTS OF WINTER CARBON MONOXIDE (PPM) MONITORING AT YELLOWSTONE NATIONAL PARK MONITORING STATIONS

Old Faithful									
Winter Carbon Monoxide	2010/2011	2009/2010	2008/2009	2007/2008	2006/2007[a]	2005/2006	2004/2005	2003/2004	2002/2003
Max 1-hour	4.3	7.6	1.1	0.9	0.9	1.6	1.6	2.2	2.9
% of Standard	12%	22%	3%	2%	3%	4%	4%	6%	8%
Max 8-hour	0.9	1.7	0.4	0.4	0.4	0.5	0.8	0.9	1.2
% of Standard	10%	19%	4%	5%	4%	6%	7%	10%	13%
Average	0.18	0.21	0.1	0.19	0.27	0.18	0.12	0.26	0.24
90th percentile [b]	0.3	0.4	0.2	0.24	0.19	0.26	0.29	0.5	0.5
West Entrance									
Winter Carbon Monoxide	2010/2011	2009/2010	2008/2009	2007/2008	2006/2007	2005/2006	2004/2005	2003/2004	2002/2003
Max 1-hour	1.0	2.5	2.4	6.1	3.7	2.1	2.8	6.4	8.6
% of Standard	3%	7%	7%	17%	11%	6%	8%	18%	25%
Max 8-hour	0.3	0.8	0.6	1.6	0.8	0.9	1.0	1.3	3.3
% of Standard	3%	9%	6%	18%	9%	10%	11%	14%	37%
Average	0.19	0.19	0.2	0.23	0.19	0.23	0.24	0.26	0.57
90th percentile [b]	0.26	0.25	0.3	0.4	0.27	0.4	0.43	0.5	1.3
West Yellowstone, Montana [c]									
Winter Carbon Monoxide	2010/2011	2009/2010	2008/2009	2007/2008	2006/2007	2005/2006	2004/2005	2003/2004	2002/2003
Max 1-hour	4.5	3.6	7.9	6.7	5.0	—	—	—	—
% of Standard	13%	10%	23%	19%	14%	—	—	—	—
Max 8-hour	1.6	1.9	3.1	2.2	2.4	—	—	—	—
% of Standard	5%	5%	34%	25%	27%	—	—	—	—
Average	0.4	0.44	0.5	0.4	0.5	—	—	—	—
90th percentile [b]	0.7	0.8	0.9	0.7	0.9	—	—	—	—

Source: Ray 2010a.

[a] The visitor parking and the monitoring station moved due to construction at Old Faithful.

[b] The 90th percentile is not used by the NAAQS. It is a useful measure to track higher concentrations without the points being dominated by possible statistical outliers.

[c] Outside the park boundary, in the town of West Yellowstone.

—= Data not available from this source.

TABLE 17: RESULTS OF WINTER $PM_{2.5}$ ($\mu g/m^3$) MONITORING AT YELLOWSTONE NATIONAL PARK MONITORING STATIONS

				Old Faithful					
Winter $PM_{2.5}$	2010/2011	2009/2010	2008/2009	2007/2008	2006/2007[a]	2005/2006	2004/2005	2003/2004	2002/2003
Max 1-hour	29	21	23	32	20	56	38	151	200
Max 24-hour	4	6	5.7	8.1	6.6	9	6	16	37
98th percentile [b]	4	6	5.2	5.8	6.4	9	9	9	21
% of Standard	23%	17%	15%	17%	18%	13%	14%	14%	33%
Average	2.6	3.2	3.1	3.2	3.3	3.5	4.0	4.9	6.9
				West Entrance					
Winter $PM_{2.5}$	2010/2011	2009/2010	2008/2009	2007/2008	2006/2007	2005/2006	2004/2005	2003/2004	2002/2003
Max 1-hour	22	88	53	44	40	44	21	29	81
Max 24-hour	6	7	5.1	9.5	8.8	7	6	8	15
98th percentile [b]	6	5	4.8	7.8	8.7	6	6	7	17
% of Standard	20%	15%	14%	22%	25%	10%	9%	11%	26%
Average	0.7	1.0	1.5	2.6	2.1	1.9	2.9	4.0	8.2
				West Yellowstone, Montana [c]					
Winter $PM_{2.5}$	2010/2011	2009/2010	2008/2009	2007/2008	2006/2007	2005/2006	2004/2005	2003/2004	2002/2003
Max 1-hour	184	154	145	167	119	—	—	—	—
Max 24-hour	33	38	27.5	24.7	32	—	—	—	—
98th percentile [b]	28	36	27	22	32	—	—	—	—
% of Standard	80%	103%	77%	63%	91%	—	—	—	—
Average	11.6	12.2	12.3	5.6	12.9	—	—	—	—

Source: Ray 2008, 2010a.

[a] The visitor parking and the monitoring station moved due to construction at Old Faithful.

[b] Statistic that best relates to the NAAQS standard at the time of the measurement (65 $\mu g/m^3$). Based on daily 24-hour average.

[c] Outside the park boundary, in the town of West Yellowstone.

—= Data not available from this source.

As described in chapter 1, after institution of BAT requirements for snowmobiles and limitations on the total number of OSVs permitted in the park, air quality improved quickly between the winters of 2002/2003 and 2003/2004 (Ray n.d.). CO concentrations have continued to decrease, with some fluctuation, since the 2002/2003 winter season. Measurements of the 8-hour CO levels improved from 1998/1999 to 2008/2009 by ten times. Maximum 1-hour concentrations of $PM_{2.5}$ have fallen at the Old Faithful monitoring location from 200 $\mu g/m^3$ during the 2002/2003 winter season to 23 $\mu g/m^3$ during the 2008/2009 winter season. Similarly, at the west entrance monitoring location, maximum 1-hour concentrations have fallen from 81 $\mu g/m^3$ during the 2002/2003 winter season to 53 $\mu g/m^3$ during the 2008/2009 winter season, with a low (between 2002 and 2009) of 21 $\mu g/m^3$ reported for the 2004/2005 winter season. Overall, from 2003 to 2009, air quality has stabilized at the monitoring stations in the park. These positive trends in air quality are primarily the result of requirements for BAT snowmobiles and fewer snowmobiles entering the park in recent years. Requiring the use of only four-stroke engine snowmobiles has improved emissions despite the increasing number of snowcoaches now entering the park. Although these changes present an overall positive trend toward lower emissions by OSVs, other local sources, such as uncontrolled wood stoves in warming huts and some facilities in the park, still contribute to winter $PM_{2.5}$ concentrations. More recent air quality monitoring in the park (Ray 2008, 2010a) revealed that although air quality at Yellowstone meets the national standards set by the EPA for CO and $PM_{2.5}$ to protect human health, CO concentrations up to 200 ppb in the park are still above the background CO concentrations at Yellowstone, which are estimated at less than 100 ppb. Results of winter 2008/2009 air monitoring for Yellowstone reveal diminishing daily average concentrations of $PM_{2.5}$ in the park, with concentrations in the town of West Yellowstone remaining constant or increasing slightly over previous years. Hourly and 8-hour average CO concentrations have recently decreased at the west entrance but remain relatively constant at Old Faithful (Ray 2010a).

On February 9, 2010, the EPA announced a revised NO_2 standard of 100 ppb as a one-hour average (75 FR 6474). This standard was promulgated as a result of scientific evidence linking short-term NO_2 exposures with increases in asthma and other respiratory illness, and the new standard is a significant change from the previous 53 ppb annual average. Because hourly NO_2 data had not been collected at Yellowstone previously, a joint plan with the Montana Department of Environmental Quality was created to do exploratory winter NO_x monitoring at the west entrance. Monitoring equipment was installed at the west entrance just before the opening of the winter season in December 2009.

On February 9, 2010, the EPA announced a revised NO_2 standard of 100 ppb as a one-hour average (75 FR 6474).

Two different NO_2 analyzers were used during the 2009/2010 study; the first analyzer barely passed audit and calibration checks; the second analyzer was new and performed well. Although NO_2 concentrations of just under 50% of the NAAQS (100 ppb 1-hour average) were observed with the first analyzer, the more reliable values are from the replacement analyzer, which recorded NO_2 concentrations up to 26% of the health standard (Ray 2010b). In addition, early winter NO_2 monitoring results for winter 2010/2011 show a daily maximum hourly concentration of 31 ppb, less than the 45 ppb maximum recorded in 2009/2010. The available monitoring data supports the conclusion that the park is in compliance with the NAAQS for NO_2. There is an insufficient record of NO_2 monitoring data to draw firm conclusions about NO_2 concentration trends in the park at this time. The NPS will continue NO_2 monitoring to better understand trends in concentrations and the relationship between NO_2 concentrations and specific OSV types.

SOUNDSCAPES AND THE ACOUSTIC ENVIRONMENT

INTRODUCTION

Pursuant to NPS *Management Policies 2006* and Director's Order 47: Sound Preservation and Noise Management, an important component of the NPS mission is the preservation of natural soundscapes associated with national park units (NPS 2006a). Natural soundscapes exist in the absence of human-caused sound. The natural soundscape is the aggregate of all the natural sounds that occur in parks, together with the physical capacity for transmitting natural sounds. Natural sounds are intrinsic elements of the environment and part of "the scenery and the natural and historic objects and the wild life" protected by the NPS Organic Act. They are vital to the visitor experience of many parks and provide valuable indicators of the health of various ecosystems. Noise is a concern because it can impede ecological function and diminish the ability of the NPS to accomplish its resource protection mission.

Natural sounds are necessary for ecological functioning and occur within and beyond the range of sounds that humans can perceive. Many mammals, insects, and birds decipher sounds to find desirable habitat and mates, avoid predators and protect young, establish territories, and to meet other survival needs.

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A majority of park visitors value and enjoy natural sounds, solitude, and quiet (Mace et al. 2004). The opportunity to experience natural sounds is perceived by winter visitors to be important to both the value of Yellowstone and the visitors' experiences (Freimund et al. 2009). For many visitors, the ability to hear clearly the delicate and quieter intermittent sounds of nature, the ability to experience interludes of extreme quiet for their own sake, and the opportunity to do so for extended periods of time are important reasons for visiting national parks.

OVERVIEW OF YELLOWSTONE SOUNDSCAPES

Currently, winter soundscapes in Yellowstone consist of both natural and non-natural sounds. Bird and animal calls, running water, wind, and thermal activity (e.g., geysers and hot springs) contribute natural sounds to Yellowstone. Non-natural sounds include those produced by snowmobiles, snowcoaches, snow groomers, aircraft, human voices, wheeled vehicles, and building operations (Burson 2011). Yellowstone's soundscapes vary greatly with location, time of day, and time of year. The audibility of OSVs in the park is influenced by environmental conditions including type of terrain, vegetation cover, wind speed and direction, presence of natural sounds (wind, bird call, and geyser activity), snow cover, and other atmospheric conditions. In general, low frequency sounds travel farther from the source at lower temperatures and wind speeds, which often signal the presence of temperature inversions. Wind sounds often mask low-level motorized sound, limiting the audibility of motorized sounds at a site; the frequency of the sound and any movement of the other sound source also contribute to audibility.

Yellowstone's winter soundscapes, as experienced by most visitors, include sound from OSV use (Burson 2009), because most visitors either use OSVs to tour the park or stay within two miles of motorized routes if engaging in non-motorized uses. Overall, audibility of OSVs has been reduced since the 2002/2003 winter season by limiting the number of OSVs, and groups of OSVs allowed in the park daily, requiring visitors to use BAT snowmobiles, limiting motorized access to a few park roads and travel corridors, and enforcing lower speed limits. Results of soundscape monitoring conducted from 2003 to 2011 show that although certain areas of the park have some of the lowest sound levels ever recorded (Burson 2004–2011), many travel corridors and developed areas, particularly those near motorized routes or with heavy use, experience higher sound levels than natural ambient conditions.

Yellowstone's winter soundscapes, as experienced by most visitors, include sound from OSV use (Burson 2009), because most visitors either use OSVs to tour the park or stay within two miles of motorized routes if engaging in non-motorized uses.

SOUNDSCAPES TERMINOLOGY

This section introduces the key terms used to evaluate soundscapes, and discusses the factors that influence human perception of sounds.

Noise

Noise is defined in the Dictionary of Acoustics as “unwanted or extraneous sound.” At Yellowstone, OSVs emit noise that is produced primarily by the engine and tracks and skis.

Percent Time Audible

Percent time audible is a metric used to describe the amount of time during the analysis period (e.g., hour, day, or season) that OSVs are audible to a human with normal hearing. Audibility of OSVs is determined, in part, by the natural ambient sound levels. Lower natural ambient sound levels result in higher OSV percent time audible. The converse is also true: higher natural ambient sound levels result in lower OSV percent time audible. The percent time audible indicator does not provide information on how loud or quiet OSV sounds are, only whether they are audible or not. Therefore, additional indicators of sound levels are also important to consider in conjunction with percent time audible.

Time Audible for Discrete OSV Passby Events

Time audible is defined as the length of time that a discrete pass-by event of either a single snowcoach or single group of snowmobiles (average group size of 6.7) is audible. The length of time OSV noise is audible can be estimated from data collected at 14 different locations throughout the park.

Sound Levels

The magnitude of noise is described by its sound pressure. Because the range of sound pressure varies greatly, the logarithmic scale decibel (dB) is used to relate sound pressure. Sound pressures described in decibels are often defined in terms of frequency-weighted scales. A sound level measurement is usually expressed as an A-weighted average energy value over a specified time interval. A-weighting provides a method of summing sound energy across the audible spectrum in a way that approximates human judgments of loudness, in other words, how loud people would perceive a sound to be. The standard way to express these measurements is $LA_{eq,T}$, where T refers to the time interval for the measurement, “A” refers to A-weighting, and “L_{eq}” refers to the energy averaging. This notation is a bit cumbersome, so this document will follow a widely used shorthand and refer to “dBA.” Unless otherwise noted, the time interval for the energy averaging (“T”) is 1 second in all NPS measurements and modeling. Several examples of sound pressure levels in dBA scale are listed in table 18, including typical sounds found in Yellowstone.

Because sound is described in a logarithmic scale (i.e., dBA), sound levels cannot be added by ordinary arithmetic. An increase of 3 dBA represents a doubling of sound energy, so two helicopters flying side-by-side would be 3 dBA louder than one. A 6-dBA increase represents four times more energy and this increase generally allows for sounds to be heard from twice as far. Decibels are often related to perceived loudness, and in some frequency bands a 10-dBA increase can result in sounds that seem twice as loud, even though this would correspond to multiplying the number of sound sources by 10. Urban noise studies have shown that community annoyance tends to double with every 5 dBA increase in noise (ANSI Standard 12.9-2005/Part 4, table F.1).

Sound Level Metrics

Sound levels depend on the distance from the sound source, the presence of natural sounds, and non-sound source variables such as atmospheric conditions, wind speed and direction, topography, snow cover, and vegetation cover.

TABLE 18: DECIBEL LEVELS OF COMMON SOUND SOURCES

Sound	Noise Level (dBA)	Effect
Shotgun firing, jet takeoff (at 100-200 feet)	130	Painful
Turbo-prop at 200 feet, rock concert	110-140	Threshold of pain begins around 125 dB
Thunderclap (near)	120	Threshold of sensation begins
Chainsaw, jackhammer	110	Regular exposure to sound over 100 dB of more than one minute risks permanent hearing loss
Jet flyover (1,000 feet)	103	
Electric furnace, garbage truck, cement mixer	100	No more than 15 minutes of unprotected exposure recommended for sounds between 90-100 dB
Lawnmower/nearby thunder Subway, motorcycle (at 25 feet)	85-90	Very annoying 85 dB is the level at which hearing damage (8 hrs) begins National Institute for Occupational Safety and Health (NIOSH) recommends hearing protection for long-term exposure at this level
Recreational vehicles	70-90	
Diesel truck (40 miles per hour (mph) at 50 feet)	84	80 dB or higher is annoying, interferes with conversation, constant exposure may cause damage
Snowcoach at 50 feet, average city traffic	77-80	
Dishwasher, washing machine	75-78	Interferes with telephone conversation.
Two-stroke snowmobile (30 mph at 50 feet), vacuum cleaner	70	
2008 Ford F-150 Crew Cab Truck, interior noise at 55 mph on pavement	63	
Four-stroke snowmobile (30 mph at 50 feet), automobile (45 mph at 100 feet)	60	Noise at 60 dB interferes with open air conversation
Croaking raven (100 feet), conversation	50-65	
Quiet Office	50-60	
Refrigerator humming, Snake River (at 100 feet)	40	Recommended background level in schoolrooms and bedrooms is 35 dBA
Summer backcountry, Snake River (at 300 feet)	30	
Natural ambient sound levels in Yellowstone	0-25	
Rustling leaves, winter backcountry	20	Desired background level in a recording studio
Normal breathing	10	
Lowest ambient sound levels in Yellowstone winter backcountry	0	Approximate threshold of human hearing at 1 kHz

Table adapted from the National Institute on Deafness and Other Communicative Disorders at http://www.nidcd.nih.gov/health/education/teachers/pages/common_sounds.aspx.

Metrics used to describe sound levels include L_{eq}, L_{min}, L_{max}, L_{50}, and L_{90}. L_{eq} can be understood as the energy average sound level or the constant sound level that conveys the same energy as the variable sound levels during the analysis period. For example, the 8-hour L_{eq} levels discussed in this section take into account the magnitude and duration of OSV sound over an 8:00 a.m. to 4:00 p.m. analysis period (including times when OSV sounds are not audible).

L_{min}—*The lowest sound level measured in the analysis period.*

L_{max}—*The maximum sound level measured in the analysis period.*

L_{50}—*The sound level exceeded 50 percent of the measurement period. L_{50} is the same as the median; the middle value where half the sound levels are above and half below.*

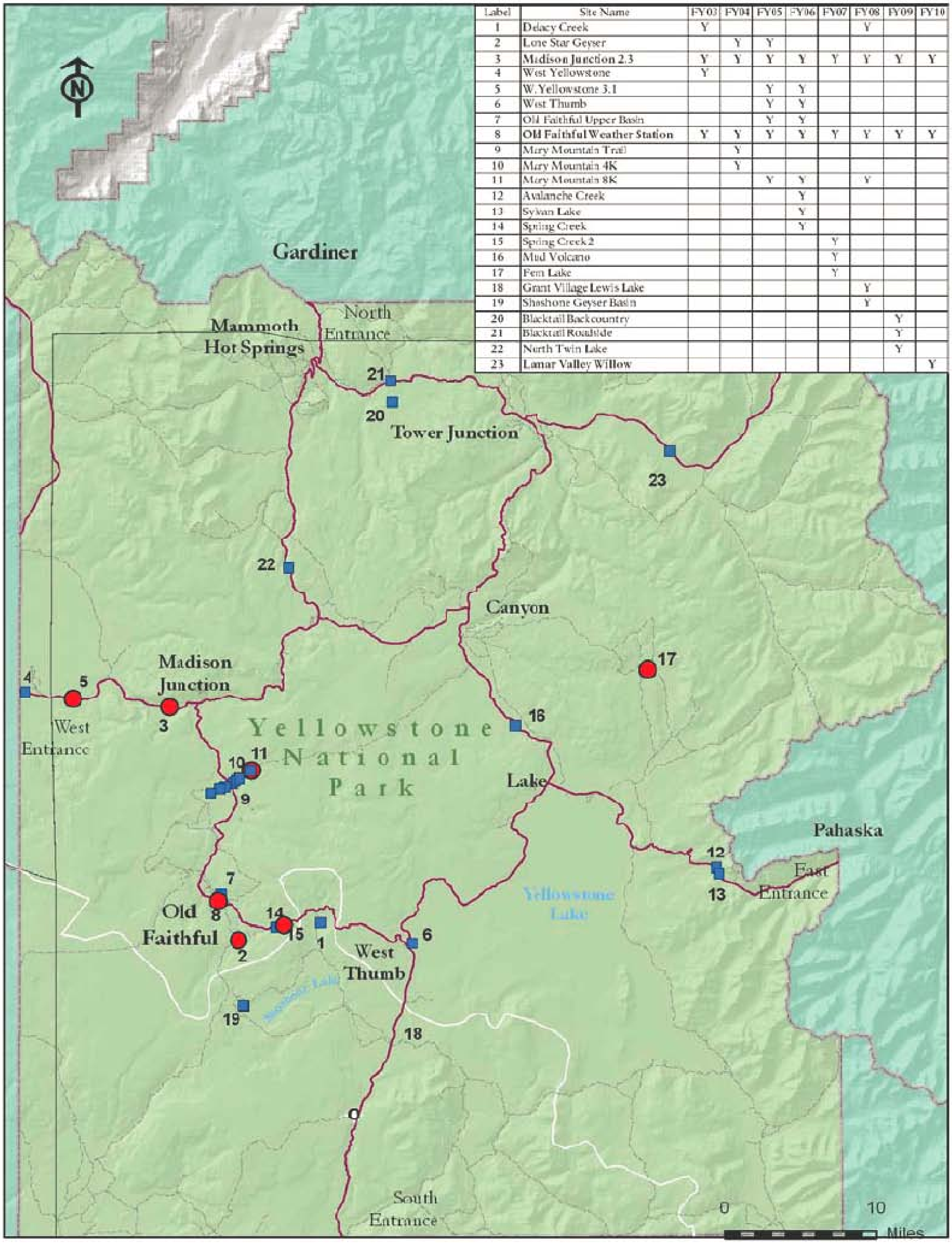
L_{90}—*The sound level exceeded 90 percent of the time during the measurement period. L_{90} is a useful measure of the natural sounds because in park situations, away from developed areas and busy travel corridors, the lowest 10 percent of sound levels are less likely to be affected by non-natural sounds. This measure is recommended by the American National Standards Institute to represent the background or residual sound level.*

Human Perception of Sounds

Percent time audible, length of time audible, and sound level metrics (L_{eq}, L_{min}, L_{max}, L_{50}, and L_{90}) are important indicators of the condition of natural soundscapes. Percent time audible and sound level metrics are the appropriate focus of NPS monitoring and management of natural soundscapes because they are measurable and objective. However, in interpreting these metrics it is important to also consider that human perception of sounds is complex and depends on the setting. Research conducted on sound perception demonstrates that a person's evaluation of a sound depends on the information contained in the sound and the context in which it is received (Carles et al. 1999; Abe et al. 2006). Specifically, perceived sound levels and evaluation of the sound vary with place, sound frequency, expectation of hearing the sound, individual experience of the listener, perceived "appropriateness" of the sound to the setting, movement of the sound relative to the listener, and visual cues (Blauert 1986; Kuwano et al. 1989; Carles et al. 1999; Ozawa et al. 2003; Schulte-Fortkamp et al. 2007). For additional detailed information regarding the factors influencing human perceptions of sounds, refer to the Scientific Assessment of Yellowstone National Park Winter Use, Section 5.1.3, "Factors that Determine Visitors' Interpretation of Sound."

SOUNDSCAPES MONITORING

NPS has conducted winter soundscapes monitoring in Yellowstone since the 2003/2004 season (Burson 2004–2011). The most recent soundscapes monitoring data at the time this 2011 Winter Use Plan and Environmental Impact Statement (plan/EIS) was prepared was for the 2010/2011 winter season (Burson 2011). A total of 23 locations in the park have been monitored during at least one winter season. Two locations have been monitored every season since monitoring began: Madison Junction 2.3 (100 feet off the west entrance road, 2.3 miles west of Madison Junction) and the Old Faithful Weather Station. Figure 8 shows the locations of the monitoring sites and indicates which sites were monitored during each winter season.



Label	Site Name	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10
1	Delacy Creek	Y					Y		
2	Lone Star Geyser		Y	Y					
3	Madison Junction 2.3	Y	Y	Y	Y	Y	Y	Y	Y
4	West Yellowstone	Y							
5	W. Yellowstone 3.1			Y	Y				
6	West Thumb			Y	Y				
7	Old Faithful Upper Basin			Y	Y				
8	Old Faithful Weather Station	Y	Y	Y	Y	Y	Y	Y	Y
9	Mary Mountain Trail		Y						
10	Mary Mountain 4K		Y						
11	Mary Mountain 8K			Y	Y		Y		
12	Avalanche Creek				Y				
13	Sylvan Lake				Y				
14	Spring Creek				Y				
15	Spring Creek 2					Y			
16	Mud Volcano					Y			
17	Fern Lake					Y			
18	Grant Village Lewis Lake						Y		
19	Shoshone Geyser Basin						Y		
20	Blacktail Backcountry							Y	
21	Blacktail Roadside							Y	
22	North Twin Lake							Y	
23	Lamar Valley Willow								Y

Note: Red circles indicate sites monitored in multiple seasons. Blue squares indicate sites monitored in winter only.

FIGURE 8: LOCATION OF SOUND MONITORING LOCATIONS 2003–2011

Automated acoustic monitors were used to collect 1-second L_{eq} sound levels and digital recordings. Digital recordings of the soundscape were either sampled for 10 seconds every 4 minutes, or were collected continuously, 24 hours per day. For sites and times that digital recordings were not collected continuously, additional 20-second recordings were made during sound events that exceeded 70 dBA for 1 second or exceeded 60 dBA for 10 seconds. The recordings were analyzed to determine the source of each audible sound (e.g., snowmobile, animal, aircraft, wind, thermal activity), as well as the percentage of time each sound source was audible. Detailed technical information on the soundscapes monitoring and data analysis can be found in Burson 2004–2011.

To distinguish between the various OSV user groups in the park (e.g., visitors, administrative), a separate observational study was conducted during the past seven winters, from 2005 to 2011. Data on the time audible and type of usage for each OSV were collected by observers at locations in developed areas and travel corridors (Burson 2011).

Percent Time Audible

Percent time audible metrics can vary considerably depending on the analysis period selected (e.g., hour, day). The 8:00 a.m. to 4:00 p.m. percent time audible provides a useful summary metric that reflects the time that most visitors are in the park. Table 19 summarizes the percent of the time between 8:00 a.m. to 4:00 p.m. that OSVs were audible at the Old Faithful Weather Station and Madison Junction 2.3. Table 20 summarizes the percent time audible information for other locations throughout the park that have been monitored only 1 or 2 years.

TABLE 19: DAILY PERCENT TIME AUDIBLE (8:00 A.M. TO 4:00 P.M.) OF OVERSNOW VEHICLE SOUNDS AT OLD FAITHFUL AND MADISON JUNCTION 2.3

Management Zone	Site Name	Map ID	2003/ 2004	2004/ 2005	2005/ 2006	2006/ 2007	2007/ 2008	2008/ 2009	2009/ 2010	2010/ 2011
Developed	Old Faithful Weather Station	8	61%	69%	67%	68%	68%	55%	55%	61%
Travel Corridor	Madison Junction 2.3	3	25%*	61%*	55%	59%	53%	47%	54%	51%

*Indicates monitoring for only 1 or 2 days (may not represent typical or average acoustic conditions).

The monitoring results show that the highest percent time audible levels are in the most developed and heavily traveled portions of the park—Old Faithful and Madison Junction 2.3. Daily percent time audible is substantially lower (between 0 percent and 35 percent) in the transition and backcountry areas farther from road corridors. Based on all the available monitoring data, the average percent time audible was 59 percent for developed areas, 38 percent for travel corridors, 20 percent for transition zone, and 15 percent for backcountry areas (Burson 2011).

TABLE 20: DAILY PERCENT TIME AUDIBLE (8:00 A.M. TO 4:00 P.M.) OF OVERSNOW VEHICLE SOUNDS AT OTHER LOCATIONS

Management Zone (described in chapter 2)	Site Name	Map ID	Year(s) Monitored	Percent Time Audible
Developed	West Thumb Geyser Basin	6	2004/2005	47% [a]
			2005/2006	62% [a]
Travel Corridor	West Yellowstone 3.1	5	2004/2005	55%
	Spring Creek	14	2005/2006	34% [a]
	Spring Creek 2	15	2006/2007	44%
	Caldera Rim Picnic Area	25	2010/2011	44%
	Grant Village Lewis Lake	18	2007/2008	37%
	Mud Volcano	16	2006/2007	26%
	North Twin Lake	22	2008/2009	24% [a]
	Pumice Point Roadside	24	2010/2011	22%
Transition	Mary Mountain Trail	9	2003/2004	32%
	Old Faithful Upper Basin	7	2004/2005	29%
			2005/2006	35%
	Mary Mountain 4k	10	2003/2004	13% [b]
	Delacy Creek Trail	1	2007/2008	20% [a]
	Lone Star Geyser Basin	2	2003/2004	3%
			2004/2005	4%
Backcountry	Mary Mountain 8k	11	2004/2005	26%
			2007/2008	26% [a]
	Shoshone Geyser Basin	19	2007/2008	18% [a]
	Fern Lake Backcountry	17	2006/2007	0%

[a] Indicates monitoring for 7 days or less (may not represent typical or average acoustic conditions).
[b] Indicates monitoring for only 1 or 2 days (may not represent typical or average acoustic conditions).

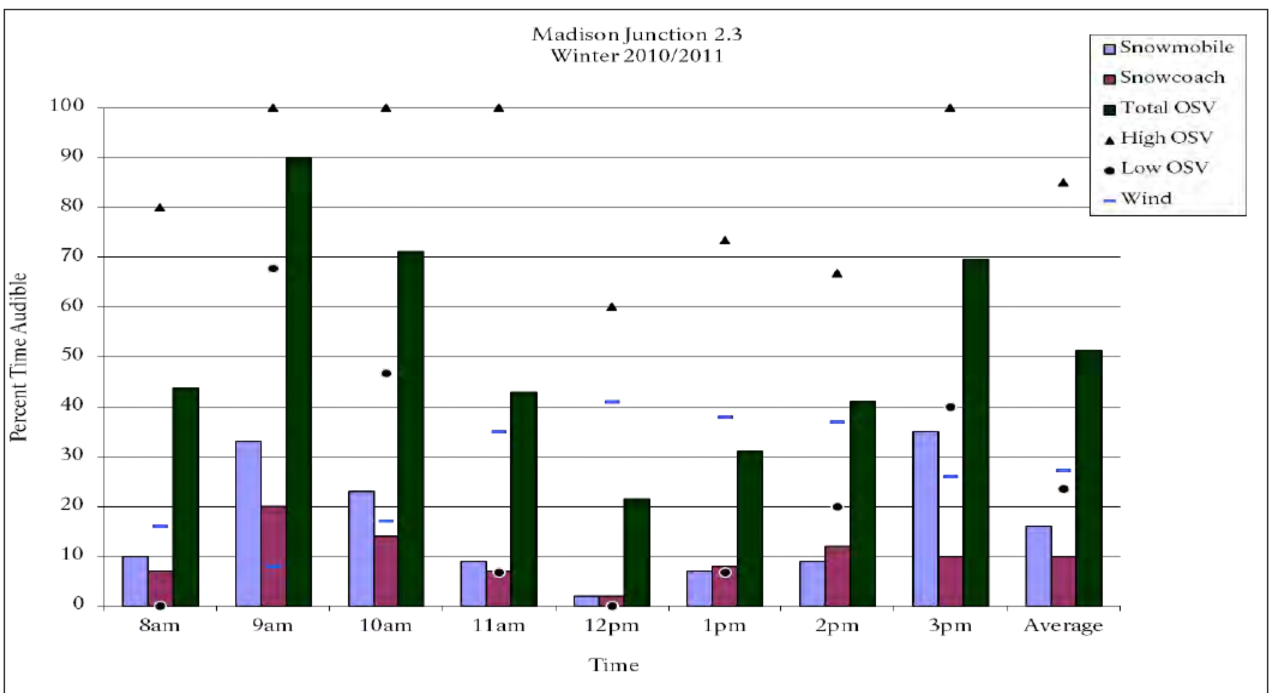
There is considerable variation in percent time audible among sites, even within the same management zone, due to factors such as regional topography and the number and type of OSVs on different road segments. Percent time audible does not always correlate with distance from roadways. For example, the percent time audible at the Lone Star Geyser Basin site was 3 percent to 4 percent, compared to 18 percent at the Shoshone Geyser Basin site. The Shoshone Geyser Basin site is four miles farther from a road than the Lone Star Geyser Basin site. Topography and frequent, prolonged geyser activity were likely the reasons that OSVs were less audible at Lone Star Geyser than at Shoshone Geyser Basin (Burson 2010a).

Prior to the implementation of snowmobile guiding and BAT requirements during winter 2002/2003, the average percent time OSVs were audible at the Old Faithful Weather Station was close to 93 percent. The percent time audible was reduced to an average of 61 percent during winter 2003/2004.

One trend that emerges in the review of the continuous record of data at the Old Faithful weather station is the decrease in percent time audible in the 2008/2009 season compared to past years. The average percent time audible at the Old Faithful weather station was between 67 percent and 69 percent from winter 2004 to winter 2008. In 2008/2009 and 2009/2010 winter seasons, the percent time audible at the Old Faithful weather station decreased to 55 percent as both snowmobile and snowcoach entries dropped. In the 2010/2011 winter season, the percent time audible at the Old Faithful weather station increased to 61 percent. However, this percentage is still lower than all of the winter seasons between 2004 and 2008.

The Madison Junction 2.3 site experienced a smaller decrease in percent time audible in 2008/2009 than the Old Faithful weather station. Unlike the Old Faithful weather station site, the Madison Junction 2.3 site experienced an increase in percent time audible from 47 percent in 2008/2009 to 54 percent in 2009/2010, and decreased in 2010/2011 to 51 percent. The increase in percent time audible in 2009/2010 is at least partially attributable to a decrease in the length of time wind was audible (wind can mask OSV sounds). Wind was audible at Madison Junction 2.3 only 15 percent of the time in 2009/2010, compared to 27 percent of the time in 2008/2009 (Burson 2010a). Similarly, the slight decrease in percent time audible in 2010/2011 is partially attributable to an increase in the length of time wind was audible; wind was audible a little more than 25 percent of the time in 2010/2011 (Burson 2011).

Figure 9 provides an example of the variation in percent time audible by hour at Madison Junction 2.3 in the 2010/2011 winter season. Percent time audible exceeded 85 percent during the morning when many OSVs are entering the park, but dropped to less than 30 percent time audible midday. A peak number of OSVs leaving the park occurred in the afternoon; resulting in a percent time audible of over 60 percent between 3:00 p.m. and 4:00 p.m. OSVs were audible for an average of 51 percent of the time during the winter use season at Madison Junction 2.3.



Note: Graphic shows the average percent time audible by hour of snowmobiles and snowcoaches (between 8:00 a.m. and 4:00 p.m.) and high and low OSV percent time audible at 2.3 miles (3.7 kilometers) west of Madison Junction on the west entrance road, Yellowstone National Park, December 15, 2010–March 15, 2011.

FIGURE 9: AVERAGE OSV PERCENT TIME AUDIBLE BY HOUR

As shown in figure 8, three sites have been monitored on the plowed roads in the northern part of the park (Blacktail Backcountry, Blacktail Roadside, and Lamar Valley Willow). The percent time audible at these sites is not influenced by OSVs—only wheeled vehicles are audible. OSVs are not audible due to the distance between these monitoring sites and the nearest OSV routes (figure 8). The Lamar Valley Willow monitor was 142 feet from the road between Tower Junction and the northeast entrance. The percent time audible for wheeled vehicles in the 2009/2010 season was 66 percent between 8:00 a.m. and 4:00 p.m. Wheeled vehicles were audible an average of 12 percent of the time in the 2008/2009 winter season at the Blacktail Backcountry site 1.5 miles from the plowed road between Mammoth and Tower Junction. At 100 feet from the road, the Blacktail Roadside had an average percent time audible of 34 percent on most days and likely masked wheeled vehicle audibility.

As shown in figure 8, two new sound monitoring sites were included in the 2010/2011 winter season: Pumice Point Roadside between West Thumb and Lake adjacent to Yellowstone Lake, and Caldera Rim Picnic Area site on the new road alignment between Madison Junction and Norris. Both locations are 100 feet (30 meters) from a groomed road. At Pumice Point, OSVs were audible an average of 22 percent of the time between 8:00 a.m. and 4:00 p.m. during the 20 days analyzed. Strong wind off Yellowstone Lake was audible on many days, which masked the low sound levels of distant vehicle sound on some days. When the wind was not present, this site had very low ambient sound levels with OSVs being audible at long distances. At the Caldera Rim Picnic Area, OSVs were audible an average of 44 percent of the time between 8:00 a.m. and 4:00 p.m. during the 13 days analyzed in January and February. Wind was audible on many days, but at relatively low levels (Burson 2011).

Length of Time Audible for Discrete OSV Passby Events

The length of time audible for a discrete pass-by event of either an individual snowcoach or a group of snowmobiles traveling together (average group size of 7) can be estimated from data collected at 14 different locations throughout the park. Measurements were made by observers positioned near the road at 14 locations between 2005 and 2011. The observer recorded a start time when OSVs were first heard and a stop time when they could no longer be heard. All measurements were for discrete guided snowcoach or snowmobile events. On average there were seven snowmobiles per event and one snowcoach per event.

Results for all locations are shown in table 21. OSV events were audible on average for about 3 minutes. Groups of snowmobiles were heard, on average, 3 minutes, 4 seconds from a single location adjacent to the travel route. Guided snowcoaches were heard on average 2 minutes, 46 seconds. The overall difference in elapsed time between snowmobiles and snowcoaches averaged 17 seconds over a total of 1,127 events. Average time audible varied considerably by location. Longest average time audible for guided snowmobile groups was 7 minutes, 47 seconds and for a guided snowcoach the average time was 7 minutes, 27 seconds, both at Bridge Bay. Shortest average time audible for guided snowmobiles was 1 minute, 22 seconds and for a guided snowcoach the average time was 1 minute, 0 seconds, both at West Yellowstone.

TABLE 21: AVERAGE ELAPSED TIME AUDIBLE PER OSV PASSBY IN MINUTES: SECONDS (2005-2011)

Location	Guided Snowmobiles	n	Guided Snowcoaches	n	Difference
West Yellowstone	1:22	56	1:00	24	0:22
Madison Junction	2:52	106	2:20	128	0:32
Mallard Lake	1:40	12	2:13	10	-0:33
Daisy	1:47	44	1:33	51	0:14
Mary Mountain Trailhead	2:30	44	2:20	30	0:10
Kepler Falls	2:00	41	1:52	15	0:08
Tuff Cliff	3:03	68	2:03	51	1:00
Caldera Rim Picnic Area	2:13	9	1:51	9	0:22
Spring Creek	3:09	79	3:38	60	-0:29
Lewis Lake	3:00	67	2:29	45	0:31
North Twin Lake	2:34	7	3:30	16	-0:56
Cygnet Lake	4:44	50	4:05	31	0:39
Hayden Valley	4:24	29	2:36	4	1:48
Bridge Bay	7:47	37	7:27	4	0:20
Average	3:04		2:46		0:17
Total Sample Size		649		478	

Average time audible, sample size *n*, and difference in time audible for guided snowmobiles and guided snowcoaches in Yellowstone National Park. *Average time audible* and sample size *n* is for **groups** of guided snowmobiles and for **individual** guided snowcoaches.

Sound Levels

Table 22 summarizes sound level metrics for the 2009/2010 and 2010/2011 winter seasons at the Old Faithful Weather Station and Madison Junction 2.3 (monitoring location located 2.3 miles west of Madison Junction). Maximum sound levels at these relatively heavily traveled locations were close to or exceeded 75 dBA between 8:00 a.m. and 4:00 p.m. Snowcoaches contributed most of the loudest events at these locations, which were close enough to the roads to prevent substantial summation of noise from most groups of snowmobiles.

TABLE 22: SOUND LEVEL METRICS, 8:00 A.M. TO 4:00 P.M.

	Old Faithful Weather Station (Developed)		Madison Junction 2.3 (Travel Corridor)	
	2009/2010	2010/2011	2009/2010	2010/2011
L_{min}	23.7	19.9	15.3	14.5
L_{90}*	30.0	29.3	22.0	23.6
L_{50}*	35.2	34.6	28.2	28.2
L_{eq}*	41.9	40.6	42.2	40.1
L_{max}	74.5	74.3	79.5	85.1

*Median from hourly calculations

The 8-hour L_{eq} sound level at Old Faithful Weather Station and Madison Junction 2.3 was slightly higher than 40 dBA.

The minimum sound levels at Old Faithful Weather Station and Madison Junction 2.3 were similar to the natural ambient sound level in the park (15 to 20 dBA). The L_{90} and L_{min} at Old Faithful Weather Station were influenced by sounds created by the exhaust and heating fans at the Snow Lodge and Ranger Station. At Madison Junction 2.3, the L_{90} and L_{min} are influenced by riffles from the nearby Madison River. The minimum sound levels are constrained by limitations of the acoustic instruments in measuring extremely quiet sounds.

Observational Study Results

The 2005–2011 observational study summarized in Burson (2011) found that in developed areas 78 percent of snowmobile traffic consisted of guided visitor snowmobiles and 18 percent consisted of administrative snowmobiles. The percentage of guided visitor snowmobiles was higher along travel corridors (92 percent) compared to the developed areas because administrative snowmobile use is more frequent in developed areas. A great majority of the loud noise events were found to be caused by snowcoaches, which are not yet BAT equipped (Burson 2009). The average visitor snowmobile group size was 6.9, whereas the average administrative snowmobile group size was just over one. Snowcoaches transporting visitors accounted for 85 percent of total snowcoach traffic in developed areas and 94 percent in travel corridors.

Visitor snowmobiles tend to travel in groups, whereas administrative snowmobile groups are typically single vehicles, and do not necessarily travel with the usual flow of visitor traffic in and out of the park. This is important in understanding the relationship between the percent time audible and OSV numbers.

Overall, motorized sounds were audible 56 percent of the time during the observational study. Snowmobiles accounted for 56 percent of the duration of motorized sounds, compared to 28 percent for snowcoaches and 7 percent for airplanes and helicopters. A total of 7,691 snowmobiles were tallied over the course of the study, compared to 1,033 snowcoaches. The time audible percentages were not in proportion to these numbers because the grouping of snowmobiles concentrates the usage time and, therefore, the time they are audible. As noted above, visitor snowmobiles tend to travel in groups, whereas administrative snowmobile groups are typically single vehicles and do not necessarily travel with the usual flow of visitor traffic in and out of the park. This is important in understanding the relationship between the percent time audible and OSV numbers. In developed areas, administrative snowmobiles are 63 percent of the snowmobile groups. Along road corridors, administrative groups are 33 percent of the snowmobilers.

VISITOR USE, EXPERIENCE, AND ACCESSIBILITY

VISITOR ACCESS AND CIRCULATION

Regional Access

Yellowstone has five entrances—one each on the north, east, west, and south boundaries and one in the northeast. Year-round wheeled vehicle road access into the park is provided from Gardiner, Montana, across the northern area of the park to Cooke City, Montana. At Cooke City, Highway 212 is closed to the east from October to May. All other park entrances are closed from early November to mid-December, re-open for the winter season, and close again in early to mid-March to allow for spring plowing.

In addition to the five main entrances to access the interior of the park, visitors may access the park on Cave Falls Road. Cave Falls Road is an approximately one-mile-long road that enters the park in the southeast corner and dead-ends at Cave Falls. This route does not provide OSV access to other locations in the interior of the park.

Park Roadways, Trails, and Winter Facilities

About half of the park's winter visitors enter the park through the north entrance. The west entrance is the next busiest, with about 33 percent of winter visitors.

Certain roads within the park are maintained for numerous reasons, including tourism and sightseeing, accessing trailheads, and park management. During the winter, most park roads are closed to wheeled vehicular traffic with the exception of Highway 191, which provides access between West Yellowstone and Bozeman, Montana, and the park road from Gardiner to Mammoth to the northeast entrance (Cooke City). The plowing of these roads totals approximately 78 miles, 20 of which are plowed by the state of Montana (NPS 2007c). These roads provide the only wheeled vehicle access through the park and are used by many visitors to view wildlife or access trailheads for cross-country skiing, snowshoeing, and/or hiking. In recent winters, the north entrance has been the busiest in the winter – about half of the park's winter visitors enter the park through the north entrance. The west entrance is the next busiest, with about 33 percent of winter visitors. The south entrance accounts for 16 percent, with the east entrance admitting 0.5 percent. During the winter, the northeast entrance is not staffed.

OSV travel is allowed on most main line interior park road segments (see figure 2 in chapter 2), with the exception of Dunraven Pass between Tower and Washburn Hot Springs overlook, which is closed due to avalanche danger. Where OSV travel is allowed, the roads are groomed. Grooming begins when there is adequate snow cover, using a tracked vehicle equipped with a blade on the front and a packer wheel and drag at the rear. The road segments from the west entrance to Old Faithful are usually groomed nightly or every other night. Most other sections are usually groomed every two to three nights. The NPS grooms 193 miles of OSV routes in the park.

About 35 miles of road are groomed for non-motorized uses in Yellowstone. These roads include the Blacktail Plateau Drive, Bunsen Peak Road, Upper Terrace Drive, North Canyon Rim Trail, Lone Star Geyser, and other trails in the Old Faithful area. The portion of the Dunraven Pass Road from Tower Junction past Tower Fall to the top of the Chittenden Road is groomed for skiing. In addition to the machine groomed roads, parallel tracks are set on the sides of some of Yellowstone's snow roads, typically including west entrance to Madison (14 miles one way); Madison to Old Faithful (16 miles one way); and Madison to Norris (12 miles one way). These are established each time the road is groomed (every two or three days) and may be obliterated by snowcoach and snowmobile travel. In addition to these examples, a list of all non-motorized use trails in the park can be found on the park's website at http://www.nps.gov/yell/planyourvisit/skiyell.htm. Although some visitors access non-motorized use trails on foot, others use OSVs to access a point in the interior of the park, and then engage in non-motorized use once they have reached their interior destination. OSV routes within the park are shown in figure 2 (see chapter 2).

Staging areas, or points of access, for oversnow routes into the park are an important logistical component of the winter visitor experience. They typically include a parking area with appropriate signage and may have restrooms and other facilities. The staging areas for snowmobile and snowcoach trips into the park are near Mammoth Hot Springs in the north, at Pahaska Teepee in the Shoshone National Forest three miles from the east entrance, at Flagg Ranch two miles from the south entrance, and in West Yellowstone adjacent to the west entrance.

Oversnow Modes of Transportation

Snowcoaches have been used in Yellowstone since the mid-1950s, several years before snowmobiles first appeared in the early 1960s. Businesses in surrounding communities have run touring enterprises based exclusively on providing snowcoach tours (whereas some offer both snowcoach and snowmobile tours). The earliest snowcoaches were Bombardiers, purpose-built machines designed for oversnow travel. Approximately 25 Bombardiers are in operation today. In the 1970s, conversion of wheeled vehicles to OSVs began. These are 7- to 33-passenger sport utility vehicles, vans, or mid-size buses whose wheels have been replaced with track and/or ski assemblages. Some conversion snowcoaches are accessible to the handicapped. Some coaches now have double-paned or vented windows that resist fogging in the cold winter air. Snowcoach operation and speed depend on a variety of conditions, especially weather and snow conditions. Under most winter conditions, however, they can maintain speeds of 15 to 25 mph. Repowered historic Bombardier snowcoaches average approximately 5 miles per gallon (mpg) while converted snowcoaches average approximately 1 to 2.5 mpg, depending on the coach and snow conditions.

In 2003, the NPS signed contracts with 14 businesses authorizing them to operate a specified number of snowcoaches for tours of the park for 10 years. A total of 78 snowcoaches have been authorized to operate every day in the park for the past 8 seasons. Snowcoaches can carry 8 to 33 passengers per day. On average, the maximum capacity of all of the coaches in the fleet is 12.3 passengers, which results in a visitor capacity of approximately 959 visitors per day (not including the driver). Average ridership per snowcoach for the past three winter seasons (2009/2010 – 2011/2012) has been 8 people/coach.

Snowmobiles were first used in Yellowstone in 1963, and by the 1980s thousands of visitors were entering the park using snowmobiles. Businesses in surrounding communities began running touring enterprises based exclusively on providing snowmobile tours and rentals (whereas others offer both snowcoach and snowmobile tours). In the early 2000s, manufacturers introduced four-stroke machines, which substantially reduced emissions and somewhat reduced the level of snowmobile sound.

Since the winter of 2004/2005, all snowmobiles have been required to be guided and to use BAT machines. From 2004 to 2009, snowmobile use levels were capped at a maximum level of 720 per day. For the 2009/2010 to 2011/2012 winter seasons, the limit was 318 snowmobiles per day. Guided OSV service is available from a total of 23 different companies at the various park entrances. Of these companies, 8 operate both snowcoaches and snowmobiles, 3 operate only snowcoaches, and 12 operate only snowmobiles.

Since the winter of 2004/2005, all snowmobiles have been required to use commercial guides in the park and to use BAT machines.

Visitation and OSV Transportation Modes

Background

Information on visitation and OSV transportation modes are provided for the winter seasons 2004/2005 to 2011/2012 (the “managed use era”). “Winter seasons” in Yellowstone during this timeframe were from mid-December to mid-March. Analyses do not include data prior to December 2004 because this period preceded implementation of limits on daily OSV numbers. Although several options for winter use in the park are being considered, there is no alternative for returning to unmanaged OSV use; therefore, these earlier years are not relevant for environmental impact assessment purposes or analysis of trends.

Accurate OSV and visitation data broken down into key metrics will help in assessing potential changes to visitation resulting from new policies. To facilitate this assessment, superfluous statistics previously reported have been removed from analysis, including automobile, recreation vehicle, and bus statistics. The current plan/SEIS focuses solely on OSV transportation on interior park snow-packed and groomed roads, not the northern road between Gardiner and Cooke City which is plowed to pavement during the winter. A breakdown of the gates through which OSV visitors are entering the park has been added to the analysis to illustrate which oversnow routes are currently used by visitors and the relative proportions of oversnow use.

Data Collection

Winter visitation and OSV use in Yellowstone National Park has traditionally been tracked using two different accounting methods. The statistics published on www.nature.nps.gov, are tracked and reported by the Visitor Services Office (VSO) under the Chief Ranger's Office. This office records the total number of OSVs and visitors coming through each entrance gate each day. Commercial tour operators "check in" with ranger staff at the entrance gate as they enter the park, submitting vouchers (at the west gate) or filling in a log book (at the south gate) with information about the number of people and machines in their group; these records are entered into a cash register and used to charge the operators for the number of vehicles entering the park.

The other winter visitation records are collected and compiled by the Yellowstone Concessions Management Office. Each month, operators provide the Concessions Management Office with a comprehensive list of all of tours that they ran during the month and the makeup of each tour event. The Concessions Management Office tracks additional levels of detail that the VSO does not. VSO statistics are the most widely reported numbers and previous winter use environmental planning documents have relied upon these data. Comparison of the VSO numbers with those from the Concessions Management Office indicated that Concessions Office data may more accurately represent the number of OSVs operating within the park at any given time. For example, VSO numbers do not include a portion of the traffic originating at Old Faithful but staying within the boundaries of the park; Old Faithful data is reported by the VSO only if OSVs leave and reenter the park, at which point they are counted at the gate. Concessions Office numbers do include Xanterra Parks and Resorts data and therefore numbers of OSVs based at Old Faithful and traveling exclusively within the park are reported. Concessions Office numbers tend to be somewhat higher than VSO numbers (about 5 percent per year for snowmobiles and 20 percent for snowcoaches) due to this inclusion.

Additionally, Xanterra Parks and Resorts, the park's largest concessioner, runs snowmobile and snowcoach tours from Mammoth Hot Springs and Old Faithful. Xanterra tracks and reports these numbers to the NPS Concessions Management Office, which incorporates these numbers into the compiled data from all of the operators, and to the VSO, which uses the number of tours that Xanterra runs out of Mammoth to inform their north gate snowmobile and snowcoach daily counts.

For maximum consistency and to enable comparison of the various data sources, the variables reported here are defined as follows and reported data has been adjusted to meet these definitions:

- Number of Snowmobiles = total number of snowmobiles, including guides
- Number of Persons by Snowmobile = total number of snowmobile riders, including guides
- Number of Snowcoaches = total number of snowcoaches
- Number of Persons by Snowcoach = total number of passengers in a snowcoach, including the drivers.

Annual OSV Numbers

Table 23 provides the total OSV numbers and commercial visitation for the previous eight winter seasons (the entire managed use era). The 2004/2005 season was the start of the managed use era, with the implementation of a 720 snowmobile-per-day limit. To enforce this limit, commercial operators were granted "allocations," or numbers of snowmobiles and/or snowcoaches they were allowed to operate in the park on a single day. In 2008/2009, park management planned a 540 snowmobile-per-day limit, but the plan was overturned in late 2008 and by court order the limit remained at 720 for that season; so, while the limit for that year was technically 720, usage rates were generally lower than in preceding years largely due to operators planning for the lower limit. In 2009/2010, the daily snowmobile limit was reduced to 318, where it has remained for the last three seasons. The numbers presented in table 23 for snowmobiles and snowcoaches include the daily numbers of OSVs operated by commercial operators for tours in the park, based either out of one of the gateway communities or out of Old Faithful, summed for the entire winter season.

TABLE 23: NUMBER OF VISITORS BY TRANSPORTATION MODE, WINTER SEASONS 1999/2000 TO 2011/2012

Winter Season	Snowmobiles	Persons by Snowmobile	Snowmobile Groups	Snowcoaches	Persons by Snowcoach
2004/2005 [a]	18,987	27,898	2,847	2,263	16,119 [b]
2005/2006	22,547	30,104	3,563	2,620	19,245 [b]
2006/2007	23,720	34,768	3,488	2,978	24,708
2007/2008	24,509	36,380	3,617	3,051	25,857
2008/2009 [c]	18,142	27,239	2,811	2,950	23,146
2009/2010 [d]	16,852	25,312	2,521	3,075	25,818
2010/2011	17,598	24,497	2,684	3,403	26,853
2011/2012	15,514	21,180	2,305	3,156	24,293
Managed-Use Era Average	19,734	28,422	2,980	2,937	23,255
720 Snowmobile Era Average	21,581	31,278	3,265	2,772	21,815
318 Snowmobile Era Average	16,655	23,663	2,503	3,211	25,655

Source: MN Spreadsheet (Concessions Data).

[a] A daily limit of 720 snowmobiles was introduced during the 2004/2005 season.

[b] Snowcoach visitor numbers from 2004/2005 and 2005/2006 do not include Old Faithful numbers due to missing data.

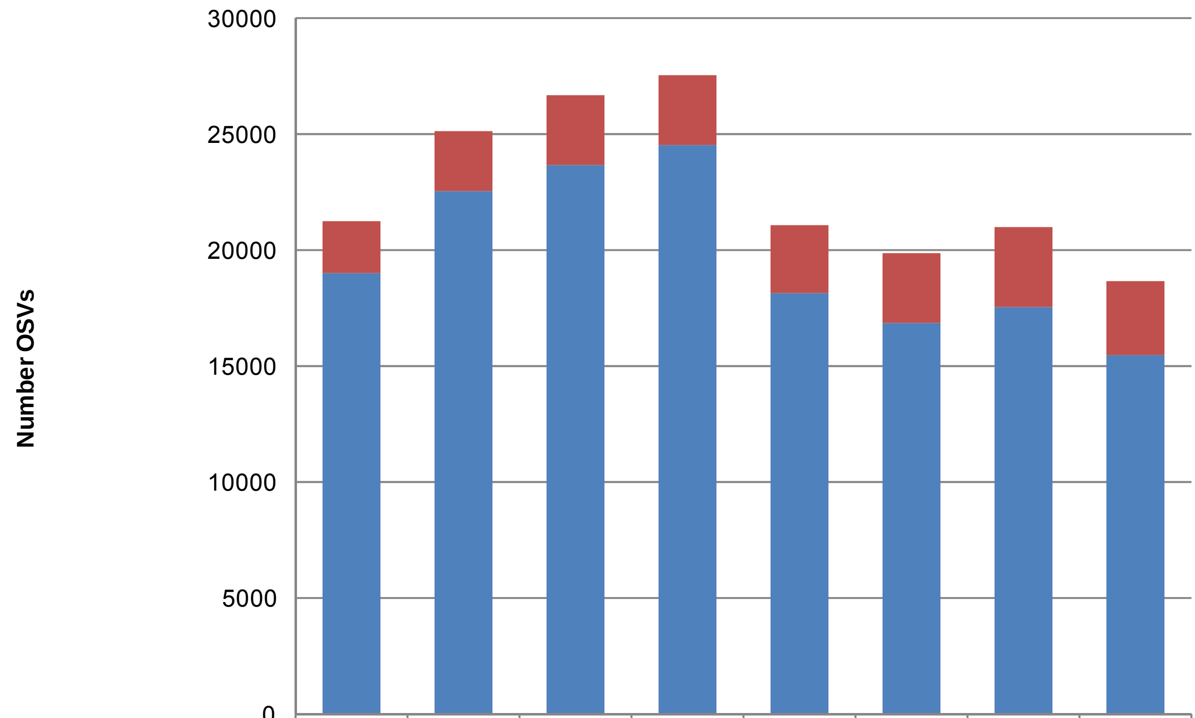
c Although the daily limit during the 2008/2009 season was 720, guides and outfitters had planned for a 540 snowmobile limit, based on a winter plan that was overturned in late 2008.

[d] The daily snowmobile limit was reduced to 318 starting during the 2009/2010 season.

From the 2004/2005 winter season through the most recent winter season (2011/2012), the total number of snowmobiles operating in the park has decreased by 18.3 percent whereas the daily snowmobile allocation decreased by 55.8 percent (720 to 318 snowmobiles daily). During the 720 snowmobile-limit era (excluding 2008/2009 for reasons noted earlier), snowmobile numbers showed a gradual rise, from a total of 18,987 snowmobiles in 2004/2005 to 24,509 snowmobiles in 2007/2008. During the 318 snowmobile-limit era, snowmobile use increased from 16,852 total snowmobiles in 2009/2010 to 17,598 in 2010/2011 but decreased to 15,514 snowmobiles in 2011/2012. A lack of snow in December 2011 caused a 16-day delay in opening the west and north entrances for snowmobile use. The delay cut into the park's planned 91 day winter season which likely was the cause of the decline in snowmobile numbers during the 2011/2012 season.

The number of snowcoaches operating in the park increased by 39.5 percent from 2004/2005 to 2011/2012 (from 2,263 to 3,156). Similarly to snowmobiles, the annual sum number of snowcoaches operating in the park increased steadily from 2004/05 through 2007/2008 (a 34.8 percent increase, from 2,263 to 3,051), but has largely stabilized over the last 3 years.

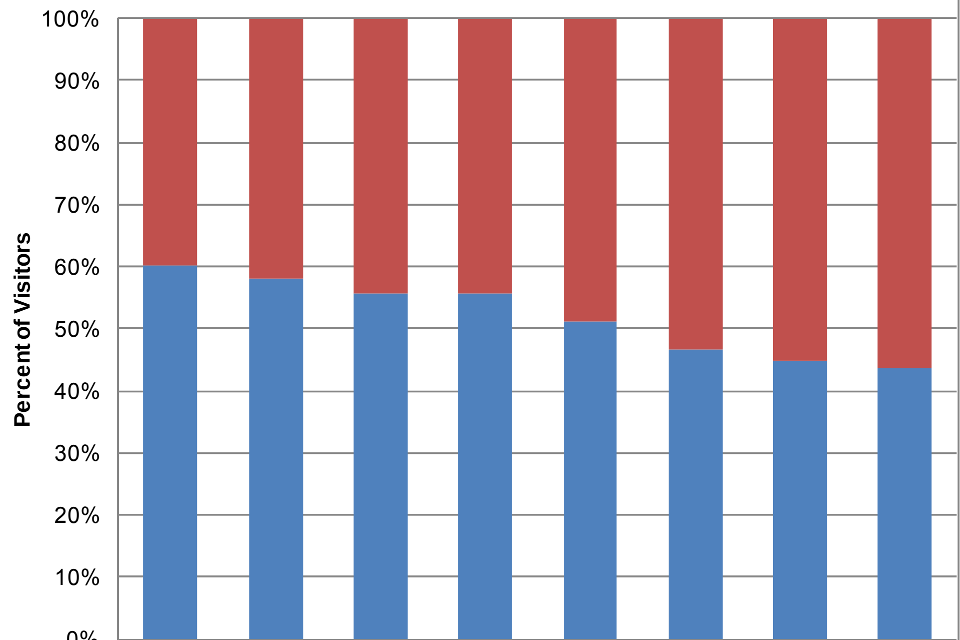
Figure 10 graphically depicts the numbers cited in table 23. It shows the total number of OSVs used over the past eight seasons and is broken down by snowmobile and snowcoach to show overall trends as well as trends for each type of OSV.



	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Number Snowcoaches	2263	2620	2978	3051	2950	3075	3403	3156
Number Snowmobiles	18987	22547	23720	24509	18142	16852	17598	15514

FIGURE 10: TOTAL NUMBER OF SNOWMOBILES AND SNOWCOACHES RUN DURING TOURS IN THE PARK FOR THE WINTER SEASONS OF 2004/2005 TO 2011/2012

Figure 11 shows the relative portions of visitors using the two OSV transportation types. This breakdown shows a shift from the majority of people using snowmobiles (60.2 percent during the 2004/2005 season) to the majority of persons using snowcoaches (56.4 percent during the 2011/2012 season) to access the park.



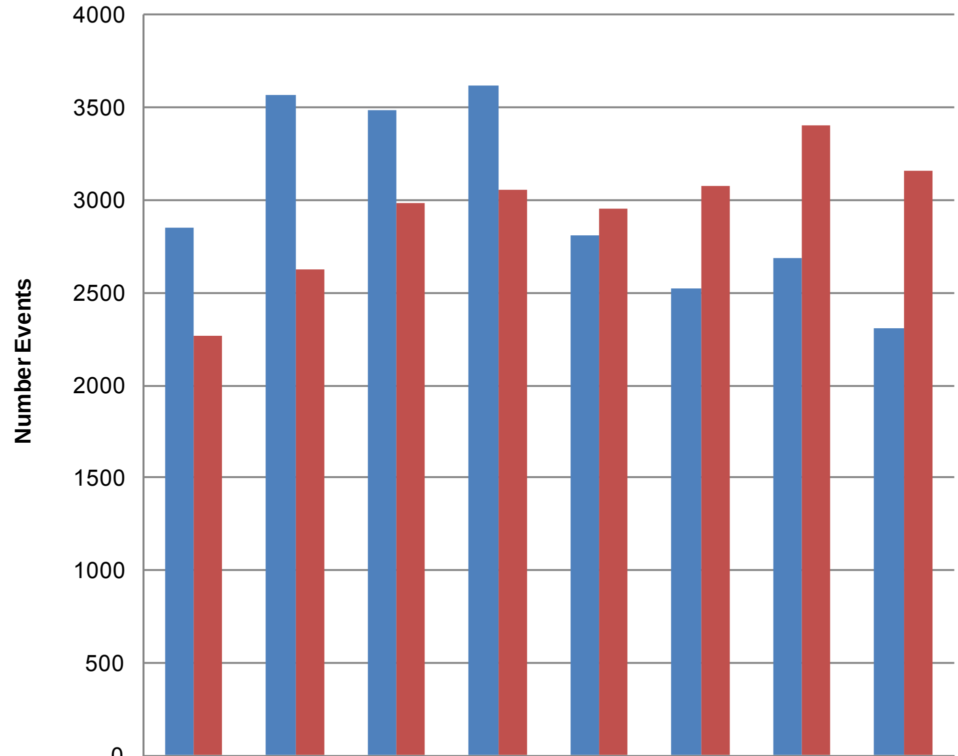
	2004 /05	2005 /06	2006 /07	2007 /08	2008 /09	2009 /10	2010 /11	2011 /12
Number Persons by Snowcoaches	18382	21865	27686	28908	26096	28893	30256	27449
Number Persons by Snowmobiles	27898	30104	34768	36380	27239	25312	24497	21180

FIGURE 11: PERCENT OF PERSONS USING EACH OSV TRANSPORTATION TYPE

Transportation Events

A snowmobile tour typically consists of a group of multiple machines traveling together (average number of snowmobiles per group for the past three seasons is 6.7) while snowcoach tours most often consist of a single machine traveling by itself. Therefore, it is helpful to think of transportation events to understand the relative number of tours given using each type of OSV (see chapter 2 for definition). Total numbers of snowmobiles do not provide the specificity to understand how many groups entered the park or how many tours ran. Therefore, a transportation event is defined as either a group of snowmobiles traveling together as a discrete group or a single snowcoach traveling by itself. This framework allows the exploration of the relative popularity of each type of transportation.

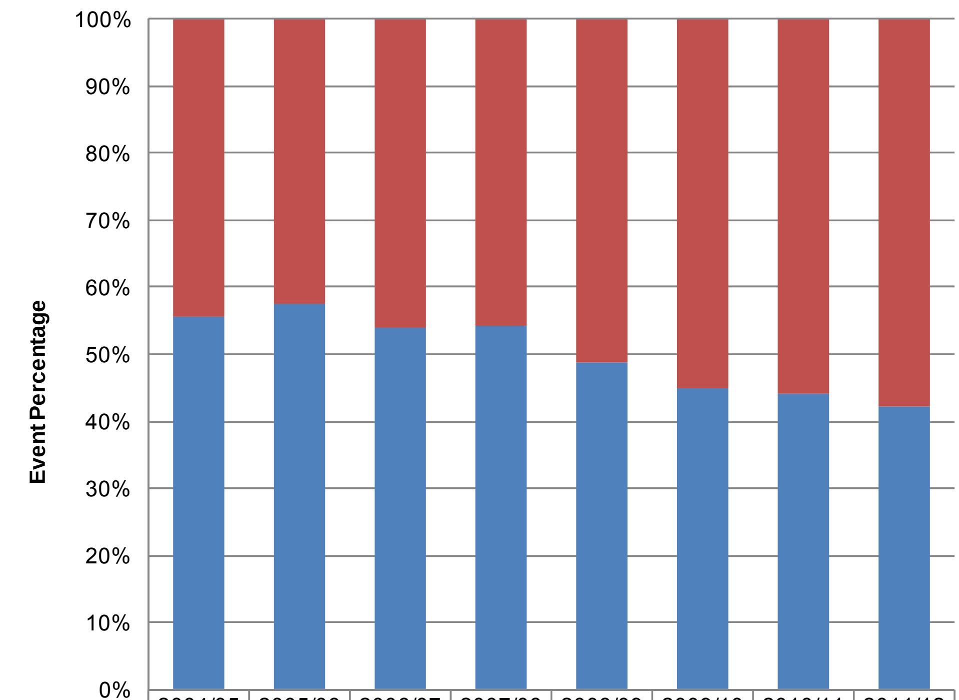
Figure 12 shows the total number of transportation events over the past eight seasons. A transportation event is defined as one snowcoach or a group of, on average, seven snowmobiles travelling together within the park. Based on evidence that with changes to current BAT standards both types of transportation events have comparable impacts to resources, this shift to an impact-centric approach in managing snowmobile and snowcoach use will result in a cleaner and quieter park, enhance visitor experience, and permit modest growth in visitation. Year-to-year trends vary, but the overall range from 2004/2005 to 2011/2012 shows a general decrease in the number of snowmobile transportation events and a general increase in the number of snowcoach transportation events. The number of snowcoach transportation events first surpassed the number of snowmobile transportation events in 2008/2009 and has continued to exceed snowmobile transportation events by an increasing number during each year since. The decline in the number of snowmobile transportation events could be due to lowered daily limits, but the increase in snowcoach transportation events is not due to limits on snowcoaches, which has been almost constant throughout the eight-year managed use era. The only change in snowcoach allocations occurred when a contract in south entrance was terminated prior to the winter of 2011/2012, reducing allocations in south entrance by 2 snowcoaches, from 13 to 11, and reducing the parkwide total from 78 to 76.



	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Snowmobile Transportation Events	2847	3563	3488	3617	2811	2521	2684	2305
Snowcoach Transportation Events	2263	2620	2978	3051	2950	3075	3403	3156

FIGURE 12: NUMBERS OF TRANSPORTATION EVENTS BY OSV TYPE PER WINTER SEASON THROUGHOUT MANAGED USE

Figure 13 shows the breakdown of transportation events by percentages. In 2004/2005, 55.7 percent of OSV transportation events were snowmobile groups, but by 2011/2012, 42.2 percent of transportation events were snowmobile groups.



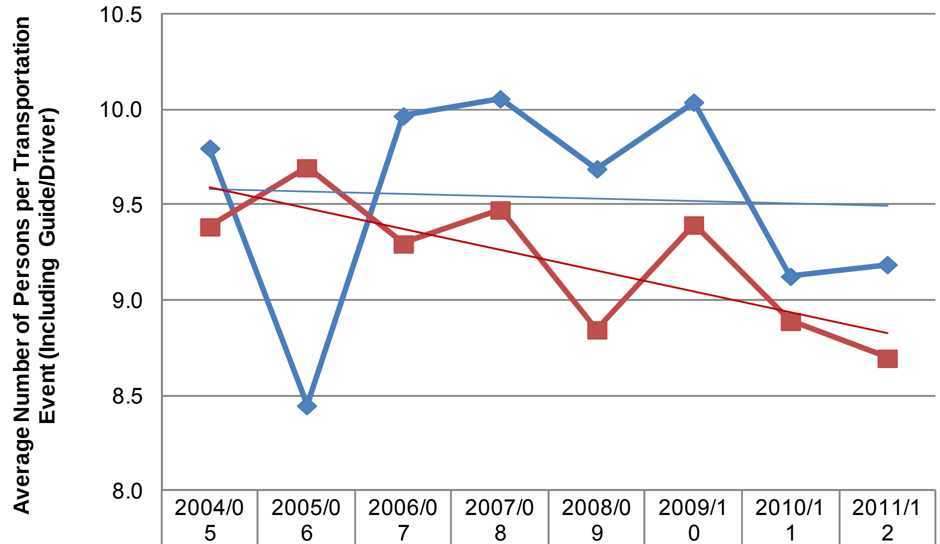
	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Snowcoach Transportation Events	2263	2620	2978	3051	2950	3075	3403	3156
Snowmobile Transportation Events	2847	3563	3488	3617	2811	2521	2684	2305

FIGURE 13: PERCENTAGE OF TRANSPORTATION EVENTS BY OSV TYPE

The characteristics of an average transportation event have changed slightly over the past eight seasons. On average over the past eight winter seasons, individual commercial snowmobile transportation events have consisted of 6.6 snowmobiles and 9.5 persons per group (including the guide), with an average of 1.4 riders per snowmobile. During the 318 snowmobile-limit era, on average 29 snowmobile transportation events occurred daily, whereas during the 720 era the average number of daily snowmobile groups was 40. For the past eight seasons, snowcoach transportation events averaged 9.2 persons per group (including the driver), but during the 318 snowmobile-limit era this average dropped to 9.0. Figure 14 demonstrates these trends.

Average and Peak Day Use

To understand how snowmobiles and snowcoaches are currently used in the park, it is helpful to understand average daily use, which gives an indication of what a typical day during a season might look like, and peak daily use, which is a snapshot of OSV use on the peak day of the season. The peak use day for a winter season, during which the most OSVs are operating, generally falls near one of three holiday periods during the winter: Christmas/New Year (around December 23 to January 5), Martin Luther King, Jr., Day, and President's Day. During these time periods, operators usually have more clients and use more of their OSV allocations than they do during the rest of the year. Illustrating these trends graphically helps to show the peak possible demand, given the current OSV limits, which can be used to assess visitor numbers and preferences for one transportation type over another.



	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Average Persons per Snowmobile Transportation Event	9.8	8.4	10.0	10.1	9.7	10.0	9.1	9.2
Average Persons per Snowcoach Transportation Event	9.4	9.7	9.3	9.5	8.8	9.4	8.9	8.7

FIGURE 14: AVERAGE NUMBER OF PERSONS PER TRANSPORTATION EVENT BY OSV TYPE

Both average daily usage figures and peak daily usage figures can be used to determine average and peak day utilization rates. Utilization rates are calculated by dividing the actual number of OSVs in use for a given day (to determine peak day utilization rate) or season (to determine average utilization rate) by the absolute number of OSVs permitted. Utilization rates under different OSV limits and how these utilization rates change within multiple seasons at a set limit can indicate how appropriate the existing limits are and how operators adjust to these limits.

Table 24 provides the average daily number of snowmobiles and snowcoaches in the park during the previous eight seasons as well as each season's peak numbers of OSVs. The daily limit column shows the maximum number of OSVs permitted daily in the park during that winter season. During the winters of 2004/2004 through 2008/2009, the maximum number of snowmobiles permitted in the park was 720. The daily average during this period ranged from 213 snowmobiles to 303, meaning that average daily utilization rate ranged from 30 percent to 42 percent. Peak use during this period ranged from 429 to 560 snowmobiles (peak utilization rate of 59 percent to 77 percent). During the most recent three seasons, 2009/2010 to 2011/2012, the daily limit for snowmobiles was 318 and the daily average ranged from 187 to 197 snowmobiles (59 percent to 62 percent average utilization rate). Peak use of snowmobiles during these years ranged from 258 to 294 (peak utilization rates of 81 percent to 92 percent).

Snowcoach daily limits remained at 78 throughout the managed use era, until the 2011/2012 winter season when they dropped to 76 due to termination of a snowcoach contract with 2 snowcoach allocations at the south entrance. Daily parkwide averages ranged from 26 to 39 (33 percent to 50 percent average daily utilization rate) during these seasons. Overall, the average daily number of snowcoaches increased by 34.6 percent, from an average of 26 coaches per day in 2004/2005 to an average of 35 coaches per day in 2011/2012. Peak daily snowcoach utilization rates ranged from 56 to 63, with peak daily utilization rates between 72 percent and 81 percent.

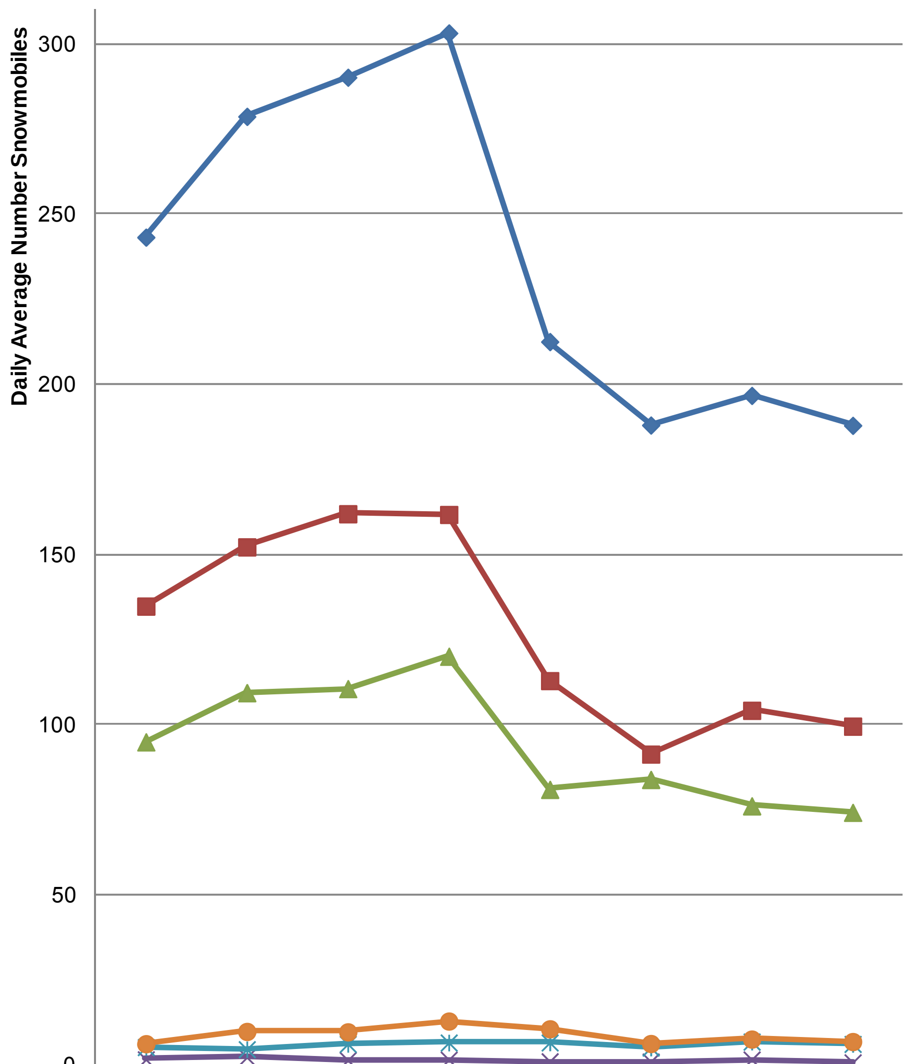
TABLE 24: AVERAGE DAILY NUMBER OF OSVS, WINTER SEASONS 2004/2005 TO 2011/2012

Winter Season	Snowmobiles					Snowcoaches				
	Daily Limit	Daily Average	Daily Average Utilization Rate	Peak	Peak Utilization Rate	Daily Limit	Daily Average	Daily Average Utilization Rate	Peak	Peak Utilization Rate
2004/2005	720	243	34%	430	60%	78	26	33%	58	74%
2005/2006	720	279	39%	494	69%	78	33	42%	60	77%
2006/2007	720	290	40%	552	77%	78	37	47%	58	74%
2007/2008	720	303	42%	560	78%	78	38	49%	63	81%
2008/2009	720 (540)*	213	30% (39%)	429	60% (79%)	78	33	43%	55	71%
2009/2010	318	188	59%	294	92%	78	35	44%	59	76%
2010/2011	318	197	62%	281	88%	78	39	49%	59	76%
2011/2012	318	188	59%	261	82%	76	35	46%	56	74%
Managed-Use Era Average	569	238	46% (47%)	413	76% (78%)	78	34	44%	58	75%
720- Snowmobile Era Average	720	266	37% (39%)	493	68% (73%)	78	33	43%	59	75%
318-Snowmobile Era Average	318	191	60%	279	88%	77	36	47%	58	75%

Source: MN Spreadsheet (concessions data except for peak numbers, which are VSO).

*Although the daily limit was 720, guides and outfitters had planned for a 540 snowmobile limit, based on a winter plan that was overturned in late 2008.

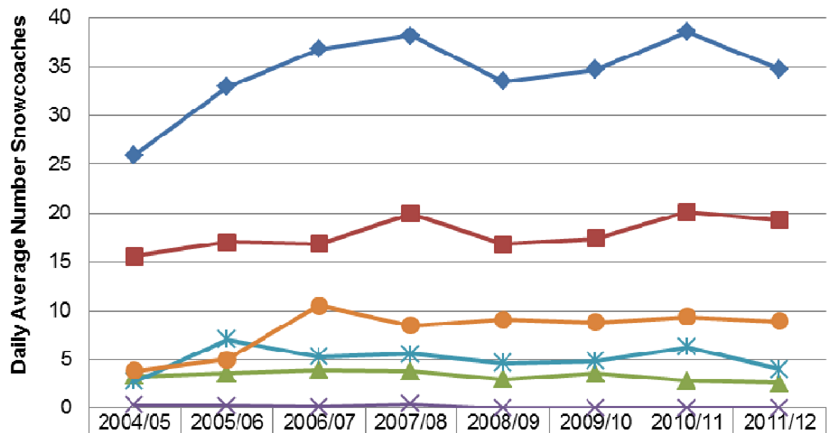
Figure 15 shows the average daily number of snowmobiles operating in the park, both parkwide and by location of origin. Daily averages increased yearly during the 720 snowmobile-limit era until 2008/2009. During the 318 snowmobile-limit era, daily averages stayed fairly constant.



	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Parkwide Daily Avg. Number Snowmobiles	243	279	290	303	213	188	197	188
West Daily Avg. Number Snowmobiles	135	152	162	162	113	91	104	100
South Daily Avg. Number Snowmobiles	95	109	111	120	81	84	76	74
East Daily Avg. Number Snowmobiles	2	2	2	2	1	1	2	1
North Daily Avg. Number Snowmobiles	5	5	6	7	7	5	7	6
Old Faithful Daily Avg. Number Snowmobiles	6	10	10	13	11	6	8	7

FIGURE 15: DAILY SNOWMOBILE AVERAGES FROM WINTER SEASONS 2004/2005 TO 2011/2012 (PARKWIDE AND BY GATE)

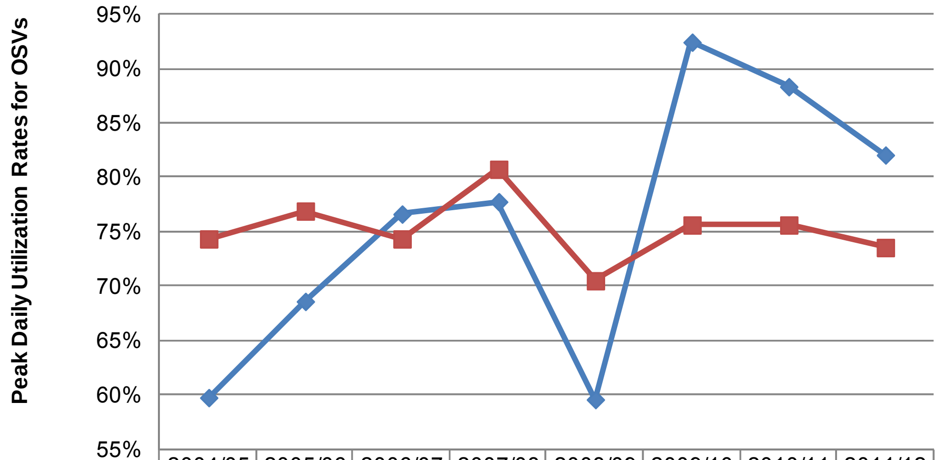
Figure 16 shows the average daily number of snowcoaches in operation in the park over the past eight seasons. Daily averages increased 46.2 percent from 26 in 2004/2005 to 38 in 2007/2008. During 2008/2009 to 2011/2012, averages ranged from 33 to 39 snowcoaches. The 2008/2009 average of 33 snowcoaches is a decrease from the 2007/2008 daily average of 38 snowmobiles. While this is only slightly more than the fluctuations seen in later years, this drop in 2008/2009 does correspond to the significant drop in snowmobile numbers in this same season, which is likely due to the anticipated snowmobile-limit decrease of that year.



	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Parkwide Daily Avg. Number Snowcoaches	26	33	37	38	33	35	39	35
West Daily Avg. Number Snowcoaches	16	17	17	20	17	17	20	19
South Daily Avg. Number Snowcoaches	3.3	3.6	4.0	3.8	3.0	3.6	2.8	2.6
East Daily Avg. Number Snowcoaches	0.3	0.3	0.2	0.4	0.0	0.0	0.0	0.0
North Daily Avg. Number Snowcoaches	2.8	7.0	5.3	5.5	4.6	4.8	6.3	4.0
Old Faithful Daily Avg. Number Snowcoaches	3.9	5.0	10.5	8.5	9.1	8.8	9.4	8.9

FIGURE 16: DAILY SNOWCOACH AVERAGES FROM WINTER SEASONS 2004/2005 TO 2011/2012 (PARKWIDE AND BY GATE)

Snowcoach peak day utilization rates have stayed within a fairly narrow range for the past eight seasons: 74 percent in 2004/2005 (58 coaches) and 74 percent in 2011/2012 (56 coaches), but ranging as high as 81% in 2007/2008. Snowmobiles had a peak day utilization rate of 60 percent in 2004/2005 (430 snowmobiles out of the 720 allowed) and a peak day utilization rate of 82 percent in 2011/2012 (261 snowmobiles out of the 318 allowed). Peak utilization rates for snowmobiles increased most dramatically between winter seasons 2008/2009 and 2009/2010, going from 60 percent to 92 percent (figure 17).

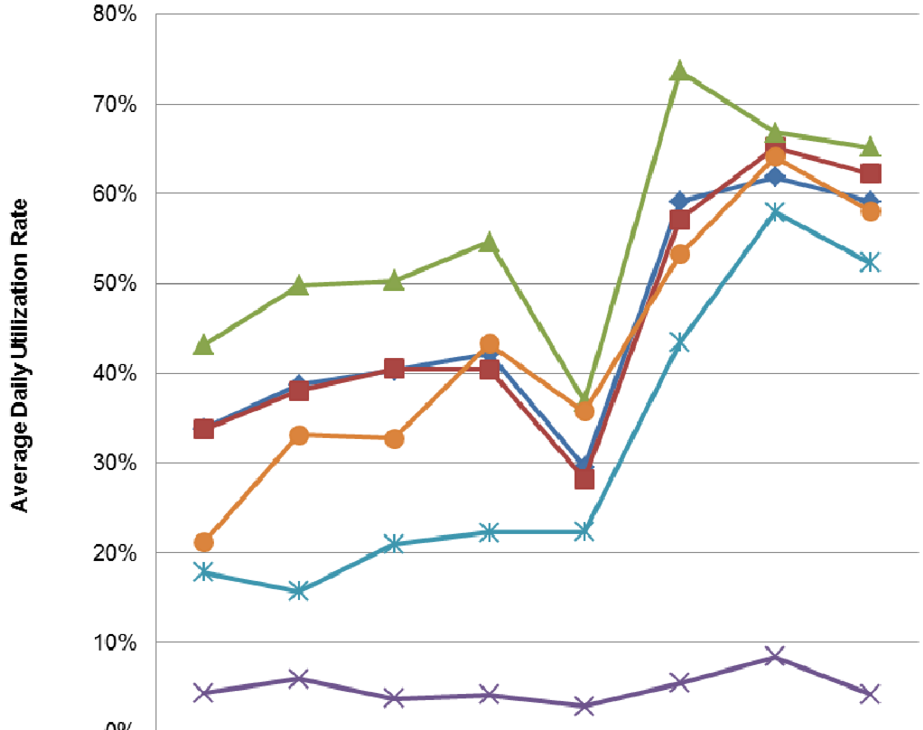


	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Peak Daily Snowmobile Utilization Rate	60%	69%	77%	78%	60%	92%	88%	82%
Daily Snowmobile Allocation	720	720	720	720	720	318	318	318
Peak Daily Snowcoach Utilization Rate	74%	77%	74%	81%	71%	76%	76%	74%
Daily Snowcoach Allocation	78	78	78	78	78	78	78	76

FIGURE 17: PEAK DAILY UTILIZATION RATES OF SNOWMOBILE AND SNOWCOACHES DURING MANAGED USE

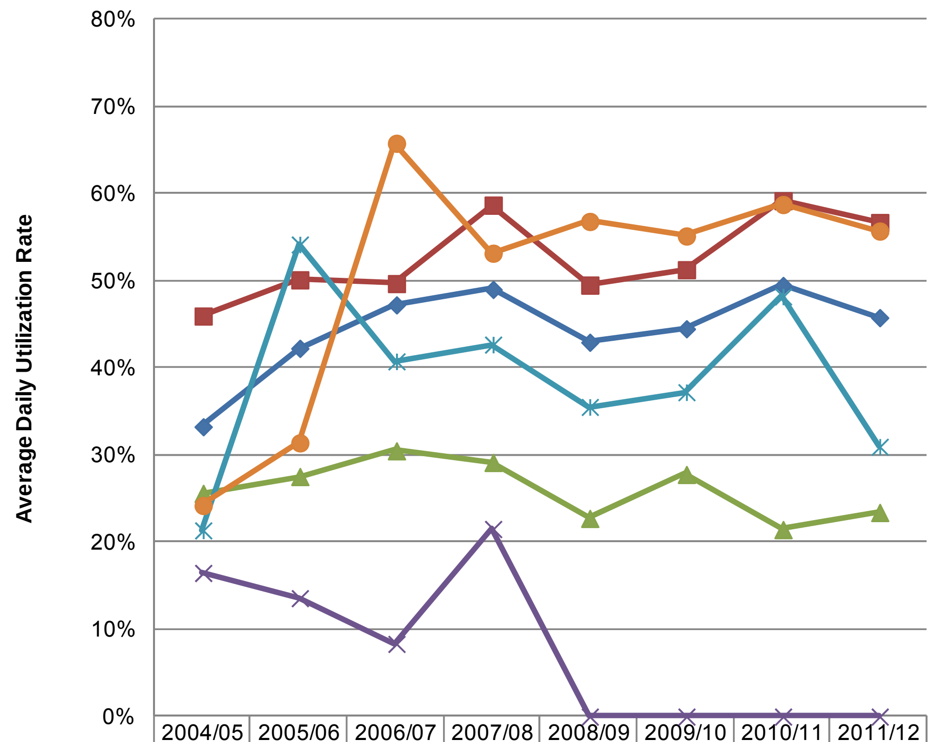
The average daily utilization rate for snowmobiles has increased over the past eight seasons at almost all gates, as depicted in figure 18. The average daily utilization rate increased steadily throughout most of the 720 snowmobile-limit era (from 2004/2005 to 2007/2008), from 34 percent to 42 percent parkwide except for a drop of 30 percent during 2008/2009 when the snowmobile limit was unexpectedly increased at the last minute. When the 318 snowmobile limit was implemented in 2009/2010, the utilization rates went up drastically, to 59 percent parkwide, and then stayed around that level (or a little higher) during the remaining two 318 snowmobile-limit years. In general, these trends were the same for the individual gates.

Overall, the average daily snowcoach utilization rates have increased more gradually than snowmobiles, going from 33 percent parkwide in 2004/2005 to 46 percent parkwide in 2011/2012, as shown in figure 19. There was a gradual increase in snowcoach use at most of the gates with the exception of the east entrance, which has a two snowcoach allotment but operators chose to stop running coaches in 2008/2009, and the south entrance, which stayed between 20 and 30 percent throughout the managed-use era. There was a fairly steep drop in snowcoach utilization rate at the north entrance in the 2011/2012 season (figure 19).



	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Parkwide Avg. Daily Snowmobile Utilization Rate	34%	39%	40%	42%	30%	59%	62%	59%
West Gate Avg. Daily Snowmobile Utilization Rate	34%	38%	41%	40%	28%	57%	65%	62%
South Gate Avg. Daily Snowmobile Utilization Rate	43%	50%	50%	55%	37%	74%	67%	65%
East Gate Avg. Daily Snowmobile Utilization Rate	4%	6%	4%	4%	3%	6%	8%	4%
North Gate Avg. Daily Snowmobile Utilization Rate	18%	16%	21%	22%	22%	43%	58%	52%
Old Faithful Avg. Daily Snowmobile Utilization Rate	21%	33%	33%	43%	36%	53%	64%	58%

FIGURE 18: AVERAGE DAILY SNOWMOBILE USE RATES THROUGHOUT MANAGED USE



	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Parkwide Daily Avg. Snowcoach Utilization Rate	33%	42%	47%	49%	43%	44%	49%	46%
West Gate Daily Avg. Snowcoach Utilization Rate	46%	50%	50%	59%	50%	51%	59%	57%
South Gate Daily Avg. Snowcoach Utilization Rate	26%	28%	30%	29%	23%	28%	21%	23%
East Gate Daily Avg. Snowcoach Utilization Rate	16%	14%	8%	22%	0%	0%	0%	0%
North Gate Daily Avg. Snowcoach Utilization Rate	21%	54%	41%	43%	36%	37%	48%	31%
Old Faithful Daily Avg. Snowcoach Utilization Rate	24%	31%	66%	53%	57%	55%	59%	56%

FIGURE 19: AVERAGE DAILY SNOWCOACH UTILIZATION RATES THROUGHOUT MANAGED USE

Visitation from Afar

Visitors can also visit the park from afar. The park offers seven webcams for visitors to remotely view the park. These webcams include two at Old Faithful; one each at the Upper Geyser Basin, Mammoth Hot Springs, and the terraces at Mammoth Hot Springs; and two at Mount Washburn. Visitors can view these webcams at any time during the year (NPS 2010l).

VISITOR ACTIVITIES

Activities such as snowmobiling, cross-country skiing, and riding snowcoaches are primary winter uses in Yellowstone. These activities allow visitors to view wildlife and take photographs in various areas throughout the park and enjoy the sounds of the natural environment. Other popular uses include camping, hiking/snowshoeing, and participating in interpretive programs. These visitor activities are generally available throughout the winter season, but the park superintendent may restrict use of any area or trail to protect visitors and park resources. Weather conditions may also warrant closing an area.

The ability of visitors to experience Yellowstone by OSV is determined, in part, by the amount of snowpack on designated routes. The variability of snowpack over numerous years helps identify realistic opening and closing dates for OSVs in the park. Rubber tracked coaches can operate in low snow conditions. Snowmobiles and steel-tracked coaches are not allowed to operate when snow is too thin. Actual opening dates for non-rubber tracked vehicles is often later than the scheduled dates shown in table 25. For example, Snowpack at Madison Junction helps dictate when the road can be opened from Old Faithful to West Yellowstone. Approximately 15 to 18 inches of cumulative snowfall is necessary to open the west-side roads to OSV use. Spring closings closely mirror changes in the snowpack, specifically when the snowpack becomes the same temperature, marking the beginning of spring melt. Mid-winter melt can also be a problem for maintaining snow on roadways; therefore mid-winter melt affects visitor use (Farnes and Hansen 2005).

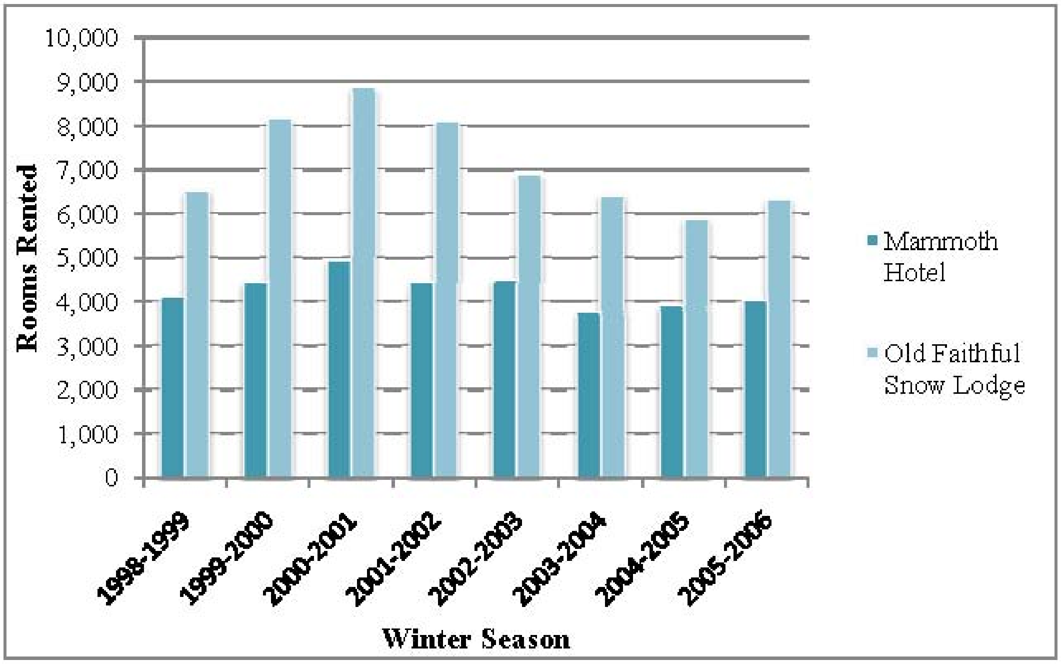
TABLE 25: TARGET OPENING DATES

Entrance	Date of Opening
South	December 15
East	December 22
West	December 15

In addition to parking facilities dispersed throughout the park, there are warming huts at various locations. Warming huts are found at Mammoth, Canyon Village, Indian Creek, Fishing Bridge, Madison, and West Thumb. Small snack bars or vending machines are available at the warming huts at Mammoth, Madison, and Fishing Bridge. NPS interpreters or volunteers staff some of the huts to answer questions and provide information and assistance to visitors. Winter fueling facilities are available at Old Faithful, Fishing Bridge, Mammoth, and Canyon Village (NPS 2007c).

Winter lodging facilities in the park include the Mammoth Hotel and the Old Faithful Snow Lodge. Together, these hotels have 228 rooms with 448 beds (NPS 2007c). In addition to these facilities, Yellowstone Expeditions operates six yurts plus a dining/community yurt and kitchen yurt near Canyon Village. The park also issues winter backcountry camping permits. Overnight stays at the hotels were at their highest during the 1999/2000 to 2001/2002 winter seasons (figure 20). The change in hotel stays closely parallels fluctuations in overall Yellowstone winter visitation. Snowmobile use and recreational visitor numbers were at their highest during these years.

Snow Lodge



Source: NPS 2007c.

FIGURE 20: HOTEL ROOMS RENTED IN YELLOWSTONE NATIONAL PARK, VARIOUS WINTER SEASONS

There are a number of museums in the area that offer a variety of different opportunities to learn about the history and heritage of the park and region. The Heritage and Research Center in Gardiner, Montana, houses the Yellowstone National Park museum collection, archives, research library, historian's office, archeology lab, and herbarium. Other nearby education resources include the Buffalo Bill Historical Center, the Carbon County Historical Society & Museum, the Eagle Rock Art Museum, the Gallatin County Historical Society and Pioneer Museum, the Museum of the Mountain Man, and the Museum of the Yellowstone, among others.

Visitor Accessibility

Yellowstone offers a wide variety of experiences in the park that can be experienced by a range of visitors. Visitors that could have difficulty accessing the park during the winter months include the very young, the elderly, and those who are mobility impaired. Within Yellowstone, visitors with access challenges can drive through the north entrance of the park and through Lamar Valley and Mammoth in their own vehicles. Additionally, tour companies offer accessibility through the north entrance of the park through wildlife viewing tours in Americans with Disabilities Act (ADA) accessible vehicles (Xanterra pers. comm. 2010). Visitors can enjoy viewing wildlife and the natural surroundings from a wheeled vehicle. Depending on individual mobility challenges, for some, snowmobiles can provide a way for visitors to enjoy the park in the winter. For others, ADA-accessible snowcoaches are the preferred mode of travel. Companies work with visitors to provide the type of transportation that best meets their needs and desires. Commercial vendors at Yellowstone offer ADA-accessible snowcoaches for those with accessibility issues. According to one company, disabled visitors use the power-lift snowcoaches on average twice a month (Johnson pers. comm. 2010).

Tour companies offer accessibility through the north entrance of the park through wildlife viewing tours in ADA accessible vehicles (Xanterra pers. comm. 2010). Visitors can enjoy viewing wildlife and their natural surroundings from a wheeled vehicle.

The Old Faithful Visitor Education Center and the Albright (Mammoth) visitor center are wheelchair accessible. Visitors with accessibility needs may require assistance to enter the Madison warming hut (NPS 2010i). Wheelchair accessible rooms are available at the Old Faithful Snow Lodge, which also offers a handicapped-accessible cabin for visitors. Trails, paths, and roads in the park are snow covered in the winter. Routes between the Snow Lodge, the Old Faithful Visitor Education Center, and the geyser basin boardwalks are kept open, but soft or fresh snow may preclude easy access among them. At Canyon, the South Rim Drive at Artist Point offers a view of the Lower Falls (NPS 2010j). At the Mammoth Hotel, two handicapped-accessible rooms are available (NPS 2010k).

VISITOR SURVEYS

Numerous studies have examined visitor use in national parks, including some specific to Yellowstone, in an attempt to understand features and elements of particular importance to different user groups. Managing OSV use can affect visitor experiences in the park directly and indirectly. The NPS directly controls several elements of OSV travel, including limits on the number of OSVs in the park each day, the size of snowmobile tour groups, the relative proportion of snowmobiles and snowcoaches allowed, the grooming of roads, and requirements for visitors to employ licensed guides and use snow machines equipped with BAT. Through these actions, the NPS also manages other aspects of OSV use that can affect the experiences of winter visitors. Much of the research that has been done addresses how noise can impact the visitor experience, however, studies on the role wildlife viewing plays in the visitor experience and the potential for visitor conflicts are also relevant to winter use in the park.

Soundscapes are a key element of the environment and natural ecology of national parks (Borrie et al. 2002; Bowles 1995). However, equally important are the ways in which visitors experience a natural soundscape (McCusker and Cahill 2010). Much of the social science research on soundscapes addresses the effects of noticeable natural and anthropogenic sounds on visitor experiences in national parks and other natural areas. This has been an important area of investigation during the last two decades. In general, social science research has found that the majority of visitors to national parks value and enjoy natural sounds, solitude, and quiet (Mace et al. 2004). At Yellowstone, a 2008 study found that those interviewed believed the natural sounds they heard were part of what made Yellowstone special. Eighty-one percent of respondents indicated that natural sounds had a positive effect on their experience (Saxen 2008).

The visitor survey report summarized below is the most recent available report of its kind. Data below was collected during the 2007/2008 winter season. The report, entitled *Winter Experiences of Old Faithful Visitors in Yellowstone National Park*, was prepared by The University of Montana, Department of Society and Conservation and released in August 2009 (Freimund et al. 2009). The methodology employed for this study was designed to address the following objectives related to noise and the visitor experience: to better understand the dynamics of visitor experiences of natural sounds and to better understand visitor perceptions of the practical need for mechanical sound presence during a park visit. Additionally, the study examined the relationship between visitor experience and wildlife and guiding.

The soundscapes sub-study sought to describe the dynamics of winter visitors' experiences of the soundscape environment in Yellowstone and document how visitors feel natural soundscapes should be protected by park management. Interviews conducted for the survey revealed that the natural soundscape assists in providing a deep connection to nature that is restorative and even spiritual for some visitors. Natural sounds influenced respondents' motivation to visit Yellowstone and were an important part of the experience for more than a third of the visitors interviewed. Specifically, experiencing natural sounds during a visit was rated as "extremely" or "very" important by 85 percent of cross-country skiers, 81 percent of snowshoers, 75 percent of snowcoach tourists, but only 55 percent of snowmobilers.

Slightly less than half of respondents said the park was particularly attractive as a place free from motorized noise. Overall, snowmobilers and snowcoach riders generally felt strongly or somewhat agreed that Yellowstone is a place for natural quiet. Because they are able to travel in different locations than motorized vehicles, survey respondents participating in non-motorized winter activities, such as cross-country skiing and snowshoeing, had a higher percentage of respondents indicating they believe the park is a place free of motorized noise (even though they all had to use OSVs to access Old Faithful). Overall, Freimund et al. (2009) report that 71 percent of respondents to the soundscape survey said they found the level of natural sound they were looking for half or more of the time they desired it, but only 15 percent of visitors were able to find these experiences all of the time they were in the park. Still, very few respondents (8 percent to 13 percent) in all groups supported closing the roads at Yellowstone to all OSVs. Somewhat greater support existed for closing roads to snowmobiles while allowing snowcoach tours to continue; but fewer than half of all groups strongly or somewhat supported this measure, and only 11 percent of snowmobilers supported it.

The majority of respondents supported requiring BAT vehicles, continuing guide requirements, limiting the total number of snow machines in the park per day, and limiting group size to 11 per guide. The closing of roads to all OSVs or to snowmobiles only was opposed or strongly opposed by the majority of respondents. Plowing the roads for automobile access was also strongly opposed by approximately 71 percent of respondents.

In addition to these most recent studies, the effect of noise on the visitor experience has been examined at the park since the late 1990s. In a study before managed winter use, Davenport et al. (2000) found that most visitors “treasured” their winter experience in the park, with the peace and quiet part of that experience, with a high level of visitor satisfaction. Littlejohn (1996) also conducted a study in the “pre-managed era” and found that in response to an open-ended question about what they liked least about their visits, 134 respondents replied that trails and roads needed grooming, but only 79 respondents replied that noise from snowmobiles was what they liked least. Borrie et al. (1997) also explored the impact of noise on the quality of the winter experience at the park during the pre-managed era. In this study, visitors tended to describe the noise impact as neutral (neither important nor not important). More recent studies (Freimund et al. 2009; Saxen 2008) of visitor satisfaction during the “managed era” at the park reported similar findings, as detailed above and in the Scientific Assessment of Yellowstone National Park Winter Use.

Wildlife Viewing and the Visitor Experience

Many studies have noted the importance of wildlife viewing as part of the visitor experience in the park (Freimund et al. 2009), with bison being the most viable animals in the park. A second sub-study of the 2007/2008 survey looked at the visitor experience and bison. This study was conducted to explore snowcoach, snowmobile, and cross-country skiing winter use visitors’ opinions of the human-bison interactions witnessed during park visits and to analyze situational and visitor characteristics that might influence those opinions. Surveys were given to 411 park visitors. From these surveys, Freimund et al. (2009) found that 71 percent of winter visitors to the park believed their opportunity to view bison was “very” or “extremely” important to their visit. When comparing cross-country skiers, snowshoers, snowmobilers, and snowcoach users, 70 percent or more of all groups rated the importance of the opportunity to view bison as very important or extremely important.

The majority of respondents indicated that the bison they encountered did not seem to notice the presence of humans or OSVs or, if they did, they quickly resumed their activities. Less than 20 percent of respondents had interactions with bison where they witnessed a defensive charge or felt bison were hurried or put into flight. Specifically, when asked to describe the most significant or “intense” encounter with bison that they witnessed, 43 percent of visitors described responses no more intense than bison noticing the presence of humans and resuming their activity. Another 36 percent witnessed interactions in which bison appeared to be vigilant, to move away in an unhurried manner, or to have their desired movement blocked. The remaining 21 percent of visitors indicated seeing interactions where bison were hurried, put to flight, defensive toward humans, or appeared to fight each other as a result of human presence.

The survey found that snowmobilers were more likely to say bison were calm, as compared to cross-country skiers and snowshoers, who indicated that the bison appeared somewhat agitated and somewhat dangerous. Respondents traveling through the park via snowcoach were more likely to report that the bison appeared calm, as compared to reports from respondents using non-motorized transportation modes.

The majority of respondents still believe that bison lead a largely free, unrestricted life and remain an authentic symbol of western culture and heritage. Respondents indicated that they believe the bison appear healthy and they gave a positive endorsement in the case of appropriateness, quality of management, and acceptability of the bison.

Guiding

In addition to visitors, Freimund et al. (2009) also conducted interviews with 22 guides at the park. The study was designed to identify the perceptions snowmobile and snowcoach winter guides in Yellowstone have on the effectiveness of recent policy changes in achieving environmental protection while promoting satisfactory visitor experiences. At the time the study was conducted (2008), the daily limit on the number of snowmobiles in Yellowstone was 720, and it was the fourth winter that guides and BAT requirements had been in place. The number of snowcoaches and their requirements had remained unchanged since 2004.

Overall, guides thought that implementing policies requiring cleaner and quieter technology vehicles is beneficial to the ecology, improves the soundscape, and enhances visitor experience. The majority of guides felt that the visitor experience was enhanced because the presence of guides resulted in a more interpretive experience while also enforcing regulation and ensuring safety. The change in visitor characteristics observed by guides suggests that people come to Yellowstone to experience the natural environment as opposed to using it as a place to ride OSVs. Few felt that the guide requirement inhibited the visitors’ and local residents’ ability to enjoy the park in the way they choose.

Guides did not believe that smaller groups had an effect on wildlife, because there are numerous groups in the same area at the same time, negating the purpose limiting the size of groups. Additionally, they felt that sufficient lands exist surrounding Yellowstone accommodate unguided snowmobiling, and the park should be a place to be educated and to enjoy nature. The majority of guides felt that that 720 snowmobile per day limit was working well. Some snowmobile guides were concerned about road conditions and the 1/3 mile rule which states snowmobiles must stay a third of a mile behind the guide, and some snowcoach guides felt that snowmobiles should be removed from Yellowstone all together.

Conflict and the Visitor Experience

Conflicts caused by OSV use in Yellowstone could be due to several impacts: engine or track noise interrupting inspirational visitor experiences, vehicle congestion at popular locations and rest areas, incompatible styles of use, perceived differences between user groups in social status, values, or identity, and conflicts arising from perceived differences in support or opposition to NPS management actions. In some cases, this conflict could be “symmetrical” (i.e., recognized and experienced by all groups that are involved in the conflict). In other cases, the conflict may be “asymmetrical” in that it is perceived only by the impacted group, but not by the group or groups causing the impact (Adelman et al. 1982). A well-established definition of behavioral conflict in the recreation social science literature is “goal interference attributed to the behavior of another” (Ruddell and Gramann 1994). Two types of visitor conflicts, noise-based and those that identify potential conflicts between user groups, have been studied at Yellowstone.

As suggested by previous noise research, the probability of conflicts arising from visitors’ annoyance with motorized sounds in Yellowstone may be highest in areas where the sounds are perceived as incongruent with the setting, such as in backcountry locations accessible only by ski or snowshoe. Expectations for experiencing tranquility, solitude, and low or zero human-produced sounds are common to backcountry users, forming an integral part of their anticipated experience and one of their primary reasons for visiting such locations (Manning et al. 2004). Based on noise modeling conducted for past winter use plans, mechanized noise may be audible to humans in areas up to 10 miles from travel corridors (Hastings et al. 2006). This means that most non-motorized visitors to the park could encounter OSV sounds during their visit. Cross-country skiers or snowshoers, who may travel by OSV to areas inaccessible to wheeled vehicles and then proceed on foot, would be most likely to notice such noise and experience conflict with OSV use (NPS 2008a), especially if they are seeking natural sounds and quiet once they reach their desired destination for skiing or snowshoeing. Active visitors might travel beyond the range of mechanized noise, but most users stay within two miles of travel corridors (NPS 2008a), putting them well within the audible range of OSVs.

According to Jacob and Schreyer (1980), four major factors contribute to conflict between individuals or groups in outdoor recreation: (1) differences in the level of significance attached to using a specific recreation resource; (2) differences in personal meanings assigned to an activity; (3) differences in expectations of the natural environment; and (4) differences in lifestyles. Information on whether winter user groups in Yellowstone believe they are in conflict with other identified groups in the park has not been systematically collected, however, information from other studies such as Freimund et al. (2009) can be used to inform this issue. During this study, similarities between OSV and non-OSV users were found, for example, all user groups believed natural sounds to be important to their experience and there was overall support for the use of snowmobiles and snowcoaches in the park. Similarities continued among user groups for the interpretation of bison-human interactions at the park (Freimund et al. 2009), indicating conflict did not exist between these groups. Other studies look at visitors based on their primary motivation for visiting the park in winter rather than their mode of transportation. Borrie et al. (1999) found the primary motivations at Yellowstone included “personal growth,” “quiet activity,” “nature study,” and “accidental.” The “accidental” category addressed those visitors who did not rank any single motivation highly. The study found differences between these groups in terms of the park entrance they preferred, acceptability of encounters with other OSV users, and tolerance of difference scenarios of OSV use. However, snowmobilers made up a large segment of each group, suggesting a simple “mode of transport” segmentation may not reveal the most meaningful differences between visitors and their experiences at the park.

OTHER SURVEYS

West Yellowstone Snowcoach Study, Visitor Profile of Snowcoach Passengers in West Yellowstone, Montana (Nickerson et al. 2006)

This study by the Institute of Tourism and Recreation Research at the University of Montana profiled West Yellowstone snowcoach passengers in Yellowstone during a two-year study conducted from January to March in 2005 and 2006. Snowcoach passengers from five West Yellowstone companies were given a 2-page questionnaire to complete during the last five minutes of their trip back to West Yellowstone. The survey period was conducted over a two-year period, resulting in 266 useable questionnaires.

Overall, travel groups were relatively large, with a mean group size of 4.4. Non-resident groups stayed an average of 5.67 nights away from home, while Montana groups stayed 3.23 nights. Those who stayed at least one night in West Yellowstone averaged 4.14 nights in the area. Non-residents' reasons for being in the area were to visit Yellowstone in the winter (50 percent) and to ski at Big Sky (41 percent) compared to Montanans, 69 percent of whom said they came to visit the park and only 8 percent of whom indicated they came to ski at Big Sky. Of those who spent a night in West Yellowstone, 24 percent said snowmobiling was a reason for visiting the area. Primary reasons visitors wanted to visit the park in the winter included viewing wildlife in the winter, seeing winter wonderland scenery, and seeing geothermal activity in the winter. Respondents reported the snowcoach tour provided them with an appreciation of nature, an educational experience, and a sense of wonderment.

Study of Preferences and Values on the Bridger-Teton National Forest Study (Clement and Chang 2009)

Bridger-Teton National Forest conducted a survey of the preferences and values in relation to the forest. The forest is adjacent to the park and allows for a variety of winter uses. The Study of Preferences and Values on the Bridger-Teton National Forest report was designed to

- Conduct a random sample survey of local residents to explore their values and preferences in relation to the Bridger-Teton National Forest
- Better understand respondents' values associated with geographic aspects of the forest
- Conduct a Q-study, used as a research method to study people's "subjectivity" or their viewpoint, to explore the main values discourses that prevail regarding the Bridger-Teton National Forest with members of local communities who participate in the survey.

Participants in the survey included members of the general public who filled out the survey online, a group of cooperating counties, and soil conservation districts. Mailings were sent to 1,500 random households in the five counties surrounding the forest, with a 32 percent response rate.

Recreational activities in the Bridger-Teton National Forest enjoyed by the greatest percentage of participants include driving, wildlife viewing, fishing, hunting, and nature enjoyment. Participants were allowed to identify all recreational activities in which they participated in within the forest. Approximately 87 percent of respondents prefer to experience the forest through non-motorized recreational activities. Forty-four percent enjoy all-terrain vehicle use, 33 percent like the four-wheel driving experience, and 56 percent like OSVs.

Approximately 42 percent of respondents indicated they felt that the current level of motorized activity was appropriate, while approximately 37 percent felt there was a need to create more motorized road access either by opening roads that were closed or through the construction of new roads. Approximately 15 percent of respondents indicated that they believe the level of motorized road access should be reduced or eliminated. Additionally, 65 percent of respondents indicated that the current level of outfitter guide use (i.e., fishing, hunting, hiking, and snowmobiling) should be maintained. Approximately 48 percent of respondents indicated that no other areas should be designated as wilderness area.

Shoshone National Forest Study (An Economic Profile of the Shoshone National Forest, Taylor, Foulke, and Coupal 2008)

Shoshone National Forest (Taylor, Foulke, and Coupal 2008) conducted a survey of public values and preferences for the counties bordering the forest in 2006. The forest is adjacent to the park and offers a variety of visitor activities. The survey inquired about the following:

- Familiarity with the Shoshone National Forest
- Forest use preferences
- Attitudes to important topics on the Shoshone National Forest
- What values respondents attach to the Shoshone National Forest, the intensity with which those values are held, and, using a map, places on the Shoshone National Forest that represent those values
- Demographic information.

A four-phase mailing was sent to 1,300 random households in Fremont, Hot Springs, Teton and Park counties. The surveys sent were split evenly between the counties according to zip codes. The mailing resulted in a response rate of 3 percent; of those responses, 69 percent included mapping data regarding valued places in the Shoshone National Forest. The survey results provided

- The forest values that residents around the Shoshone National Forest have in relation to that forest;
- The preferences and attitudes associated with uses and issues in relation to the Shoshone National Forest; and
- The places in the Shoshone National Forest associated with these resident preferences, attitudes, and values.

Responses were weighted according to the relative county population numbers. First, county populations were divided by the number of respondents from that country and that number was used to weight results. Recreational activities in the Shoshone National Forest enjoyed by the greatest percentage of participants include driving, nature enjoyment, wildlife viewing, fishing, hiking/backpacking, and hunting. Participants were allowed to identify all recreational activities in which they participated in the forest. Approximately 37 percent of respondents prefer to experience the forest through non-motorized recreational activities. Forty percent enjoy all-terrain vehicle use, 37 percent like the four-wheel driving experience, and 28 percent like OSVs.

Approximately 39 percent of respondents believed the level of existing road access was appropriate (recognizing that roads may be relocated or rehabilitated to protect resources). Nineteen percent believed there was a need for more motorized road access and 8 percent commented that the level of motorized open roads should be reduced. Thirty-four percent of respondents replied as being “very satisfied” with winter recreation experiences in the forest. Additionally, 72 percent of respondents indicated that the current level of outfitter guide use (i.e., fishing, hunting, and snowmobiling) should be maintained.

PREVIOUS STUDIES

Other studies have been conducted related to visitor use and experience in the winter at Yellowstone. However, most of these occurred prior to the managed use era and have limited applicability for impact analysis. These studies are further described in the Scientific Assessment of Yellowstone National Park Winter Use.

HEALTH AND SAFETY

Three primary health and safety issues regarding winter visitor use were identified and are addressed in this plan: the effect of motorized vehicular emissions and noise on employees and visitors, avalanche hazards, and safety problems where different modes of winter transport are used in the same place or in close proximity.

In the last 15 years, the NPS (both nationally and in Yellowstone) has become increasingly concerned about providing safe work environments for all employees. In part, the agency's concern was heightened after the Occupational Safety and Health Administration (OSHA) found more than 600 safety violations in Yellowstone in 1997. Yellowstone's injury rate was two to three times as high as that of industries known to be risky, such as oil and gas drilling. In response to this problem, Yellowstone partnered with OSHA to improve employee safety. With OSHA's assistance, the NPS has improved workplace safety, an improvement reflected in an overall drop in employee injuries. The NPS remains committed, as does the Department of the Interior, to providing safe work places, with a goal of no lost-time accidents for its employees.

PERSONNEL AND OCCUPATIONAL EXPOSURE TO CONTAMINANTS

Air Quality

Although managed use of OSVs has reduced health and safety issues related to OSV accidents over the years, health and safety issues related to the noise and air emissions from OSV use remain. Historically (pre-four-stroke engine technology), snowmobiles in national parks have been a major source of air pollution, including CO, which is emitted as a byproduct of incomplete combustion of carbonaceous fuels (e.g., gasoline, diesel) (Flachsbart 1998). After inhalation into the body, a CO molecule binds with hemoglobin (Hb) in the blood to form carboxyhemoglobin (COHb) and can cause headaches, nausea, and irritation when exposure is over the National Institute for Occupational Safety and Health (NIOSH) peak level (Flachsbart 1998; NPS 2005c). In a summer 2005 study at Yellowstone, peak CO levels were associated with older, un-tuned vehicles and/or motorcycles that were idling for several minutes at the entrance station window (NPS 2005c). Formaldehyde, another contaminant associated with snowmobiles and snowcoaches, is classified as a proven carcinogen (group 1) by the International Agency for Research on Cancer. NIOSH has a recommended exposure limit (REL) of 0.016 ppm (8-hour time-weighted average (TWA)) but also recommends that exposure to carcinogens be as low as technologically feasible (USDOI 2009).

Numerous occupational air quality studies have been conducted at Yellowstone, focusing on the west entrance, the busiest winter access point to the park for OSV access. The major objective of these studies was to evaluate NPS employee exposure to PM, air contaminants, and noise emitted by snowmobiles. The studies were performed during anticipated peak levels of snowmobile use in an attempt to obtain worst-case measurements during winter use work activities. Most sampling was completed during the busiest winter weekends in the park, for example the Martin Luther King three-day weekend and the President's Day three-day weekend.

Some of these studies, conducted when unlimited two-stroke machines were allowed, indicated concerns regarding employee safety and health, particularly on days with atmospheric inversions. Because snowmobiles entering the west entrance are now BAT with reduced numbers, exposure levels to a variety of chemicals have dropped appreciably, as shown in tables 26 and 27. In 1997, personnel exposure measurements for CO were conducted at the west entrance (Radtke 1997). The 8-hour TWA for CO was between 2 and 4 parts per million (ppm). The OSHA permissible exposure limit (PEL) is 50 ppm and the threshold limit value (TLV) is 25 ppm. The more restrictive 8-hour NAAQS is 9 ppm. The study concluded that CO did not appear to be an important hazard for employees at the west entrance.

TABLE 26: AVERAGE PERSONNEL EXPOSURE TO SOUND LEVELS

Sample Description	Kiosk A	Kiosk B	Kiosk C	Rider Average
Radtke 1997 – no snowmobile count taken, mostly two-stroke sleds through west entrance	70.9 dBA	Not sampled in 1997	Not sampled in 1997	Not sampled in 1997
OSHA 2000 – 976 two-stroke sleds through west entrance	72.1 dBA	75.2 dBA	88.3 dBA	93.1 dBA riding two stroke snowmobile
IHI Environmental 2004 – average of 220 sleds, primarily four-strokes through west entrance	62.9 dBA	68.8 dBA	Not used during 2004	82.4 dBA riding four stroke snowmobile
Spear and Stephenson 2005 – average of 180 sleds, primarily four-strokes through west entrance	60.6 dBA	Not sampled in 2005	Not used during 2005	85.5 dBA riding four stroke snowmobile
Spear, Hart, and Stephenson 2006 – average of 216 sleds, primarily four-strokes through west entrance	71.3 dBA	71.0 dBA	Not used during 2006	Not used during 2006

Dosimeter settings set to evaluate compliance with OSHA Hearing Conservation Amendment (threshold = 80 dB; exchange rate = 5 dB Criterion Level = 90 dB; Time Constant = slow). Results are A-weighted.

TABLE 27: MAXIMUM EXPOSURE TO SOUND LEVELS

Sample Description	Kiosk A	Kiosk B	Snowmobile Riders
IHI Environmental 2004 – average of 220 sleds, primarily four-strokes through west entrance	114.0 dBA 108.3 dBA 106.6 dBA 89.6 dBA 106.8 dBA 97.8 dBA	112.5 dBA 112.8 dBA 108.3 dBA 103.8 dBA 108.3 dBA	110.3 dBA 111.6 dBA
Spear, Hart, and Stephenson 2006 – average of 216 sleds, primarily 4 strokes through west entrance (P) Denotes personnel sampling; (A) Denotes area sampling	109.0 dBA (P) 96.0 dBA (A) 105.0 dBA (A) 114.0 dBA (P) 112.0 dBA (A) 109.0 dBA (A) 110.0 dBA (P) 104.0 dBA (A) 111.0 dBA (A)	113.0 dBA (P) 94.0 dBA (A) 110.0 dBA (A) 108.0 dBA (P) 96.0 dBA (A) 107.0 dBA (A)	

In 2000, OSHA conducted personnel and area sampling for benzene, gasoline, formaldehyde, and CO. They concluded that exposures were below PELs and TLVs, except for exposure to benzene, formaldehyde, and CO which exceeded the NIOSH REL for one employee at the west entrance express lane.

A 2001 study included personnel exposure monitoring for respirable PM, CO, formaldehyde, acetaldehyde, and benzene. The study recorded an average benzene level of 0.035 ppm and an average overexposure of 0.029 ppm to benzene (Kado et al. 2001). Measured levels of benzene were below OSHA PEL and NIOSH REL levels. For formaldehyde and acetaldehyde, concentrations of 0.072 ppm and 0.024 (respectively) for a 170-minute sampling period were measured, which is also below OSHA PEL and NIOSH REL levels. Average particulate levels were measured at 0.1 mg/m^3, also below OSHA PEL and NIOSH REL levels. In 2004, after the managed OSV program was in place, occupational exposures to aldehydes, VOCs, respirable PM, CO, and noise were evaluated. This study concluded that concentrations of all airborne contaminants were well below current standards and RELs (IHI Environmental 2004).

A 2005 study evaluated exposures at the west entrance for aldehydes, VOCs, total hydrocarbons, elemental and organic carbon, oxides of nitrogen, CO, and respirable PM. All employee exposures to the above air contaminants and noise were below OSHA PELs and other RELs. During this study, a ventilation survey was performed in kiosks A and B at the west entrance. The survey showed that both kiosks were under strong positive pressure. At the time of the survey both kiosks were achieving slightly over one air exchange per minute with the window open 30 inches (Spear and Stephenson 2005).

Spear, Hart, and Stephenson conducted a similar study in 2006 (Spear et al. 2006). Although there were some minor variances, the 2006 report confirmed employee exposures below all current standards set by regulatory agencies except for 2 of 13 benzene samples (mean concentration of 0.0032 ppm). The minimal risk level for chronic-duration inhalation exposure (365 days/year) is 0.003 ppm for benzene; the intermediate-duration inhalation exposure is 0.006 ppm and the PEL is 1.0 ppm. Although the two benzene samples averaged slightly higher than the minimal risk level, employees would have to be exposed to these levels every day of the year (which they are not) for a concern to be present. Rather, the two samples that were higher than 0.003 ppm were short-term samples collected to minimize dilution effects and thereby portray potential worst-case exposures.

In addition, one of the tradeoffs in converting to BAT is that four-stroke machines produce more benzene (and some other hazardous air pollutants) than the two-stroke engines used historically (Air Resource Specialists, Inc. 2006). Although Spear, Hart and Stephenson found no correlation between VOC concentrations and the number of vehicles entering during their 2005 and 2006 studies, there were fewer than 250 snowmobile entries on the days with higher benzene exposures. However, recent benzene exposure levels are an order of magnitude lower than they were when two-stroke machines were allowed in the park—a decrease possibly attributable to fewer numbers of snowmobiles. Overall, emissions are well below federal safety levels; monitoring and adaptive management activities will continue.

In 2009, air monitoring for snowmobile and snowcoach exhaust was conducted at the West Yellowstone entrance station over President’s Day weekend. Monitoring showed CO slightly elevated from 2008 readings, but still below occupational exposure limits. On one sample day, snowcoaches and snowmobiles were separated. The exposure results showed CO was slightly higher over the sampling period for snowmobiles; however, the peak reading for CO was higher for the snowcoaches (the sample period included 19 snowcoaches and 221 snowmobiles). The elevated levels of CO were likely due to the absence of ventilation in booths (USDOI 2009). Otherwise, exposure levels to other pollutants measured were similar. An exposure assessment of the entrance station employees was also conducted in 2008. Results of VOC testing showed most levels were below detection limits, with the relative highest exposure being to benzene, which was approximately 2 percent of the OSHA PEL. Three of the nine aldehyde samples had detectable levels of formaldehyde. These measurements were only approximately 2 percent to 3 percent of the OSHA PEL. Maintaining adequate positive pressure ventilation and minimizing time outside of the kiosk when snowmobiles and snowcoaches are idling will keep these exposures low (USDOI 2008).

Noise Exposure

Noise associated with OSV use can also have adverse effects on both park staff and visitors. Noise has a range of effects on performance, and the effects are dependent on the type of noise and the demands made by the task. Exposure to noise has other effects, such as the potential to contribute to cardiovascular disease. Noise can disrupt sleep and the functions sleep provides in modulating cardiovascular function. Studies have also shown that noise exposure can result in changes in heart rate, blood pressure, vasoconstriction, stress hormones, and electrocardiogram (ECG) readings. Animal studies of long-term exposure to high noise levels shows permanent changes in heart muscle. Epidemiological studies of noise exposure have found an increased risk for hypertension and myocardial infarction in environments dominated by road traffic or aircraft noise (Babisch 2011; Jarup et al. 2008) In contrast to the airport and roadway noise studies, railroad noise has not been shown to increase cardiovascular disease risk (Bluhm and Eriksson 2011). As a result of the road and airport studies, the World Health Organization (WHO) Night Noise Guidelines for Europe establish an interim target nighttime noise level (as measured outside) of 55 dBA and a night noise guideline of 40 dBA (WHO 2009). The interim target noise level is intended for situations where the 40 dBA night noise guideline is not practicable. The evidence of noise related cardiovascular effects is limited because of the relatively small number of studies, inconsistencies between studies, and difficulties in accurately measuring indoor noise exposure (Stansfeld and Crombie 2011). Further studies are needed to fully understand the underlying casual relationship observed in the epidemiological data and to establish a dose-response relationship to allow the prediction of cardiovascular health impacts from noise exposure (Ndrepepa and Twardella 2011). No studies specific to snowmobile or snowcoach noise and health impacts have been conducted.

Noise exposure was measured for both snowmobile riders and employees working at the west entrance in studies conducted between the years 1997 and 2005. The exposure measured included noise from all sources, including snowmobiles and other equipment. One way to measure employee exposure to noise, as below, is to compute the eight-hour TWA (time weighted average, or the average exposure to noise to which workers may be exposed without adverse effect over a period such as in an 8-hour day or 40-hour week) of their exposure to noise, with hearing protection required when the TWA is above 85 dBA.

In 1997, personnel exposure measurements for noise were conducted at the west entrance. The 8-hour TWA for the noise samples ranged from 70.9 dBA to 82.0 dBA. These levels are below the action level of 85 dBA and the OSHA PEL of 90 dBA. The study concluded that noise did not appear to be a major hazard for employees at the west entrance (Radtke 1997). A 2000 OSHA study conducted personnel and area sampling for noise. The study concluded that exposures were below PELs and TLVs, but the express lane employee was overexposed to the American Conference of Industrial Hygienists (ACGIH) action level and NIOSH standard for noise of 85 dBA. The only noise overexposures to west entrance employees occurred when two-stroke machines were allowed.

In 2004, after BAT limits and commercial guiding were in place, occupational exposure to noise was evaluated with the conclusion that exposure did not exceed recommended limits. In 2005, another study at the west entrance concluded that noise exposures were below OSHA permissible limits and other recommended maximum exposure levels (Spear and Stephenson 2005).

A recent study found that employee noise exposures at the west entrance averaged 60.6 dBA for the winter 2004/2005 and 65.2 for the following winter, or 3.5 percent and 5.5 percent of the allowable noise exposure, respectively. Peak 8-hour TWAs for those two winters were 75 and 80 dBA, or 12.5 percent and 26.0 percent of the allowable exposure, respectively (Jensen and Meyer 2006). Clearly, although employees are exposed to some noise, those exposures are well within safeguards.

Since the change to four-stroke technology, employee exposure at the west entrance has been below 85 dBA. Snowmobile rider exposure levels have also decreased with the use of four-stroke technology, but rider exposure levels remain over the OSHA action level when operated for more than four hours. As noted earlier, 98 percent of loud OSV sounds are from coaches, which tend to be louder at closer range, than snowmobiles, which tend to be louder at longer ranges. Even new coaches can have high interior and exterior noise levels. A 2010 Glaval coach was tested in March 2010. At cruising speed (21 mph), it measured 73 dBA on the outside and 83 to 84 dBA on the inside. At top speed, 28 mph, the Glaval measured 77 dBA on the outside and 86 dBA on the inside (Burson pers. comm. 2010b). Noise exposure while riding on or in snow machines can be controlled with standard ear plugs, which are provided by snowmobile and snowcoach operators to users entering the park. All commercially available NIOSH-rated foam plugs provide enough attenuation to protect employee hearing. An estimated exposure of 77 dBA for 8 hours when wearing earplugs falls within acceptable exposure limits set forth by OSHA, NIOSH, and ACGIH.15.

The OSHA hearing conservation standard (29 CFR 1910.95) states that employee exposures should not exceed the peak, or maximum level of sound, of 115 dBA for more than 15 minutes. OSHA also recommends that employees never be exposed to impulsive or impact noise that generates sound levels greater than 140 dBA. No noise sampling in the park has indicated a maximum exposure above 115 dBA.

Additional noise studies were conducted during the winter 2011/2012 to assess the noise levels experienced by OSV users in the park. OSV noise levels were measured to assess their impact on visitor experience, including communication between the guide and clients, as well as for health and safety considerations of those traveling by OSV in the park. Noise exposure was measured in the interior of snowcoaches and near the ear of operators during snowmobile travel.

For snowcoaches, interior noise levels were measured in five different vehicles operating at typical cruising speeds of approximately 20 to 25 mph on snow-covered groomed roads in the interior of Yellowstone National Park (table 28). These five vehicles ranged from a repowered and retrofitted Bombardier with skis and long tracks to a 32-passenger bus. These vehicles were selected because they represent a cross-section of relatively late model snowcoaches currently in operation in the park. Noise levels inside snowcoach cabins were measured using a calibrated Larson Davis Type 1 sound level meter and microphone. Measurements were taken in the front seat and the back seat of each snowcoach at approximate ear level as the snowcoach traveled at typical cruising speed on a snow-covered road. Average dBA was calculated as the logarithmic mean of the front and back seat measurements. Measurements were taken over a three-day period during the week of March 5, 2012.

TABLE 28: AVERAGE INTERIOR SNOWCOACH NOISE MEASURED IN DBA AT INDICATED CRUISING SPEEDS

Snowcoach	Average dBA	Cruising Speed (mph)
2011 Ford F-F550 32 Passenger, Grip Tracks	70	22
2011 Ford Vanterra, Mattracks	74	24
2008 Chevy Express Van, Mattracks	77	24
2011 Ford F-450 Glaval, Mattracks	81	27
1956 Bombardier B-12, V8 Motor, Skis & Tracks	84	26

On February 20, 2006, sound levels were measured on a 2006 Arctic Cat T660 4-stroke machine on packed (groomed snow) at the West Entrance of Yellowstone. On February 27, 2006, additional sound level measurements were conducted on a 2004 Arctic Cat T660 on unpacked snow at Mammoth, Montana. The average overall sound pressure level was measured near the operator's ear while the machine was idling and at up to six traveling speeds. These measurements were performed with a Quest Sound Pro DXL Type 1 real-time analyzer and a Quest Model 2700 type 2 sound level meter fitted with a Quest Model OB-50 octave filter.[3]

In relation to visitor use, noise can obscure the human voice by *masking*[4] the sound of the voice, covering the voice and making it difficult to hear. When noise masks human speech, *speech interference* is occurring.[5] Speech interference causes a listener to miss some proportion of what is being said in conversation. In response to speech interference, speakers raise the volume of their voices.

People with average voice strengths discussing unfamiliar material face-to-face raise their voices when background noise reaches 50 dBA.[6] In telephone conversations with the phone against the ear, speech interference begins at background noise levels of 60 dBA.

Snowcoach noise measurements appear in table 28.[7] Results for snowmobiles appear in table 29.

TABLE 29: SOUND LEVEL MEASUREMENTS IN DBA MEASURED AT OPERATOR'S EAR

Speed (mph)	dBA 2006 Arctic Cat T660 packed snow	dBA 2004 Arctic Cat T660 unpacked snow
0 (Idle)	69	67
15	87	84
20		85
25	91	89
30		97
35	92	92
40		91
45	97	92

Findings indicate that speech interference for snowcoach passengers is likely while the vehicle is at typical cruising speed. Without amplification, operators and passengers may be able to successfully communicate only when the OSV is traveling slower than typical cruising speed. Interior snowcoach noise in tested snowcoaches would interfere with spoken communication inside the snowcoach. Average snowcoach interior noise of the quietest snowcoach was 70 dBA, similar to running a vacuum cleaner. Two of five were louder than average city traffic. The noise inside the 2008 Chevy Express Van snowcoach (77 dBA average) was louder than the comparison sounds for a typical conversation, the inside a Ford F-150 pickup truck traveling at 55 mph (63 dBA), and a vacuum cleaner (70 dBA); but

[3] Rocky Mountains Cooperative Ecosystem Studies Unit,RM-CESU Cooperative Agreement Number:J1580050167, Yellowstone Winter Use Personal Exposure Monitoring, June 1, 2006, Terry M. Spear and Julie Hart, Montana Tech of The University of Montana, Dale J. Stephenson, Boise State University http://www.sengpielaudio.com/TableOfSoundPressureLevels.htm.

[4] http://www.sfu.ca/sonic-studio/handbook/Mask.html.

[5] http://www.sfu.ca/sonic-studio/handbook/Speech_Interference_Level.html.

[6] Figure 1 chart from http://www.sfu.ca/sonic-studio/handbook/Speech_Interference_Level.html.

[7] Average dBA combines measurements taken in the front and rear of each vehicle.

quieter than average city traffic (80 dBA). Figure 21 graphically presents the loudness of one snowcoach and several comparison sources. The bar chart in figure 21 shows dBA measurements for reference sounds (Ford truck at 55 mph) and measured interior noise of a typical snowcoach, the 2008 Chevy Express Van with Mattracks.

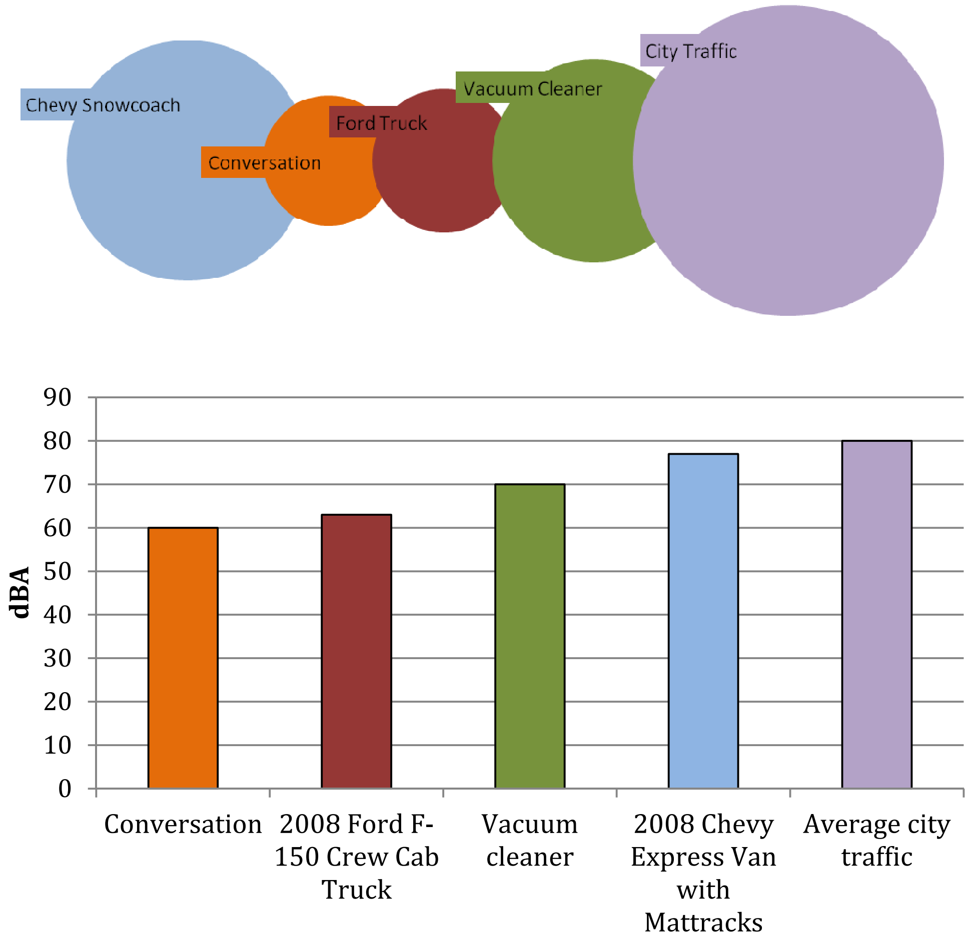


FIGURE 21: COMPARISON OF SNOWCOACH NOISE COMPARED TO OTHER SOURCES

OSV noise of all tested OSVs would interfere with spoken communication (table 28). In the snowcoach with the quietest measured sound level (70 dBA), passengers and guide would have to raise their voices or voices would need to be amplified in order to be heard. Communication with raised voices would remain difficult between guide and passengers as passengers would not be able to see the guide’s face, limiting the possibility of reading lips to assist communication. Interior noise may reach levels were communication between snowcoach passengers is impossible while the vehicle is at cruising speeds. Many current snowcoaches have amplification systems from guide to passengers, but not from passengers to the guide or among passengers. Conditions for spoken communication in the louder snowcoaches would be worse. These elevated sound levels may contribute to increased fatigue and reduced visitor comfort.

Because of the higher operator noise exposure levels for snowmobile operators (table 29), verbal communication between two riders on one snowmobile or between two snowmobiles would be more difficult than within a snowcoach. Snowmobile operators and passengers wear helmets, further reducing hearing ability.

Speech interference occurs with all measured OSVs. In addition to raising voices, approaches to improving communication might include amplification equipment, noise mitigation efforts including sound dampening materials, and quieter OSV equipment. In their absence, communication at cruising speeds on all types of OSVs is difficult.

Further information on the impact of noise and its impacts to motor abilities is provided in the Scientific Assessment of Yellowstone National Park Winter Use. Average and maximum exposure levels at the west entrance are summarized in tables 26 and 27.

AVALANCHE HAZARDS

NPS staff conducts avalanche control operations in the park as needed. Routine forecasting and control occurs only on the east entrance road to maintain Sylvan Pass for OSV travel; additional forecasting and control work may occur as a component of the spring road opening process, such as at Dunraven Pass, and in emergencies such as search and rescue operations. Although spring road opening operations and park emergencies may require avalanche control, those operations are outside the scope of this plan/SEIS. This discussion focuses on operations at Sylvan Pass, but also discusses parkwide operations and the Talus Slope area on the south entrance road.

Avalanche control at Sylvan Pass has long represented a safety concern to the NPS. Sylvan Pass is an approximately one-mile-long portion of the east entrance road that splits the Absaroka mountain range near the eastern edge of the park. The pass connects the park's east entrance with Lake Village and goes between Top Peak on the south and Hoyt and Avalanche peaks to the north. Sylvan Pass is situated at an elevation of 8,530 feet and receives a great deal of snow in the fall, winter, and spring. It is extremely windy and its nearly 45-feet slopes are prone to avalanches (Comey 2007). There are approximately 20 avalanche paths that cross the road at Sylvan Pass. They average over 600 feet of vertical drop, and the east entrance road crosses the middle of several of the paths, putting travelers at risk of being hit by an avalanche and swept down the slope.

Since 1973, avalanche hazard mitigation work has been conducted on Sylvan Pass to accommodate snowmobile and snowcoach traffic (Yochim pers. comm. 2005). Historically, Sylvan Pass has been closed multiple times during a season for several hours to a full day during the winter to allow avalanche management to occur. That is, the pass has almost never been open for the entire season. Most reasonable avalanche mitigation techniques would result in the pass being closed for at least some days in the winter to conduct avalanche mitigation. Past winter planning documents concluded the health and safety risks of operating an avalanche control program in Yellowstone at Sylvan Pass are considerable. These risks have become better known in recent years, with at least two agencies (OSHA 2001; State of Montana, Department of Military Affairs 2004) examining and explaining some of the risks the NPS incurs in its avalanche control program. Use levels have always been relatively low at Yellowstone's east entrance. Even during the highest winter use years in the 1990s, total use for the season rarely exceeded 5,000 people, less than 5 percent of Yellowstone's total winter visitation.

These concerns led the NPS, in its 2007 winter planning decision, to close Sylvan Pass. However, in that decision, the NPS agreed to work with the City of Cody; Park County, Wyoming; and the state of Wyoming to determine the future of OSV travel over Sylvan Pass. These three entities and the NPS formed the Sylvan Pass Study Group and met a number of times in 2008. The meetings resulted in the Sylvan Pass Agreement in June 2008.

The Sylvan Pass Study Group recommended to the Intermountain Regional Director of the NPS that Sylvan Pass be kept open in future winter use seasons to motorized and non-motorized oversnow travel between December 22 and March 1. The group recommended continued use of a combination of avalanche mitigation techniques, including forecasting and helicopter and howitzer dispensed explosives.

This recommendation to operate within a defined core season will reduce risk, improve safety, and maximize visitor access. The Sylvan Pass Study Group reached agreement based on the following guiding principles:

- That the safety of visitors, guides and NPS employees is the first priority in any avalanche mitigation operation on Sylvan Pass.
- That snowmobile and snowcoach motorized oversnow winter use access should be as regular and predictable as possible given weather constraints.
- That regular communications between the park, the City of Cody, Park County, the state of Wyoming and the Cody community is a key ingredient of any future winter operations on Sylvan Pass.

The City of Cody, Park County, and the state of Wyoming agreed, in good faith, to work cooperatively to explore funding of safety and access improvements. The members of the Sylvan Pass Study group agreed to establish consistent ongoing communications regarding Sylvan Pass winter use operations. The NPS agreed to make funding for safety and access improvements on Sylvan Pass a priority.

The agreement guided management of Sylvan Pass during the 2009 to 2012 interim regulations. Under the agreement, the park may use a combination of techniques that have been used in the past (howitzer and helicopter), as well as techniques that may be available in the future. Area staff may use whichever tool is the safest and most appropriate for a given situation, with the full understanding that safety of employees and visitors comes first. Park staff make the operational determination when safety criteria have been met and operations can be conducted with acceptable levels of risk. The NPS will not take unacceptable risks (figure 22). When safety criteria have been met, the pass will be open; when they have not been met, the pass will remain closed. Extended closure of the pass may occur.

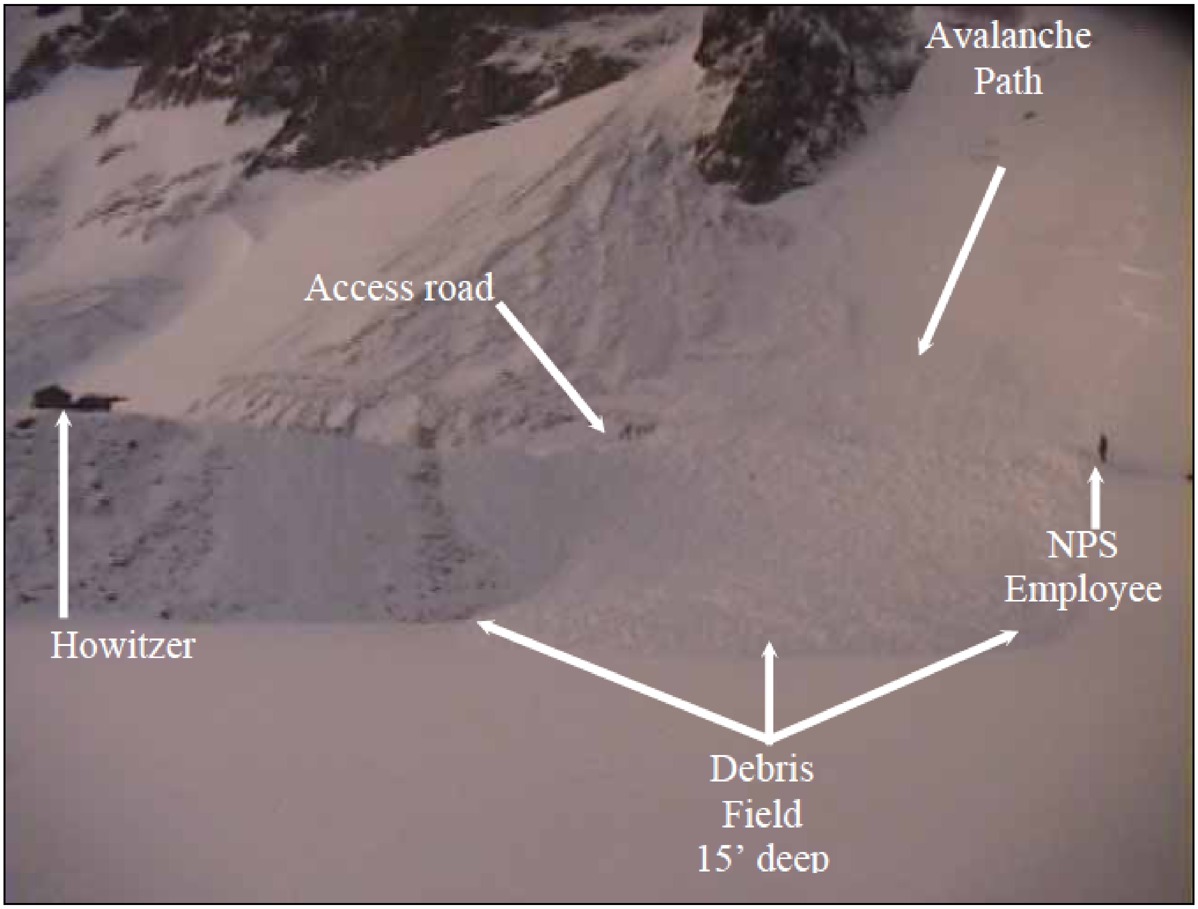


FIGURE 22: AVALANCHE THAT CROSSED THE ACCESS ROAD TO THE HOWITZER PLATFORM

Sylvan Pass Avalanche Forecasting and Hazard Mitigation Program

For avalanche mitigation activities at the park, an operational profile exists that defines standards for communication, safe travel, and all operations at Sylvan Pass. The pass (and east entrance) is closed from 9:00 p.m. until 8:00 a.m. or until the determination is made about whether the pass is open or closed. This closure applies to park staff (except those conducting avalanche mitigation activities) as well as visitors. Avalanche mitigation measures include the use of a howitzer (cannon) to deliver explosives that trigger snow release or the use of a helicopter to deliver the explosives.

Prior to and since the Sylvan Pass Agreement, the NPS has adopted several mitigation measures to reduce the dangers to its employees and visitors:

- Installing a radio repeater on Top Notch Peak to improve communications in the pass area
- Providing additional, extensive, ongoing avalanche and howitzer training so that skilled staff perform control missions
- Conducting additional avalanche forecasting on site
- Constructing a berm above the howitzer platform to catch rock and cornice fall from the cliff behind it

- Realigning the east entrance road to reduce avalanche danger from some of the paths
- Modifying access to the gun mount, where the howitzer is located, to be farther from avalanche paths
- Acquiring a second howitzer (with the help of Wyoming)
- Having an enclosed vehicle available on site to support avalanche operations (again through assistance from Wyoming)
- Adding staff
- Adding additional weather equipment to improve forecasting (NPS 2010n).

The following is a discussion of the avalanche mitigation procedures summarized from the recent Operational Risk Management Assessment (ORMA) report (NPS 2010n).

Communication and Documentation

Road conditions are reported daily to the Yellowstone Communications Center. Changes in road status are sent via email and forecasters brief the Sylvan Pass staff on potential changes in weather. Following daily avalanche briefings, the weather forecast is updated. Discussions are posted for review by all staff working at Sylvan Pass. Forecasters complete documentation of avalanche hazard mitigation missions, natural avalanche occurrences, and snow observations. Regional Avalanche Forecast Centers provide the park with general condition reports and advisories. Forecasters for Sylvan Pass contribute site specific observations to regional centers.

Weather Forecasting

The Sylvan Pass Avalanche Forecasting and Hazard Mitigation Program begins and ends with weather forecasting. Each day a weather forecaster and an assistant check the weather for wind speeds, 24-hour snowfall, and air temperature. They also check for snowpack instability, visibility for driving, road conditions, weather factors, and any changes from the last observation. Weather factors include recent strong winds, recent heavy snow or rain, water content exceeding one inch from last observation, sudden warming (+12 to 15°F (-11.1 to -9.4°C) over 12 hours), recent wind loaded slopes, and localized areas of convexity, especially with thin snowpack and rocks underneath. The team practices open communication, teamwork, and safe travel practices. Forecasters use remote automated weather stations and SNOTEL (SNOwpack TELemetry) sites that provide hourly updated information to track weather influences on avalanche formation. The most useful stations are placed near a potential avalanche location.

Loaded slopes can occur when rain or snow has fallen in the past 48 hours or when one inch of snow per hour for the past 6 hours has fallen on or near the pass. Both terrain features and high winds can contribute to a higher chance of an avalanche. If the team decides to close the pass, the road will remain closed until the avalanche hazard has decreased or been mitigated, signs indicate increased stability, and visibility improves. After avalanche mitigation is complete, a road groomer smoothes the road surface to allow for OSV travel. At this point the forecaster will make the determination whether to re-open based on current and predicted conditions.

The Process of Avalanche Mitigation

When a decision is made to conduct an avalanche mission, avalanche mitigation begins with ensuring that current, trained staff are available. If it is a howitzer mission, artillery training, hazardous material training, and proper experience of all team members is required. A crew is assembled from Lake and east entrance, and other districts, and the avalanche hazard is assessed by an avalanche forecaster. This assessment is used to determine the potential effectiveness of using the howitzer and the ability of personnel to safely access the gun mount. The Go/No Go decision may be based on the potential for avalanches to reach or cross the road along the west side of the avalanche zone. The decision to proceed is determined by the forecaster with consensus of the howitzer crew. The method of accessing the gun mount will vary based on the evaluation of the avalanche hazard, conducted by the avalanche forecaster.

Prior to the howitzer mission, a briefing is conducted outside the avalanche zone and the access route and other operational considerations are reviewed with the howitzer team. During the howitzer mission, approximately 20 rounds are fired into the starting zones of the avalanche paths, depending on snow conditions and observed results. At the conclusion of a mission, if conditions are safe, a groomer rebuilds the snow road to make it passable for OSVs. The groomer operator also has basic avalanche safety training, and the forecasters and other staff maintain a close watch during the grooming to watch for unexpected releases of snow. A single avalanche control mission requires a 10-hour work day for five to seven specially trained employees.

The park works closely with other regional avalanche forecasters to compare Sylvan conditions with those being observed in the vicinity of the park. The park is also a member of the Avalanche Artillery Users of North America Committee, has adopted their M101-A1 Howitzer Avalanche Control Firing Manual, and attends the annual Avalanche Artillery Users of North America Committee meeting to stay current on nationwide avalanche management.

The howitzer is on loan from the U.S. military, and the Wyoming National Guard assists with annual maintenance and training.

A contract helicopter may be used instead of a howitzer, especially when access to the howitzer is unsafe. NPS employees are not aboard the helicopter and do not drop the explosive charges. That is the role of the contractor. NPS employees brief the pilot and crew, and the pilot and crew make the decisions about where to drop the charges. As with howitzer missions, an NPS groomer rebuilds the road, and the east entrance road may be re-opened for public and administrative travel. Figure 23 shows avalanche paths at Sylvan Pass.

Unexploded Ordnance

Unexploded ordnance (ammunition that remain unexploded, whether by malfunction, design, or any other cause) at Sylvan Pass presents many more concerns, both for public safety and regarding homeland security. Over the years, unexploded ordnance has accumulated, primarily from past use of a 75-mm recoilless rifle for control work. The total number of unlocated unexploded ordnance is estimated at 300. Six unexploded ordnance have occurred in the past two winters from both helicopter and howitzer operations; three were recovered and three have not been recovered. The ammunition used contains a mixture of explosives that is highly toxic to humans and the environment. Both exploded and unexploded ordinance have the potential to release toxic materials (State of Montana, Department of Military Affairs 2004). The fate of the partially unexploded and unexploded ordnance and its toxic filler is unknown but of concern in the Sylvan Pass area. Visitors may come into contact the unexploded ordnance; for example, in 1997 a visitor picked up a round and transported the live shell into the Fishing Bridge Visitor Center to give to a ranger. Unexploded shells have also fallen onto the roadway (Comey 2007). When one did so in 2006, the roadway had to be closed for 24 hours while a military team was brought in to remove the hazard. On a larger scale, before the July 2004 mud and rock slide on Sylvan Pass could be removed from the road, the 10,000 cubic yards of material had to be laboriously searched for unexploded ordnance.

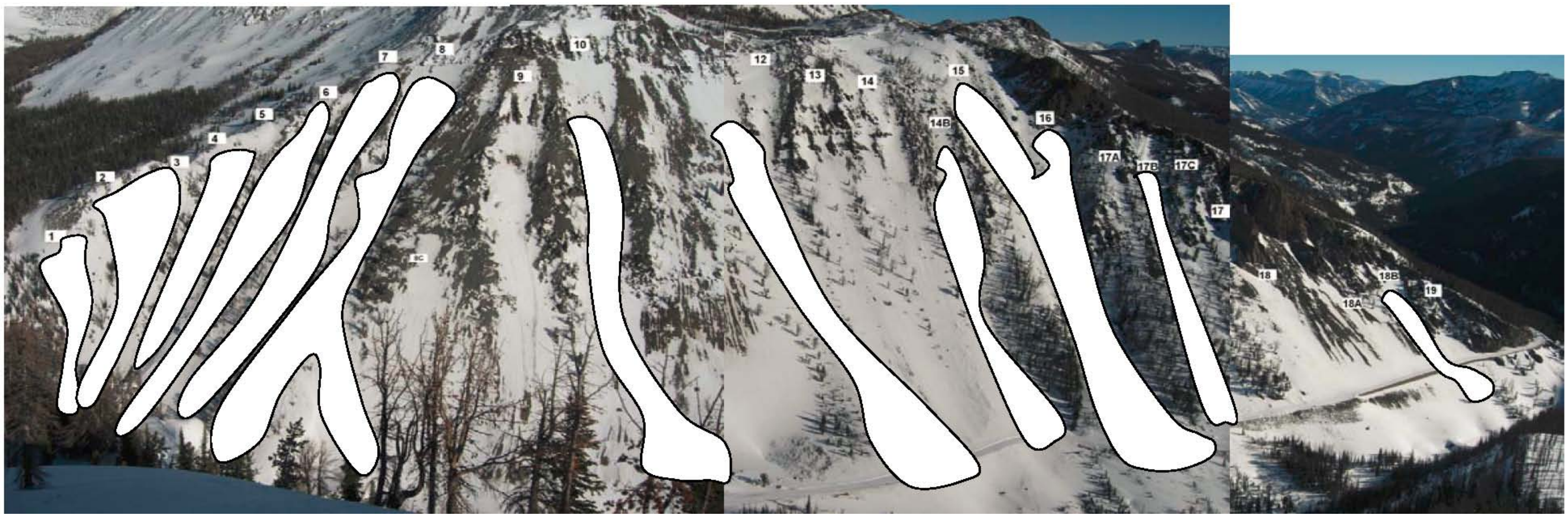


FIGURE 23: MAP OF SYLVAN PASS (AVALANCHE PATHS INDICATED BY NUMBER)

OSV Use in Sylvan Pass

Commercial OSV operators receive an orientation on safe travel practices through Sylvan Pass. Visitors can access the park website to check the status of open or closed roads, check for daily winter weather reports (including minimum and maximum temperatures, new snow accumulation, snow depth, weather, and an avalanche danger rating), and learn more about avalanche forecasting and hazards. A closure of Sylvan Pass occurs from 9:00 p.m. each night until 8:00 a.m. the next morning, when staff can make the operational determination for opening the pass.

Talus Slope

The “Talus Slope” area on the south entrance road also contains some avalanche zones. In contrast to those at Sylvan Pass, there are only seven avalanche zones, averaging less than a 200-foot vertical drop within a 1,700-foot section of the road. The south entrance road does not cross the avalanche paths, but rather the run-out zones attributed to the avalanches. If a vehicle were pushed off the roadway by a slide, it would drop about five to ten feet, a fall unlikely to be fatal. In cases where a vehicle has been caught in a slide at the Talus Slope, the slide has merely moved around the vehicle without moving it or coming close to covering it (Johnson 1999; NPS 2007b; Mossman 2003).

In the late 1990s, following a series of winters with above average snowfall, several avalanche-related deaths in the park, and the death of a ski-patroller at Big Sky related to hand-charge use (Livingston Enterprise 1997), park staff evaluated options for avalanche management at Talus Slope and elsewhere. The review recommended use of an avalauncher (rather than the hand-charges that had historically been employed) (NPS 2002b). After 2 to 3 seasons of avalauncher use (which included considering its use at Sylvan), further reviews of the avalanche situation at Talus occurred (NPS 2002c). Those extensive reviews, which included input from avalanche experts outside the NPS, concluded that the risk of substantial avalanche activity at Talus Slope was low under normal conditions (Mossman 2003; Johnson 1999) and that the risk to employee safety of avalaunchers misfiring substantially exceeded the expected risk of a life-threatening avalanche discharging at Talus Slope (Keator pers. comm. 2004). The review also concluded that avalanche risk there would be best managed through careful observation of snow and weather conditions, signs for the visiting public prohibiting stopping in the avalanche zone, possible structural designs, and use of helicopter-dropped explosives (Johnson 1999; NPS 2003a). In accordance with the review, park staff has continued to review the avalanche risk reduction program and, coincidentally, winters have brought lower snowfall amounts, producing little to no avalanche activity at Talus Slope.

For these reasons, park staff determined that avalanches in the Talus Slope area do not pose the same level of real and substantial risk to park employees and visitors as those at Sylvan Pass (Keator pers. comm. 2004; NPS 2007b). Even so, Yellowstone park staff monitor the Talus Slope area just as regularly, and with just as much vigilance, as they do other infrequent slide zones in the park. Should a heavy storm produce severe avalanche conditions, or should such conditions develop in other ways (as was documented in the 1999 report by Alan Sumeriski), park staff would close the roadways until conditions improve or until such avalanches could be discharged. The same policy applies to the numerous other roadside slopes in the park that are prone to slides given the right snow and wind conditions. Park policy is uniform for all locations: monitor (using both regional and site-specific information), close the road if conditions are unsafe, control for avalanches (currently with helicopter-dispensed explosives), and reopen when safe (NPS 2003a). No management changes are proposed for the Talus Slope, Dunraven Pass, other road segments, or for park backcountry areas with avalanche hazards.

SAFETY CONCERNS AMONG DIFFERENT MODES OF WINTER TRANSPORTATION

Winter use in Yellowstone occurs mainly on groomed park roads for cross-country skiers, snowshoers, snowmobilers, and snowcoaches. Past planning efforts have raised safety concerns between the use of non-motorized use and motorized use, including the concern that the use of a snowcoach or snowmobile on the same roadway as a cross-country skier or snowshoer could pose a threat to their health and safety. There are several established trails that are groomed specifically for non-motorized uses and are not accessible to motorized users, which could reduce this perceived conflict. Safety concerns are addressed in part, by the requirement for OSV use to be guided within the park.

Since the winter of 2004/2005, all snowmobilers have been led by guides. Some visitors to Yellowstone have never ridden a snowmobile, and guides help to teach how to safely travel through the park. Guides are experts at snowmobile and/or snowcoach driving in Yellowstone and know the conditions that may be encountered with such travel. All guides are trained in basic first aid and cardiopulmonary resuscitation. In addition to first-aid kits, they often carry satellite or cellular telephones and radios for emergency use. They also carry shovels and equipment necessary to respond to avalanches and to vehicles that may need to be pulled from a soft road shoulder. Guides use a "follow-the-leader" approach, stopping often to talk with their group. They lead snowmobiles single-file through the park, using hand signals to pass information down the line from one snowmobile to the next. Signals are effectively used and warn group members about wildlife and other road hazards, indicate turns, and indicate when to turn the snowmobile on or off.

As shown in figure 24, introduction of guided snowmobile tours has reduced the number of law enforcement incidents since 2003/2004. Based on these raw numbers, OSV related incidents are down 90 percent from 2002/2003(282 incidents) to 2009/2010 (27 incidents). Although the number of violations related to OSV travel has been reduced, violations still occur, mostly unrelated to winter visitor recreation use. In 2009, four snowmobilers were apprehended when park rangers caught them riding in Yellowstone's backcountry. The offenders were operating rented machines off trail, more than a mile inside the park boundary near West Yellowstone. The use of OSVs in the backcountry, on trails, and off-road has always been prohibited. Despite this prohibition, rangers have observed off-road snowmobile tracks up to 2.5 miles inside Yellowstone's backcountry. Rangers regularly patrol the boundary and have the option to ticket, arrest, and confiscate the snowmobiles of the violators, who can expect to face aggressive prosecution (NPS 2009c).

Severe Weather Conditions

According to industry standards established by the ACGIH, all non-essential work should stop at a temperature of -25°F (-31.7°C) if there is a 20 mph wind. With no noticeable wind, the temperature at which non-essential work should cease is -45°F (-42.8°C). Travel by snowmobile may produce wind-chill factors of -40 °F (-40°C).

Current Yellowstone employee procedures state that snowmobile travel is not advised for non-essential work at temperatures below -20°F (-28.9°C). Non-essential work includes activities such as travel to meetings, training, and other administrative travel; avalanche control procedures; interpretive programs and roving interpretation; resource monitoring; research fieldwork, etc. Temporary park closures may be enacted as necessary to provide for the safety of the public and employees during severe weather.

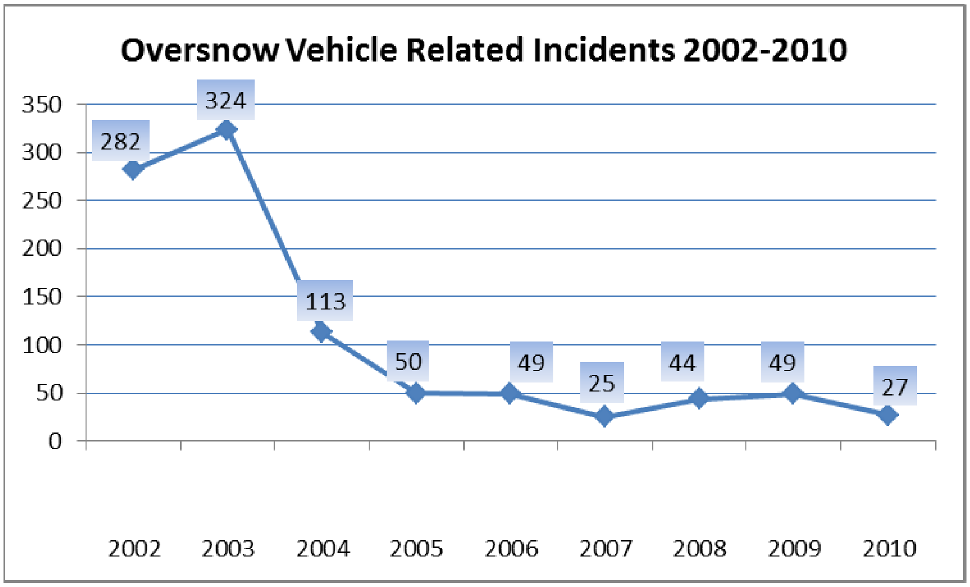


FIGURE 24: WINTER LAW ENFORCEMENT STATISTICS, 2002–2010

SOCIOECONOMIC VALUES

EXISTING AND HISTORIC SOCIOECONOMIC CONDITIONS

Economy of the Greater Yellowstone Area

The affected environment for socioeconomics of the greater Yellowstone area is described at three different levels: the state level (Idaho, Montana, and Wyoming), the county level (Fremont County in Idaho, Gallatin and Park counties in Montana, and Park and Teton counties in Wyoming), and the community level (Cody and Jackson, Wyoming, and West Yellowstone, Montana) where data is available. These three levels provide context for the magnitude of the impacts (both absolutely and relatively) at multiple geographic levels. These were also the levels used in analysis in the previous EIS (NPS 2000b), SEIS (NPS 2003c), EA (NPS 2004a), and EIS (NPS 2007c) for winter planning. The three communities at the local scale (Cody, Jackson, and West Yellowstone) provide a representative example of the possible effects at the city or town level. Also, these communities have been previously identified as most likely to be affected by changes in winter use policies.

Visitors also use other gateway communities or areas. For example, skiers and snowboarders at Big Sky, Montana, often spend part of their winter trip taking a snowmobile or a snowcoach tour into Yellowstone. Similarly, Livingston, Cooke City, and Gardiner, Montana, are important gateway communities to Yellowstone’s north and northeast entrances. Dubois, Wyoming, is a gateway community to both Yellowstone and Grand Teton. Island Park and other Idaho communities are gateways to Yellowstone. Other areas, within the counties or states but outside the communities can also be affected by the winter use alternatives. The effects on these smaller areas may be apparent, even when looking at a smaller area, such as within a zip code. Where these effects cannot be see within a zip code, qualitative measures were used.

Table 30 presents the relative sizes of the economies of the five counties within the affected region. The range of total economic output among these areas ranges from $248 million annually in Fremont County to $3.9 billion in Gallatin County. This range suggests that a change in visitor activity that is generally small in the context of the five-county area has the potential to be substantial in the context of the smaller economy of a community like Fremont County. However, this does not mean that individuals and businesses in the area have not been affected by changes in visitor activities. Some businesses that relied specifically on snowmobile access have reported being adversely affected. Others have noted that their ability to retain highly qualified, year-round workers has been diminished (Ecosystem Research Group 2006). In a 2009 study, the NPS looked at the economic benefits to local communities from national park visitation. Using the Money Generation Model version 2 (MGM2) this study found that the nearly 3.3 million visitors in 2009 spent around $297 million year-round in the local communities year-round (NPS 2009d).

TABLE 30: ECONOMIC OUTPUT AND EMPLOYMENT LEVELS FOR THE GREATER YELLOWSTONE AREA, 2008

County	Total 2008 Output in $(2012)	Total 2008 Employment
Gallatin County, MT	8,697,185,428	67,737
Park County, MT	1,049,197,379	8,730
Fremont County, ID	534,172,959	4,418
Park County, WY	2,689,466,448	19,448
Teton County, WY	4,504,893,629	30,458
Cody, WY	1,598,036,298	11,876
West Yellowstone, MT	195,295,238	1,740
Jackson, WY	3,405,209,913	22,562
Five-County Area Total	17,474,915,469	130,791
Three-State Area Total	307,639,982,309	1,942,947

Source: IMPLAN 2008.

Table 31 illustrates breakdown of employment by industry for the five-county affected region. The four largest industries are government and government enterprises; accommodation and food services; construction; and retail trade (BEA 2012).

TABLE 31: EMPLOYMENT BY MAJOR INDUSTRY AND GEOGRAPHIC REGION, 2009

Industry	Five-County Area (Employees)	% of total Employees
Government and government enterprises	17,786	14.1%
Accommodation and food services	15,547	12.3%
Retail trade	13,755	10.9%
Construction	12,302	9.7%
Real estate and rental and leasing	9,459	7.5%
Professional, scientific, and technical services	9,069	7.2%
Health care and social assistance	8,350	6.6%
Other services, except public administration	6,808	5.4%
Finance and insurance	5,691	4.5%
Arts, entertainment, and recreation	4,952	3.9%
Manufacturing	4,019	3.2%
Administrative and waste services	3,914	3.1%
Farm employment	3,457	2.8%
Transportation and warehousing	2,482	2.0%
Wholesale trade	2,065	1.6%
Mining	1,668	1.3%
Information	1,603	1.3%
Educational services	1,728	1.4%
Forestry, fishing, and related activities	1,140	0.9%
Utilities	230	0.2%
Management of companies and enterprises	191	0.2%
Total	126,234	100%

Source: BEA 2012.

Looking specifically at the travel industry, Taylor, Foulke, and Coupal (2008) presented information for the three Wyoming counties that contain most of the Shoshone National Forest (table 32). Park County had the highest earnings between 1997 and 2006. Taylor et al. also present information in their report on the counties surrounding Bridger-Teton National Forest. After adjusting for inflation, total visitor spending in Fremont, Lincoln, Sublette, and Teton counties in Wyoming (the counties surrounding Bridger-Teton National Forest) increased from $467.4 million in 1997 to $605.4 million in 2005 (+29.5 percent) (Taylor et al. 2008).

TABLE 32: TRAVEL INDUSTRY EARNINGS FOR SHOSHONE NATIONAL FOREST AREA (FREMONT, HOT SPRINGS, AND PARK COUNTIES), 1997–2006

Year	Deflated Fremont	Deflated Hot Springs	Deflated Park	Deflated 3-County Area
1997	$22,009,349	$4,506,676	$44,018,697	$70,534,722
2001	$24,316,644	$4,882,860	$49,023,916	$78,223,420
2002	$24,475,222	$4,703,082	$51,062,033	$80,240,337
2003	$24,905,079	$4,793,053	$52,441,638	$82,139,769
2004	$26,867,472	$4,752,070	$52,638,313	$84,257,855
2005	$27,433,628	$5,221,239	$53,274,336	$85,929,204
2006	$28,481,474	$6,262,493	$49,928,367	$84,672,334
Total Change 1997 to 2006	29.4%	39.0%	13.4%	20.0%
Annual Change 1997 to 2006	2.9%	3.7%	1.4%	2.0%

Source: Dean Runyan Associates (in 2000 dollars), from Taylor, Foulke, and Coupal 2008.

RECENT TRENDS IN PARK VISITATION

Previous estimates of changes in greater Yellowstone area visitation in response to changes in winter use policies relied primarily on visitor surveys to predict future policy impacts (Duffield and Neher 2000; RTI 2004). The current analysis, however, benefits from several years of data collected during periods of varying winter use visitation levels. These sources of observed data allow the current analysis to incorporate trends in winter economic activity to supplement predictions based on visitor survey responses. Visitation data for the park is presented in the “Visitor Access and Circulation” section in this chapter.

RECENT TRENDS IN THE GREATER YELLOWSTONE AREA ECONOMY

Analyses for previous winter use planning efforts in the park has predicted that restrictions on some types of winter use (primarily snowmobiles) would be at least partially offset by winter visitors still recreating in the greater Yellowstone area but using other recreational opportunities outside of the park. As a general example, it was predicted that restricting access to the park for some uses, such as snowmobiling, could lead to offsetting increases in use of other greater Yellowstone area recreational opportunities, such as snowmobiling in the national forests; however, there have been declines in both snowmobile visits and total winter visitation to Yellowstone in the past six years. An examination of key tourism-targeted tax collections in the greater Yellowstone area counties bordering the park provides information on the degree to which the economies of these counties and communities are economically dependent on park winter visitation.[8]

[8] All the tax information reported in the tables and figures are as reported by the respective states and do not include an inflation factor. Lodging costs typically increase as a result of inflation; thus, lodging tax revenue (which is a percentage of the cost of lodging) will also increase. When inflation is included, the inflation-adjusted tax revenue may be lower, even though the tax dollars stay the same or increase (Taylor 2007). The NPS chooses to present lodging tax information without an inflation adjustment since there are a variety of possible indices, but notes through the reference to Taylor 2007 that such adjustments can be made. Also, another similar report examining tourism in Wyoming (Dean Runyan Associates 2006) and cited by Taylor 2007 does not (except for one table in a 71-page report) take inflation into account.

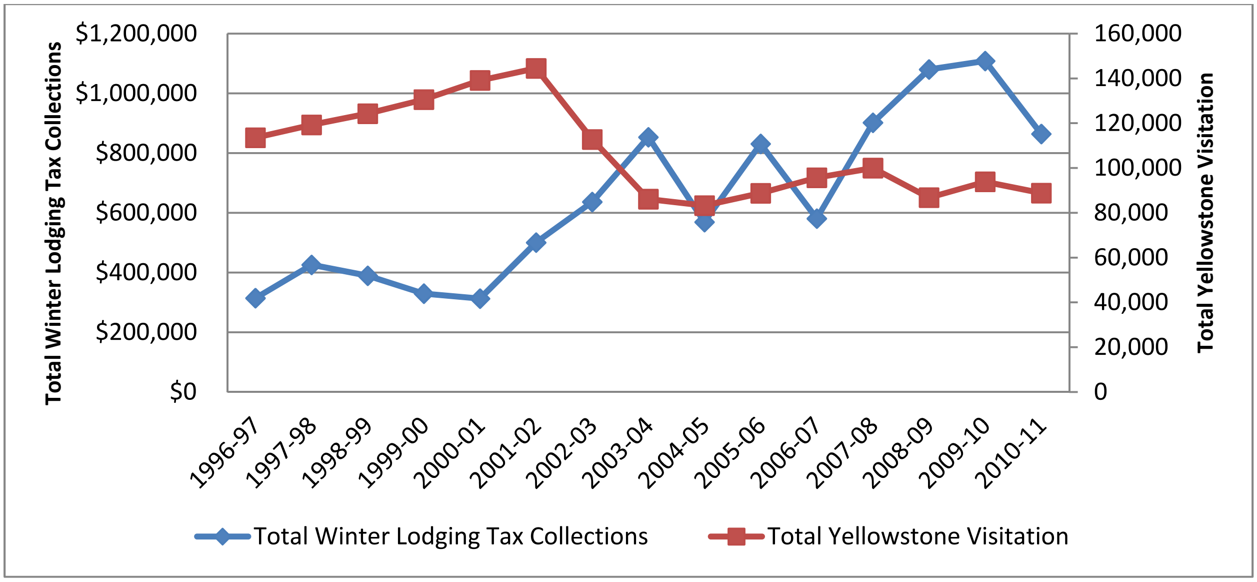
Table 33 and figure 25 present winter lodging collections for Fremont County, Idaho. In general, during the period when winter visitation to Yellowstone was decreasing (2002/2003 through 2005/2006), winter lodging tax collections in Fremont County trended upwards—the opposite of Yellowstone visitation trends. Fremont County winter lodging tax collections in 2005/2006 were more than double the level in the four years prior to 2002 (and the management changes that began in 2003). As table 33 shows, between 2003/2004 and 2009/2010 total sales for lodging in Fremont County for the months of December through March increased by almost 30 percent. Over the same period, annual tax collections for lodging for the State of Idaho increased 18 percent. However, many other factors affect lodging tax revenues in different parts of the state. Therefore, the NPS is unable to draw conclusions or determine causality about differences across different parts of the state.

TABLE 33: FREMONT COUNTY, IDAHO, WINTER LODGING TAX COLLECTIONS COMPARED WITH YELLOWSTONE NATIONAL PARK WINTER VISITATION, 1996/1997 THROUGH 2010/2011

Winter Season	December	January	February	March	Winter Fremont County Lodging Tax Collections	Total Yellowstone Winter Visitation
1996/1997	$42,441	$44,183	$83,866	$143,806	$314,296	113,504
1997/1998	$204,652	$34,754	$114,365	$71,945	$425,716	119,271
1998/1999	$93,591	$55,816	$180,620	$59,299	$389,326	124,275
1999/2000	$76,263	$70,473	$112,822	$69,865	$329,423	130,563
2000/2001	$80,688	$58,952	$101,676	$71,411	$312,727	139,122
2001/2002	$123,261	$76,855	$144,869	$155,416	$500,401	144,490
2002/2003	$61,374	$131,383	$239,068	$204,393	$636,218	112,741
2003/2004	$246,769	$107,345	$406,135	$92,864	$853,113	86,107
2004/2005	$116,323	$4,661	$335,441	$112,605	$569,030	83,235
2005/2006	$221,627	$261,024	$236,964	$111,201	$830,816	88,718
2006/2007	$56,010	$274,561	$101,271	$148,902	$580,744	95,675
2007/2008	$101,340	$366,934	$169,966	$263,416	$901,656	99,975
2008/2009	$199,351	$586,581	$23,043	$271,072	$1,080,047	86,784
2009/2010	$200,363	$185,892	$196,378	$525,717	$1,108,350	93,838
2010/2011	$159,999	$77,092	$358,843	$268,090	$864,024	88,807

Note: Not adjusted for inflation.

Source: Idaho State Tax Commission 2012.



Note: Lodging collections not adjusted for inflation.
Source: Idaho State Tax Commission (2012).

FIGURE 25: COMPARISON OF FREMONT COUNTY, IDAHO, WINTER LODGING COLLECTIONS AND YELLOWSTONE NATIONAL PARK WINTER RECREATIONAL VISITATION, 1996/1997 THROUGH 2010/2011

Park County, Wyoming, on the east side of Yellowstone has similar winter lodging tax information during this same period (table 34 and figure 26). The main community in Park County is Cody. In addition, Park County encompasses the northern portion of Yellowstone, including the Mammoth Hot Springs Hotel, which is open during the winter (Snow Lodge, at Old Faithful, is in Teton County, Wyoming). This table shows both total recreational winter visitation levels for Yellowstone and total winter lodging tax collections for the county. As is the case in Fremont County, winter lodging tax collections did not follow the decrease in Yellowstone OSV visitation between 2002 and 2006. The Mammoth Hot Springs Hotel accounts for 41 percent of the Park County lodging tax in the winter.

Table 35, from Taylor, Foulke, and Coupal (2008), shows local tax revenue collections for the entire year, adjusted for inflation, for Fremont, Hot Springs and Park counties. Between 1997 and 2006, tax revenues increased in a similar manner to the winter lodgings tax revenue displayed in table 35. Park County has higher travel-related tax revenue than Fremont and Hot Springs. The report by Taylor et al. (2008) also presented information on local tax receipts for the counties surrounding Bridger-Teton National Forest (Fremont, Lincoln, Sublette, and Teton counties in Wyoming). Local tax receipts from travel spending, adjusted for inflation, increased from $9.5 million in 1997 to $11.3 million in 2005 (+19.0 percent, and a compound average growth rate of 2.2 percent per year).

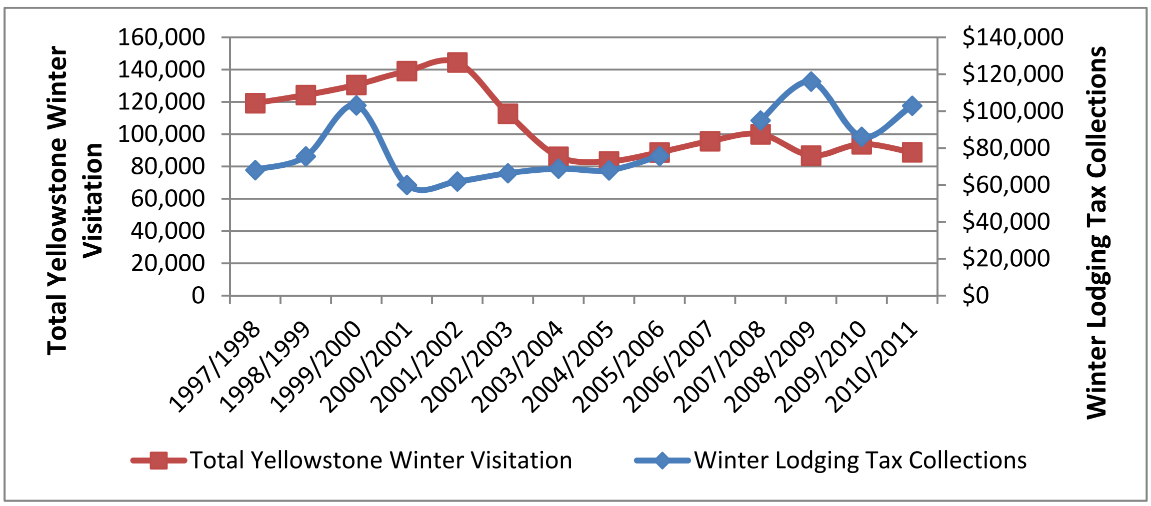
TABLE 34: PARK COUNTY, WYOMING, WINTER LODGING TAX COLLECTIONS, IN TAX YEAR DOLLARS, COMPARED WITH YELLOWSTONE NATIONAL PARK OVERSNOW VISITATION, 1997/1998 THROUGH 2010/2011

Winter Season	Dec	Jan	Feb	Mar	Winter Lodging Tax Collections	Total Yellowstone Winter Visitation
1997/1998	$33,155	$8,498	$13,458	$12,965	$68,075	119,271
1998/1999	$24,258	$9,523	$12,509	$29,218	$75,509	124,275
1999/2000	$59,379	$14,971	$10,617	$18,184	$103,151	130,563
2000/2001	$20,467	$9,384	$16,200	$13,955	$60,006	139,122
2001/2002	$26,971	$9,477	$12,352	$13,072	$61,872	144,490
2002/2003	$27,486	$14,217	$10,417	$14,256	$66,376	112,741
2003/2004	$28,765	$12,527	$9,455	$18,090	$68,837	86,107
2004/2005	$27,841	$13,210	$13,313	$13,556	$67,919	83,235
2005/2006	$20,520	$21,382	$20,532	$13,244	$75,679	88,718
2006/2007	(data not available)					95,675
2007/2008	$28,909	$14,111	$25,512	$26,425	$94,957	99,975
2008/2009	$46,397	$18,128	$29,360	$22,199	$116,084	86,784
2009/2010	$31,478	$16,577	$13,463	$24,625	$86,143	93,838
2010/2011	$26,345	$29,678	$23,509	$23,420	$102,952	88,807

Notes: Not adjusted for inflation.

The report, “Economic Trends in the Winter Season for Park County, Wyoming” by David T. Taylor (2007) presents different winter lodging tax information (excluding December and lagged 2-months) for 5 of the 9 years presented above (from 1997 to 2006). However, the general lodging tax trends (without regard to inflation) are the same in both reports. Additionally, 2007/2008 tax collection data were not available.

Source: Wyoming Department of Revenue 2012.



Note: Data for 2007-08 are not available. Lodging tax collections not adjusted for inflation.
Source: Wyoming Department of Revenue 2012.

FIGURE 26: COMPARISON OF PARK COUNTY, WYOMING, WINTER LODGING TAX COLLECTIONS, AND YELLOWSTONE NATIONAL PARK OVERSNOW VISITATION, 1997/1998 THROUGH 2009/2010

TABLE 35: TRAVEL INDUSTRY LOCAL TAX REVENUE FOR SHOSHONE NATIONAL FOREST AREA (FREMONT, HOT SPRINGS AND PARK COUNTIES), 1997–2006

Year	Deflated			
	Fremont	Hot Springs	Park	3-County Area
1997	$524,032	$209,613	$1,781,709	$2,515,354
2001	$585,943	$292,972	$2,050,801	$2,929,716
2002	$671,869	$287,944	$2,207,569	$3,167,382
2003	$657,870	$281,944	$2,255,554	$3,195,369
2004	$639,702	$274,158	$2,193,263	$3,107,123
2005	$707,965	$353,982	$2,389,381	$3,451,327
2006	$772,088	$428,938	$2,316,264	$3,517,290
Total Change 1997 to 2006	47.3%	104.6%	30.0%	39.8%
Annual Change 1997 to 2006	4.4%	8.3%	3.0%	3.8%

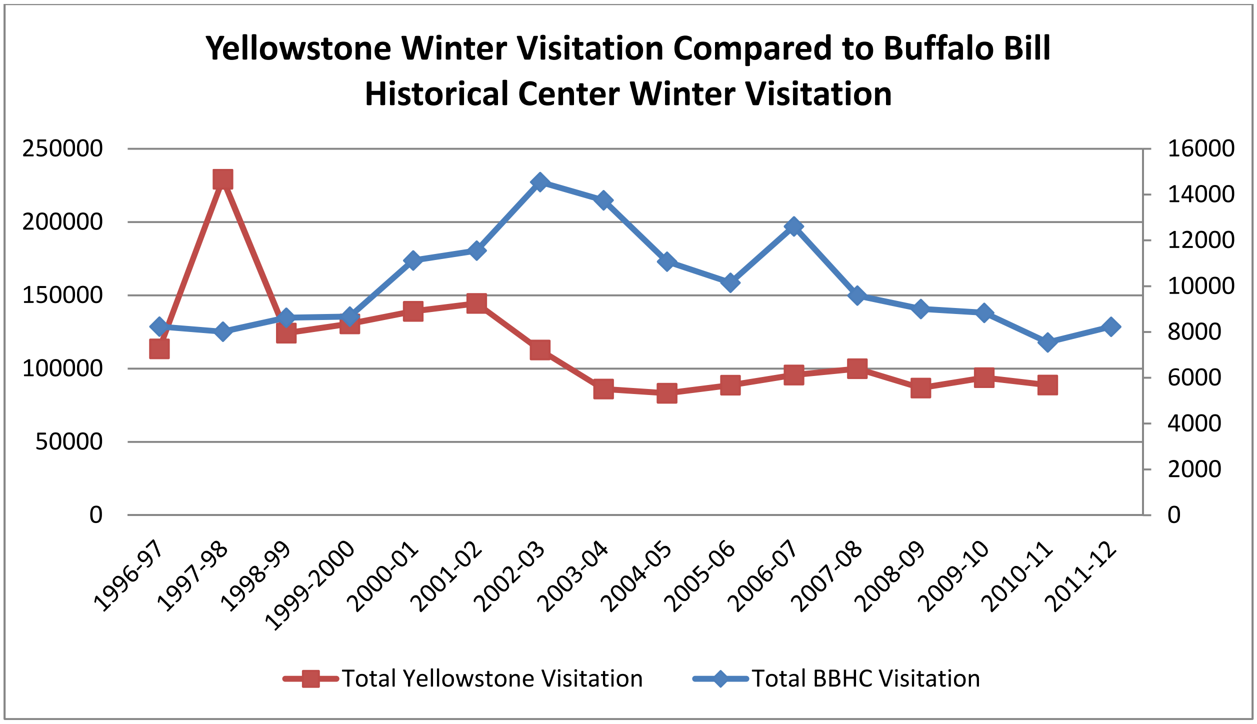
Source: Dean Runyan Associates (in 2000 dollars), from Taylor, Foulke, and Coupal 2008.

Recent lodging and tax data for Fremont and Park counties indicate that declines in snowmobile entries in winter visitation in the park in general, and into Yellowstone in particular, have not detectably impacted the overall winter tourist economy in the counties as measured by monthly lodging tax collections. This is despite the fact that the economies of these counties are relatively small. Visitation to Yellowstone can also be compared to other local attractions. The Buffalo Bill Historic Center is in Cody, Wyoming. Figure 27 indicates that overall Yellowstone winter visitation and Buffalo Bill Historic Center winter visitation seem to move together.

Two other adjoining counties, Gallatin County in Montana (including Bozeman) and Teton County in Wyoming (including Jackson) have relatively large economies where even substantial changes in Yellowstone and Grand Teton National Park winter visitation would not be detectable. For example, the observed change in visitation at the south entrance in response to the 2004 Temporary Winter Use Plan was estimated to have an expenditure impact on the order of $4 million per year. By comparison, the five-county greater Yellowstone area economy (largely driven by Gallatin and Teton counties) was on the order of $6 billion in 1999 and in 2008 (the most recent data available for modeling) had grown to about $8 billion. Similarly, impacts from changes in the park's winter visitation levels for the three-state economy would not be detectable.

However, the size of the economic impacts relative to the size of the county economies masks impacts on some individual businesses, which have indicated a considerable reduction in their winter operations. Other employment patterns have changed (year-round work for some employees is no longer available) as a result of changing visitation patterns (Ecosystem Research Group 2006).

At the north entrance gateway of Gardiner, Montana (Park County), almost all winter use is wheeled vehicle entries. Neither the 2004 Temporary Winter Use Plan (NPS 2004a) nor the 2007 FEIS (NPS 2007c) had a noticeable effect on visitation through this entrance. Visitors there are destined for Mammoth Hot Springs and sites such as the Lamar Valley in the park's northern range (which are both in Park County, Wyoming), other Yellowstone locations, or to recreate in and around Cooke City, Montana (which is in Park County, Montana).



Source: BBHC 2012.

Note: Data on visitation to Buffalo Bill Historical Center missing for 2006 and 2008.

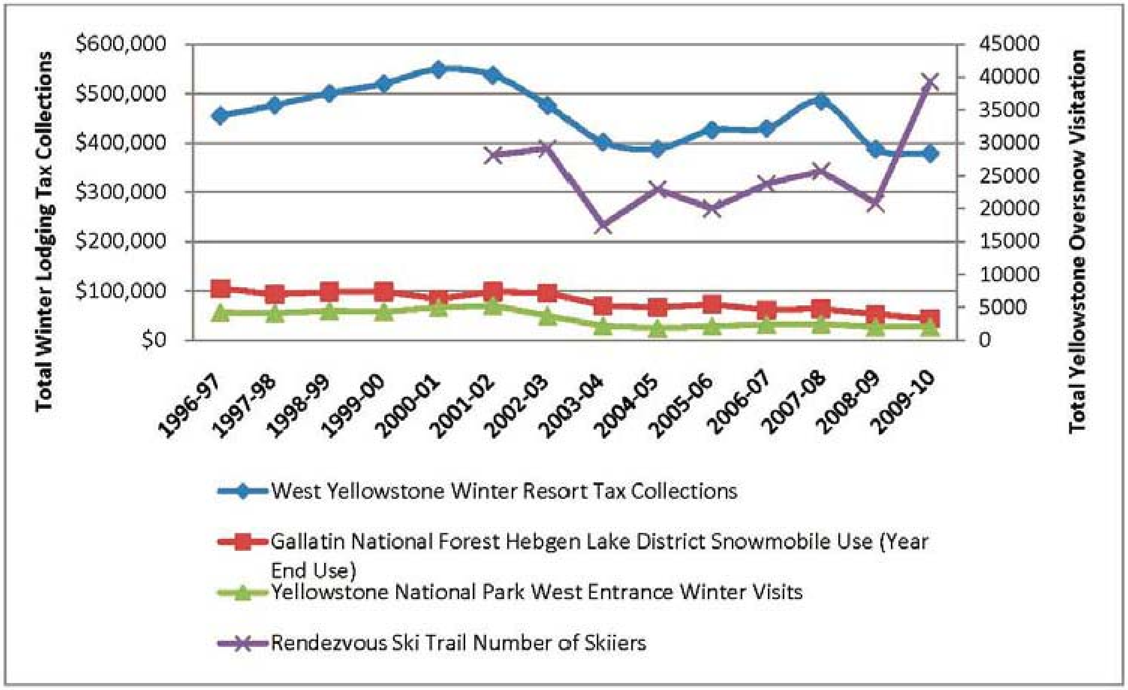
FIGURE 27: COMPARISON OF BUFFALO BILL HISTORIC CENTER WINTER VISITATION WITH AND YELLOWSTONE NATIONAL PARK OVERALL WINTER VISITATION (WHEELED AND OVERSNOW), 1996/1997 THROUGH 2009

Another indicator of change in the winter economy is wildlife viewing in Yellowstone. A 2004-2006 year-round survey looked at the economic effects of wolf watching and wolf presence to Yellowstone visitors. Winter visitors, who constitute about 3.1 percent of the annual visitation to Yellowstone, contribute about $1.3 million to the 17-county economy just related to wolf presence in Yellowstone. This is about 5.8 percent of the total annual $22.5 million direct spending impact of wolf watching to the 17-county economy (Duffield, Neher, and Patterson 2006).

The remaining major gateway community for Yellowstone is West Yellowstone, at the west entrance to Yellowstone. Table 36 provides time series data for this entrance, shown graphically in figure 28. Included in the table are winter resort tax collections for the town of West Yellowstone, winter entries through the west entrance to Yellowstone, winter snowmobile visits to the Hebgen Lake District of the Gallatin National Forest, which abuts the town to the west, and the number of skiers at the Rendezvous ski trail. Unlike the cases of Park and Fremont counties discussed above, reductions in winter park visits through the west entrance and to the national forests between 2002/2003 and 2005/2006 are correlated with declines in resort tax collections. However, the decline was not in proportion to the decrease in west entrance visits. Specifically, comparing average levels for the four years immediately before and after management changes (2002/2003 through 2005/2006 to the four years immediately preceding this period) shows that although park visitation fell 48.5 percent on average, winter tax collections only fell 19.7 percent. However, Montana’s statewide lodging tax rose 17 percent during the same time period. Montana’s statewide lodging tax rose 17 percent during the same period; however, many other factors affect lodging tax revenues in different parts of the state so it is difficult to draw conclusions about differences across different parts of the state.

TABLE 36: WEST YELLOWSTONE WINTER RESORT TAX COLLECTIONS, HEBGEN LAKE DISTRICT SNOWMOBILE USE, YELLOWSTONE WEST ENTRANCE WINTER VISITS, AND RENDEZVOUS SKI TRAIL VISITS 1996/1997 THROUGH 2009/2010

Winter Season	West Yellowstone Winter Resort Tax Collections	Gallatin National Forest Hebgen Lake District Snowmobile Use (Year End Use)	Yellowstone National Park West Entrance Winter Visits	Rendezvous Ski Trail Number of Skiers
1996/1997	$455,035	105,182	56,212	n/a
1997/1998	$476,508	93,208	54,859	n/a
1998/1999	$500,473	98,326	59,928	n/a
1999/2000	$520,566	98,838	58,154	n/a
2000/2001	$549,182	83,721	66,302	n/a
2001/2002	$536,996	98,595	70,371	28,139
2002/2003	$476,037	95,924	49,703	29,139
2003/2004	$401,664	69,996	28,880	17,461
2004/2005	$388,222	66,889	24,510	22,912
2005/2006	$425,933	73,065	28,243	19,974
2006/2007	$429,336	61,240	31,686	23,741
2007/2008	$484,278	64,019	32,942	25,714
2008/2009	$387,444	52,791	26,830	20,799
2009/2010	$378,687	44,031	26,527	39,322



Note: Sales tax receipts not adjusted for inflation.

FIGURE 28: WEST YELLOWSTONE WINTER RESORT TAX COLLECTIONS, HEBGEN LAKE DISTRICT SNOWMOBILE USE, YELLOWSTONE WEST ENTRANCE WINTER VISITS, AND RENDEZVOUS SKI TRAIL VISITS 1996/1997 THROUGH 2009/2010

The observed data for West Yellowstone resort tax collections and west entrance visits were used to estimate a linear regression model explaining tax levels as a function of west entrance visits for a time series of the December through March winter months for the 1989/1990 through 2005/2006 winters. This estimated model explains a substantial proportion (73.2 percent) of the variation in winter resort tax collections. The model indicates a $5.26 increase in tax collections for each west entrance visit. Because the tax rate is 3 percent, this implies $175.33 of taxable expenditures in West Yellowstone for each park visit. The model also implies that in 1989-1990, some other factor accounted for a substantial share of resort tax collections. This could possibly be snowmobile use on the adjacent national forest lands, as discussed below.

Table 36 and figure 28 present data for snowmobile use in the Hebgen Lake District of the Gallatin National Forest. This district includes many miles of groomed snowmobile trails that are accessible primarily from the West Yellowstone area. In the last three winters, snowmobile use in this national forest area adjacent to West Yellowstone has declined at the same time as park visits through the west entrance declined. Causation; however, is complicated by the short time series and a drought and relatively low snow pack in recent years, including the winter of 2004/2005. These data do suggest that restrictions on snowmobile access at the west entrance have not led to noticeable increased use in the adjacent national forest.

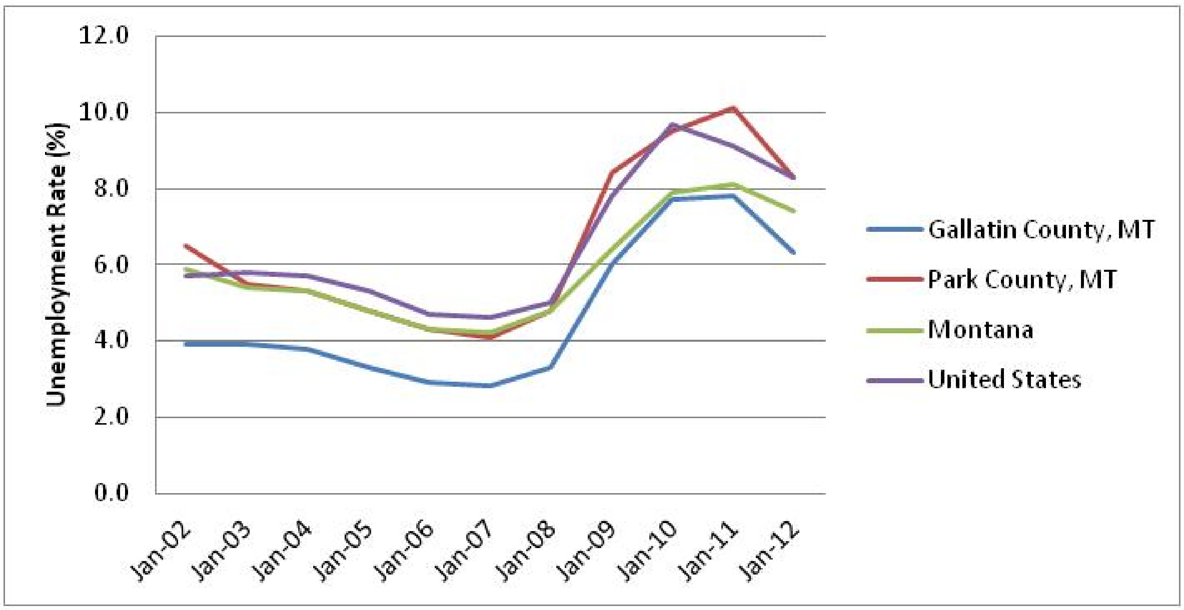
Table 36 and figure 28 indicate that even in West Yellowstone, a community located at a park entrance and with an economy heavily dependent on tourism spending, changes in park winter use management may impact local economic activity but the economy is not wholly dependent on winter park snowmobile access. Among other activities, snowmobiling in the adjacent national forests is also important for the West Yellowstone economy. That hypothesis was tested by estimating a second linear regression model of winter West Yellowstone tax receipts, this time including snowmobile counts in the Hebgen Lake District as an explanatory variable in addition to Yellowstone west entrance winter visits. In this model, both park visits and forest visits are statistically important factors explaining tax receipts. Additionally, this model now accounts for most if not all of the resort tax collections. The results strongly support the hypothesis that, in addition to Yellowstone west entrance visits, snowmobiling in the adjacent national forests is also important for the West Yellowstone economy (Duffield and Neher 2006).

Of the five regional economic areas examined in this analysis, there is a detectable impact on West Yellowstone’s economy from winter use in Yellowstone (and in the surrounding national forests). These results are consistent with the predicted impacts from the socioeconomic impacts section of the SEIS (NPS 2003d), where the authors noted that measurable impacts from changes in winter use policy in the park would only be found in the community of West Yellowstone.

It is notable that winter access by autos, recreational vehicles and buses, all of which in a normal winter would be through the north entrance, has been relatively stable. This seems to indicate that visitors are not substantially substituting access between entrances in response to changes in winter use management. Also, because access through the west, south, and east entrances to Yellowstone is all oversnow under current and historic management, there does not seem to be a shift in access modes between cars and OSVs. To conclude, the main changes with respect to visitor use levels brought about by current park management are the reduction in total snowmobile use and the partial substitution within motorized oversnow use from snowmobiles to snowcoaches. Snowmobile visitation dropped by some 60,000 and snowcoach visitors increased by approximately 10,000.

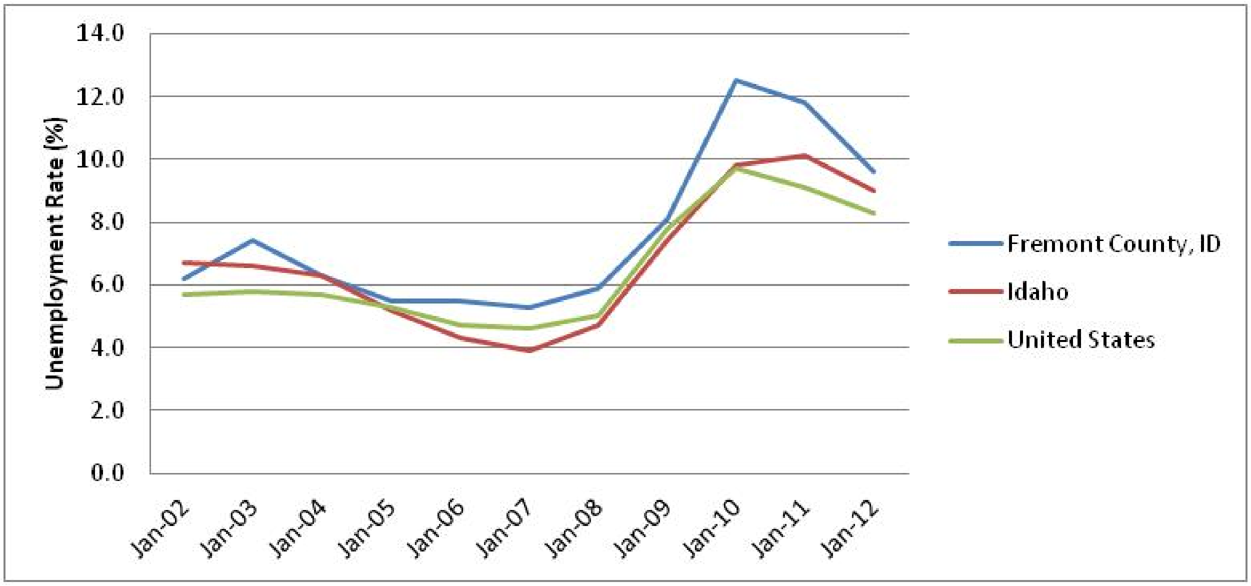
The Recent Economic Downturn

Economic conditions have worsened considerably since September 2008. The economic downturn has most likely impacted visitation to the greater Yellowstone area and spending by visitors who come to the area. Figures 29 to 31 compare the unemployment rates in each of the affected counties to those of their respective states as well as the United States as a whole. In Montana (figure 29), unemployment in Gallatin and Park counties has remained below that of the United States for the most part, although Park County's unemployment rate surpassed the national rate in 2010. After a spike near the end of 2009 and continuing into 2010, unemployment in Idaho's Fremont County (figure 30) declined back toward the statewide rate in 2011. In Wyoming, Park County generally mirrored the statewide unemployment rate until 2008 when the rate began growing more steeply. In Teton County, though staying below both the national and statewide rates, the unemployment rate grew steeply from 2008 to 2010 then began to grow less steeply 2011 (figure 31). As of December 2011, all counties in the affected area except for Park County, Montana, and Fremont County, Idaho, had unemployment rates below the national average. However, all counties continue to experience unemployment rates well above levels seen prior to 2008. As the economy improves, visitor spending should increase through the area. Montana, Idaho, and Wyoming, as well as the counties contained in these states, experience much more seasonal variation in unemployment rates than observed at the national scale.



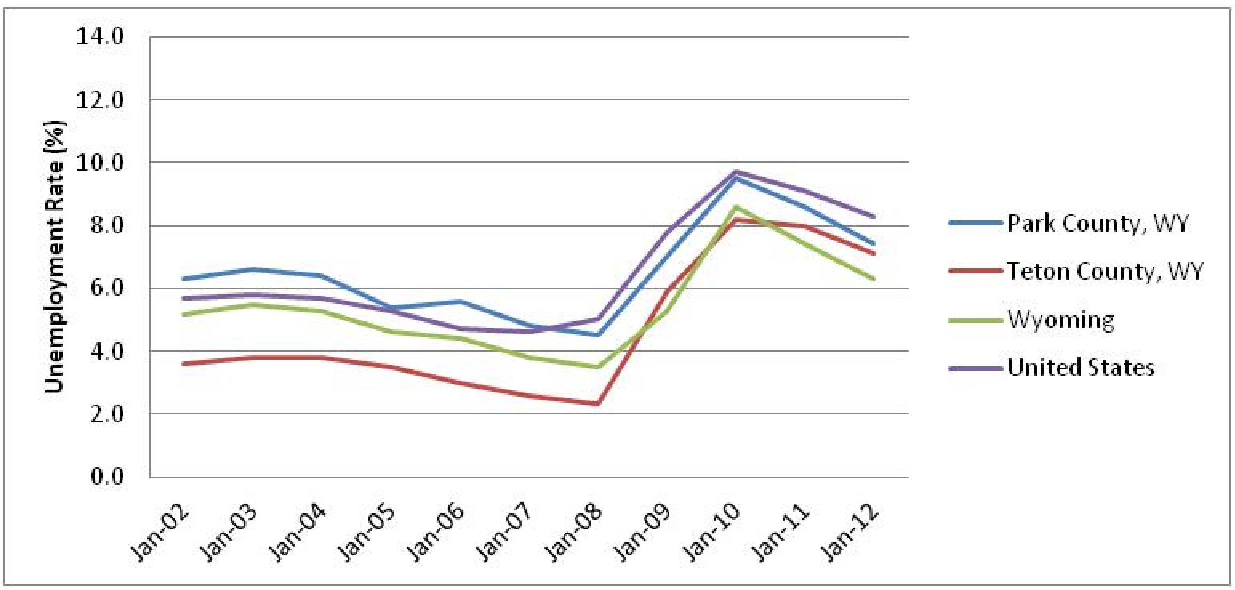
Source: Bureau of Labor Statistics 2012. Series LAUCN30031006, LAUCN30067006, LAUST30000006, LNS14000000.

FIGURE 29: UNEMPLOYMENT RATES IN GALLATIN COUNTY, PARK COUNTY, MONTANA, AND THE UNITED STATES, JANUARY 2002–JANUARY 2012



Source: Bureau of Labor Statistics, 2010. Series LAUCN16043006, LAUST16000006, LNS14000000.

FIGURE 30: UNEMPLOYMENT RATES IN FREMONT COUNTY, IDAHO, AND THE UNITED STATES, JANUARY 2002–JANUARY 2012



Source: Bureau of Labor Statistics, 2010. Series LAUCN56029006, LAUCN56039006, LAUST56000006, LNS14000000.

FIGURE 31: UNEMPLOYMENT RATES IN PARK COUNTY, TETON COUNTY, WYOMING, AND THE UNITED STATES, JANUARY 2002–JANUARY 2012

PARK OPERATIONS AND MANAGEMENT

The NPS, park concessioners, contractors, researchers, and other duly permitted parties depend on snowmobiles and snowcoaches for their administrative functions. These uses of the park are not within the purpose and need of this plan, but are within the scope of analysis in this plan/SEIS because as shown in the analysis for some impact topics, such as soundscapes, winter operations have an effect.

NPS EMPLOYEES AND CONCESSIONS

Approximately 82 permanent and seasonal NPS employees, including those at the west entrance, plus their family members, overwinter in the interior of Yellowstone. Additionally, Xanterra Parks & Resorts stations approximately 150 employees in the interior during the winter season, almost exclusively at Old Faithful (Regula pers. comm. 2010). These NPS and Xanterra employees not only provide critical law enforcement, interpretive, and guest services to winter visitors, but they also maintain and protect Yellowstone's natural and cultural resources. For example, some employees clear accumulating snow from the park's wide array of historic buildings, including National Historic Landmarks such as the Old Faithful Inn and the Fishing Bridge, Madison, and Norris museums.

The employees living in the park's interior occupy a unique environment because they have no wheeled vehicle access to their homes. Their only access to groceries, supplies, and medical care is by OSVs. Almost nowhere else in the United States, outside Alaska, are whole communities of people living and working in an oversnow environment such as the interior of Yellowstone. Due to their unique situation, using snowmobiles for both work-related and personal use is clearly appropriate under executive orders and policy.

Other NPS and concessions employees, as well as permitted researchers and authorized contractors, conduct similar work and personal activities by OSV. Park guides and outfitters are also authorized to use snowmobiles and snowcoaches in the park for administrative access to repair or tow disabled vehicles. These and other administrative uses are necessary for the park to carry out its mission in accordance with the NPS Organic Act, and are focused on ensuring the health and safety of visitors and park residents, providing for public enjoyment of the park, and protecting park resources.

Guests of any employees are required to use BAT OSVs when authorized to enter the park. Permitted researchers are also required to use BAT vehicles as a condition of their permit unless special circumstances exist.

The vast majority of the NPS administrative OSV fleet in Yellowstone is now BAT. For the 2011/2012 winter season, Yellowstone had 118 snowmobiles (both leased and owned) in its administrative fleet, of which 93 percent met BAT requirements. The non-BAT snowmobiles (8 in total) are needed for specialized use, such as law enforcement (boundary patrol, search and rescue) and other administrative purposes on a limited basis where the heavier weight and lower horsepower of current BAT machines do not perform adequately.

In addition to administrative snowmobiles, Yellowstone operates 14 other OSVs. These include groomers, two OSVs on loan from the state of Wyoming, ambulances, fire trucks, vans, and trucks, which are seasonally tracked and converted to OSV use.

The NPS has been shifting to a leased snowmobile fleet, rather than purchasing snowmobiles, to save on maintenance costs. An average of 1,700 miles is put on each snowmobile per winter. The park uses about 23,000 gallons of biodiesel (primarily for grooming equipment) and about 14,000 gallons of ethanol blend gasoline per winter in its oversnow fleet (average of the winters 2002/2003 through 2005/2006).

The NPS transports goods and materials to support winter operations via some of these OSVs. Although all fuel and larger goods are transported to interior locations by wheeled vehicle before the start of the winter season, during the course of the winter, additional supplies are conveyed via OSV to support park personnel accomplishing their work in the winter. Other OSV uses include resource monitoring, personal use, and concession support such as laundry and luggage service.

COST OF WINTER USE MANAGEMENT

Analyses were undertaken to further understand total wintertime operational expenses at Yellowstone National Park. Fiscal Year 2011 was used by the Yellowstone National Park Budget Focus Group as the baseline year for these analyses. Winter operational expenses include the cost of grooming snow roads; leasing and maintenance of park OSVs (snowmobiles and tracked vehicles); fuel, supplies, and material; Sylvan Pass management; operation of the warming huts; utilities; and the employees needed during this time. Wintertime operational costs do not include spring plowing activities. Approximately 131 park staff are duty stationed in interior locations, including the west entrance.

In Fiscal Year 2011, total winter operational expenses were $5,586,858 (base and non-base sources). The park collected $707,033 in revenue during the winter season (December 15, 2010, through March 15, 2011). Of these expenses, approximately $124,868 is related to the operation of the east entrance (Sylvan Pass).