

Lower Madison Valley
Wolf-Ungulate Research Project



2002-03 Annual Report

Justin Gude and Bob Garrott
Montana State University



The Montana State University research team for the 2002-03 year consisted of:

Scott Creel, Associate Professor, Ecology Department
Julie Fuller, Research Technician, Ecology Department
Bob Garrott, Professor, Ecology Department
Justin Gude, Graduate Research Fellow, Ecology Department
Gretchen Howard, Laboratory Technician, Ecology Department
Jon Salerno, Research Volunteer, Ecology Department
Terra Scheer, Work-Study Assistant, Ecology Department
Renee Wulff, Research Volunteer, Ecology Department

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Carroll Ranch
CB Ranch
Corral Creek Ranch
Elk Meadows Ranch

Elkhorn Dude Ranch
High Valley Ranch
Rising Sun Mountain Estates Homeowners
Sun Ranch

Cover photo: calf elk near the Firehole River, Yellowstone National Park, courtesy of Jason Bruggeman.

All data presented in this report are preliminary. Please do not cite this report without author consent. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of our funding sources, collaborators, or cooperators.

Summary

The lower Madison valley wolf-ungulate research project is designed to investigate demographic and behavioral interactions between wolves and ungulates, and the project completed its third year of data collection in the 2002-03 winter. Data collection focuses on ungulate populations, wolf populations and predation, hunter harvest, ungulate behavior, and environmental conditions.

Elk again were the most abundant ungulate in the lower Madison study area in 2002-03, averaging about 86% of the total number of ungulates in the study area over the course of the winter. While elk numbers have been variable within and across years, FWP trend counts indicate approximately 2300-2600 elk wintered in the study area in each of the last three winters. Ground crew estimates reveal that approximately 4000 elk occurred in the study area in mid-winter of 2001-02 and 2002-03, the two years for which ground survey protocol was fully developed and implemented. At less than 50 and approximately 150, respectively, numbers of pronghorn and mule deer in the study area during mid-winter 2002-03 were similar to numbers in mid-winter 2001-02, though the timing of migrations was slightly different in the two years for both species.

The Taylor Peak II wolf pack, consisting of four animals, used the study area in 2002-03. The 2002-03-winter territory of the pack encompassed most of the study area and extended west of the Madison River beyond the study area. Patterns of wolf landscape use have been similar over the last three winters, with activity centered around Wolf Creek and Moose Creek on the Sun Ranch. Fifty-four definite and probable wolf kills were located in 2002-03, the same total amassed in 2000-01 and over twice as many as were located in 2001-02. As in previous winter seasons, wolf predation focused on elk, particularly elk calves. Kill rates per wolf are high in this study area compared to other areas, and vary throughout the winter. Even with such high wolf kill rates (average 11.2 elk kills/wolf/100 days in 2001-02 and 13.75 elk kills/wolf/100 days in 2002-03, the two years during which wolf tracking protocol was fully developed and implemented), the modest number of wolves occupying the study area has resulted in predation losses that represent less than 7% of the elk calves and less than 5% of the elk cows present in the study area during each of the last two winters.

Hunters harvested 135 elk in the study area over the 2002-03 winter. This 61% increase from 2001-02 total can be attributed to the establishment of a new A-7 hunting season in the study area. Hunter harvest has focused on adult cow elk, as season regulations dictate, but has not yet led to a detectable decrease in the population size of the wintering elk herd in the study area.

Based on data collected by Fred King of the Montana Department of Fish, Wildlife, and Parks at Wall Creek Wildlife Management Area, several variables were found to influence elk group sizes and distribution in the Madison valley in the absence of wolf predation pressure. Analyses of the effects of wolf presence relative to these variables using data collected in the lower Madison valley study area have begun but are incomplete at this point. Thus far, elk distribution appears to be more dynamic in areas used frequently by wolves, perhaps altering elk grazing patterns.

Overall, the 2002-03 winter conditions were milder than conditions in 2001-02. Temperature, wind, and snow conditions, however, varied throughout both seasons and were even harsh for portions of the 2002-03 winter.

The success of the past year for the research program is again the result of cooperation between the university research team, the Madison valley community, government agencies, and many others. The project will continue for at least two more years under the direction of a new MS student, Julie Fuller.

Study purposes

The lower Madison valley wolf-ungulate research project is designed to investigate both demographic (population) and behavioral interactions between wolves and ungulates (big game species). The project is now in its third full year, including three winter seasons of data collection. The pilot season of 2000-01 was spent determining which pertinent data were possible to collect in this valley, developing field data collection protocols, and beginning to develop databases. Data collection methods have been improved and databases have been further developed over the seasons of 2001-02 and 2002-03. Due to the longevity of the study animals, inherent year-to-year variability of many aspects of the study system, and the importance of rare events such as harsh winters to ecosystems in the northern Rockies, the overarching research question cannot be adequately addressed in one pilot season and two full seasons of data collection; it will take several years to document the range of possible effects that wolves might have on ungulate populations. To speed up the process of delineating potential wolf effects on ungulate populations, this study was designed to be a part of a larger research effort, with two other study systems in the southwest Montana region. One of these systems is in the Madison-Firehole region of Yellowstone National Park where elk population research was first initiated in 1991, and the other is located in the canyon portion of the Gallatin River watershed and was initiated in 2000. These study sites differ in several ways that might have major effects on wolf-ungulate interactions, including prey densities, winter conditions, and human influence, and documenting wolf-ungulate interactions in such varied conditions should provide insights into how these variables affect wolf-ungulate dynamics more quickly than if all efforts were concentrated in one area. A more detailed description of the larger research program is available at:

<http://www.montana.edu/ecology/staff/garrott/wolf%20ungulate/index.htm>. Despite the necessity for continued, longer-term research to adequately address wolf-ungulate interactions, we can begin to provide insights into some effects that wolves are having on ungulate populations in the lower Madison valley by summarizing relevant data collected over the last three winter seasons and making some comparisons between the three study systems where applicable. This is the primary purpose of this report.

This project was also initiated with the purpose of training graduate students, and as such it was turned into a MS graduate program research project for Justin Gude at Montana State University. This necessitated the development of smaller-scale questions that could be more fully addressed in the course of a 2-year degree program while data collection was focused on the longer-term research goals. The two questions that have been developed for this purpose include:

- (1) What factors affect the rates of wolf offtake from the wintering elk population in the study area?, and
- (2) What factors affect the grouping behavior and distribution of elk in the study area?

The secondary purpose of this report is to begin to shed light on how we are addressing these questions, to give some preliminary results from analyses, and to explain how these questions fit into the larger research program.

Study area

While each of the three study areas involved in this research project has a slightly different focus, the research program at each individual site is directed at determining how newly-established wolf populations will affect wintering ungulate populations. Tackling such a question requires strict definitions of study area boundaries such that communities of wintering ungulates can be defined and studied. As described in previous reports, the Lower Madison Valley study area is bordered on the west by US Highway 287, on the north by Indian Creek, on the east by the top of the first foothills of the Madison mountain range, and on the south by Deadman Creek (Figure 1). Seven private ranches and one subdivision exist within these boundaries, including the CB Ranch, the Elkhorn Dude Ranch, the Corral Creek Ranch, the Carroll Ranch, the Sun Ranch, the High Valley Ranch, the Elk Meadows Ranch, and the Rising Sun Mountain Estates subdivision, as well as USDA Forest Service, BLM, and State of Montana lands.

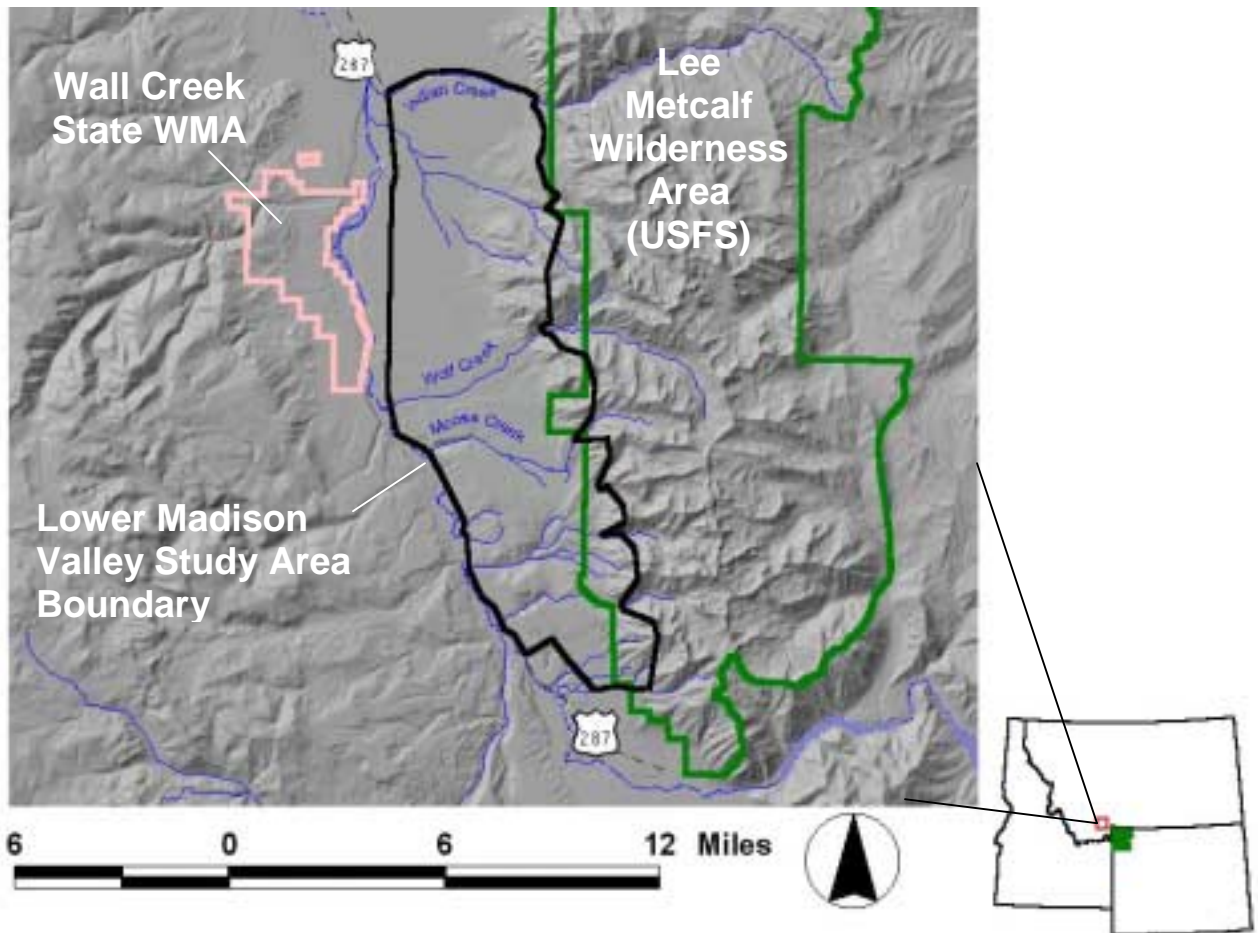


Figure 1. Lower Madison valley study area

Open, flat grasslands dominate the study area, constituting 43% of the landscape. Forest also covers 32% of the study area, and includes coniferous and deciduous forest communities typical of mountainous and riparian areas in the Greater Yellowstone Ecosystem (GYE). Open hills created by glacial activity and sagebrush-dominated communities are also significant in the area, constituting 15% and 10% of the landscape, respectively. Elk, mule deer, pronghorn, white-tailed deer, moose, and occasionally mountain goats all exist within the study area boundaries during winter. Wolves colonized the study area in 1999, following the range expansion of the wolf population reintroduced to Yellowstone National Park in 1995-96.

Summary of 2003-03 field effort

Julie Fuller, Justin Gude, Terra Scheer, Jon Salerno, and Renne Wulff conducted the majority of fieldwork in the 2002-03 winter. The data collection season began on November 24, 2002, and lasted until April 28, 2003. Data were collected on 144 out of 154 days during this period, and focused on five major areas: ungulate populations, wolf activity and predation, hunter harvest, elk behavior, and environmental conditions.

Mike Ross conducted the annual Montana Department of Fish, Wildlife, and Parks (Montana FWP) elk trend count on April 4th, 2003. Ungulate population surveys were also conducted by the field crew on 44 days during the winter season. Seventy surveys were conducted in the open flats, 50 surveys in the sagebrush flats, 30 in the open hills, and 58 in forested areas (40 in forested hills and 18 in riparian areas). Complete classification counts were attempted during 3 survey periods, but only completed during one survey period.

Radio-collared wolves were searched for on 142 days in the 2002-03 winter, and located on 134 days for a total of 311 wolf locations. The Taylor Peak II pack was located 301 times, and the remaining 10 locations are attributed to the Sentinel Pack. Wolf tracking was conducted on 116 days in order to search for kills and monitor elk behavioral responses to wolves.

Age information, incisor teeth, and/or fecal samples from 135 hunter-harvested elk were collected on many days during the months of December, January, and February with aid from Sun Ranch, Carroll Ranch, CB Ranch, and Papoose Creek Lodge personnel, as well as Lane Adamson of the Madison Valley Ranchlands Group and Fred King and Ken Hamlin of Montana FWP. This data collection would not be possible without the cooperation of these many people.

Elk behavioral surveys were conducted in 1 km² areas around 262 wolf locations and areas without recent wolf presence. Fifty-nine surveys were conducted in the open flats, 93 in the sagebrush flats, 62 in the open hills, and 48 in forested areas.

Environmental condition data was collected throughout the winter season in 2002-03. Temperature and wind conditions were noted during most other types of data collection, providing a comprehensive view of conditions in the daylight hours. Scott McClintok also recorded the daily high and low temperatures at the High Valley Ranch on all 158 days from November through April, and made the data available to the research team. Bi-monthly snow surveys were conducted in the different habitats over the course of the winter, taking up 31 person-days and providing a total of 1600 snow depth

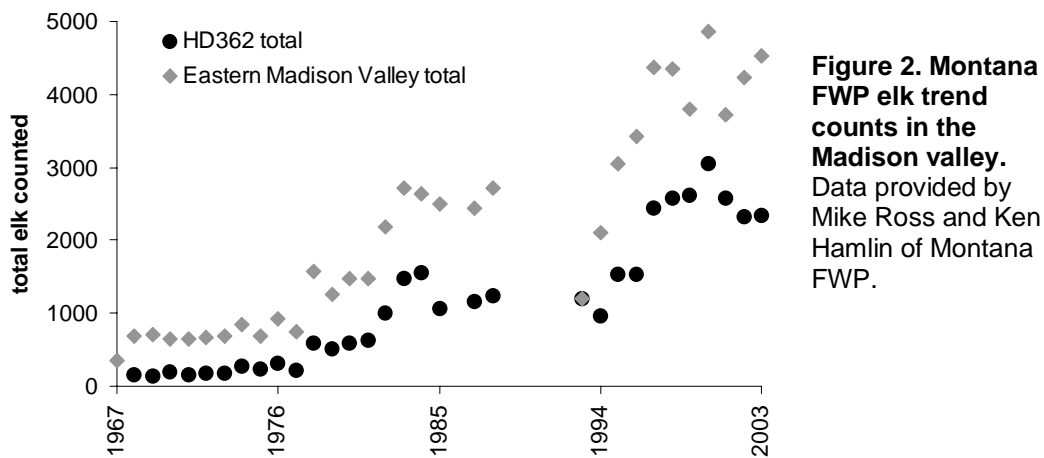
and penetrability measures. Additionally, snow conditions were recorded at wolf kill sites, providing another 354 measures of snow depth and penetrability in the study area.

Portions of 2 days in the 2002-03 field season were devoted to educational activities, and 4 presentations were given to public and professional communities in the 2002-03 year.

Ungulate demographics

An understanding of ungulate population sizes, trends, and age structure is required in order to understand the effects of wolves on the ungulate community. Removing the same number of animals from a small population and from a large population will not have the same effect, just as removing a certain number of juveniles will not have the same population-level effect as removing the same number of adults. Therefore, considerable effort has been put into developing methods to quantify ungulate populations in the study area over the last three winters, including spatial distribution patterns. This information is summarized here, with an emphasis on the data collected in the 2002-03 winter season.

Mike Ross from Montana FWP conducted the annual HD362 elk population trend count on April 4, 2003 (surveys are conducted in the portion of the hunting district from Indian Creek to Earthquake Lake on the east side of the Madison River). A total of 2334 elk were counted in 2003, which was very similar to the 2002 spring count of 2332 elk (Figure 2). Due to the one-day count methodology and the spatial and temporal dynamics characteristic of the elk population in the area, trend counts are most useful when considering the average trajectory of the counts from several years. Considering the Montana FWP elk trend data in this manner reveals that the number of wintering elk in HD362 has been growing since the mid-1970's. It is also useful to look at a larger spatial extent in order to capture some of the spatial dynamics of the system. For example, despite a small decrease in trend counts in the HD362 survey area over the last three years, the trend count totals for the eastern portion of the Madison Valley (including areas north of HD362) have increased in each of the past three springs (Figure 2).



In order to capture some of the finer-scale spatial and temporal dynamics of the elk and other ungulate populations in the study area, a method for estimating ungulate population totals based on counts from the ground has also been developed over the past three winters. The method was conceived in 2000-01, but implementation for that winter was incomplete and the data collected were of poor precision. The method has been refined over each of the last two winters, leading to more precise datasets. In order to estimate ungulate population totals for the study area, each of five habitat types (open flats, sagebrush flats, forested hills, riparian zones, and open hills) has been divided into several survey units, which are randomly sampled during bi-monthly survey periods to estimate the total number of each ungulate species in each habitat type, which are then extrapolated to the total study area. Elk dominate the ungulate community in the study area (Figure 3), and most of the elk typically reside in the open and sagebrush flats during the core of the winter in February and March. Thus, survey efforts are concentrated in these habitats in order to obtain the best possible estimate of the abundant elk population. This estimation procedure, however, leads to less precise estimates during the hunting seasons and ungulate migration periods, when a large portion of the elk population moves out of the open and sagebrush flats and into areas that are more difficult to sample (Figure 4).

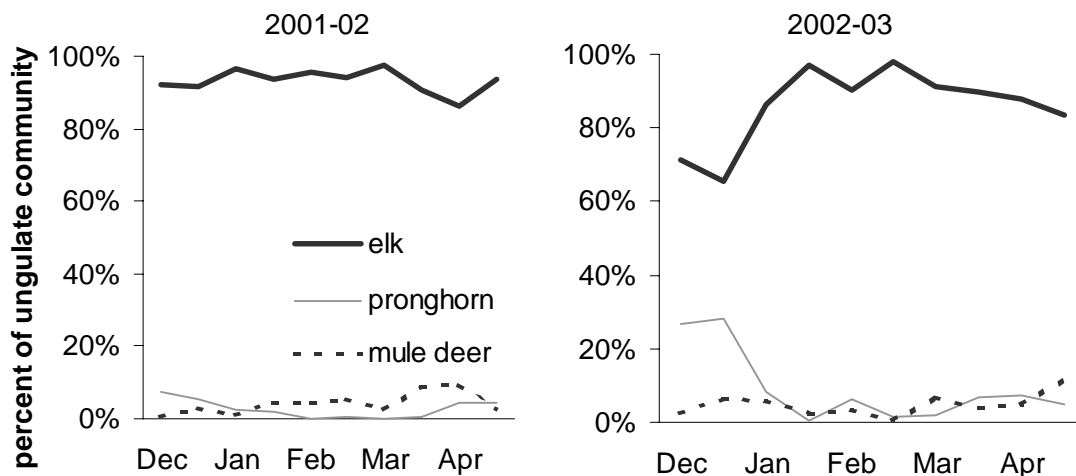


Figure 3. Makeup of ungulate community in lower Madison valley study area.

Consistent with the Montana FWP trend counts, estimates for the total number of elk in the study area gained using the methods described above were similar during February-March in 2003 and 2002, with the exception of one survey period in early March of 2003 (Figure 5). This period was marked by worsening snow conditions, which likely led to the mass exodus of elk to lower elevations north of the study area. Similarly, Fred King's counts of the elk herd on the Wall Creek Wildlife Management Area (WMA) west of the Madison River were also lower during this period, indicating that a factor such as snow that was similar between the areas caused the elk movement out of the higher elevations in the southern portion of the valley. The difference in elk numbers in

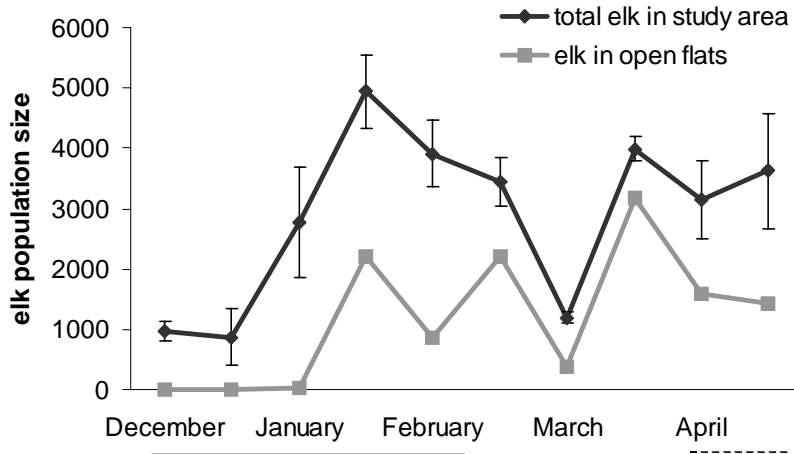


Figure 4. Elk population estimates in 2002-03. The solid bar marks the 2002-03 hunting season, and the spring elk migration period is marked by the dashed line. Elk movement out of the open flats during these periods is evidenced by a larger distance between open flat counts and population estimates for the study area. Error bars are also relatively large during these periods, showing how estimates of elk population size become less precise when large numbers of elk move out of the flats. Bars= 1 standard error.

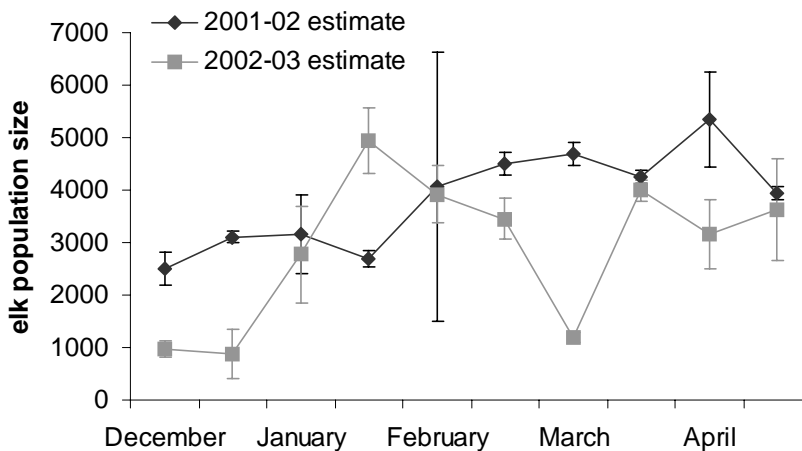


Figure 5. Comparison of 2001-02 and 2002-03 wintering elk populations. Bars= 1 standard error.

the early winter periods of 2001-02 and 2002-03 might be attributed to differences in snow conditions between the years, or perhaps a difference in hunting pressure exerted on the elk population in 2003 with the addition of a new A-7 hunt in the area and a new outfitter operating on the Sun Ranch.

Understanding the impacts of wolves on the elk population in the study area requires a definition of the wintering elk population. Due to the spatial and temporal dynamics of elk numbers in the area, there is obviously mixing with elk from other

wintering areas in SW Montana occurring in this system. However, elk numbers were most stable in February and March of 2001-02 and 2002-03, and estimates of elk numbers were relatively precise during most of these survey periods. Thus, averaging the elk population estimates from these survey periods might approximate the core wintering population of elk in the lower Madison valley study area (excluding the early survey period in March of 2003 that was marked by a temporary exodus of many wintering elk from the study area). Using this method, the number of elk wintering in the study area in 2001-02 was a little larger than the number in 2002-03, at 4381 and 3787 elk respectively.

Over the course of surveys used to determine total ungulate numbers, we are also able to spend time classifying individuals of different species into age and sex classes. Of primary importance to the wolf-ungulate dynamics in the study area are the recruitment ratios for the ungulate populations, expressed here as the number of calves per 100 cows for the elk population. Recruitment is defined as the number of young surviving to one year of age, or the number of calves recruited into the adult portion of the elk population.

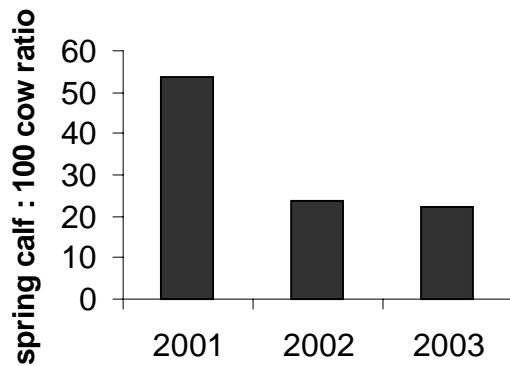


Figure 6. Three-year elk recruitment pattern in the lower Madison valley study area.

This number is important because it speaks to the yearly productivity of a population. The spring elk recruitment ratio recorded in 2003 was similar to that recorded in 2002 at 22 and 24 calves per 100 cows, respectively, but both 2003 and 2002 showed lower spring recruitment than in 2001 (Figure 6). A pattern of high recruitment in 2001 followed by two years of lower recruitment in 2002 and 2003 tracks the pattern observed in the Madison-Firehole region of Yellowstone National Park as well

as in the Gallatin River canyon, suggesting a regional factor is involved in elk recruitment patterns in the area. Using the ratio of calves to cows to obtain the percentages of each age-sex class in the population over the last two winter seasons, there were approximately 798 calves in the in the 2001-02 and 606 calves in the 2002-03 wintering elk herds, respectively, while there were 3198 cows present in 2001-02 and 2840 cows in 2002-03.

During surveys designed to enumerate the elk population, the numbers of other ungulates in the study area are also tracked. Because the majority of pronghorn usually occur in the open and sagebrush flats, where ungulate survey efforts are concentrated, the number of pronghorn in the study area typically can be estimated with high precision. Overall, pronghorn population estimates in 2002-03 were roughly similar to the estimates for 2001-02, with less than 50 animals in the study area during the core of the winter and higher numbers during the early and late winter periods (Figure 7). However, there were considerably more pronghorn in the study area in the early winter period of 2002-03 than in 2001-02, as well as during the early February survey period in 2003. This large immigration of pronghorn into the study area in mid-winter can be attributed to a period

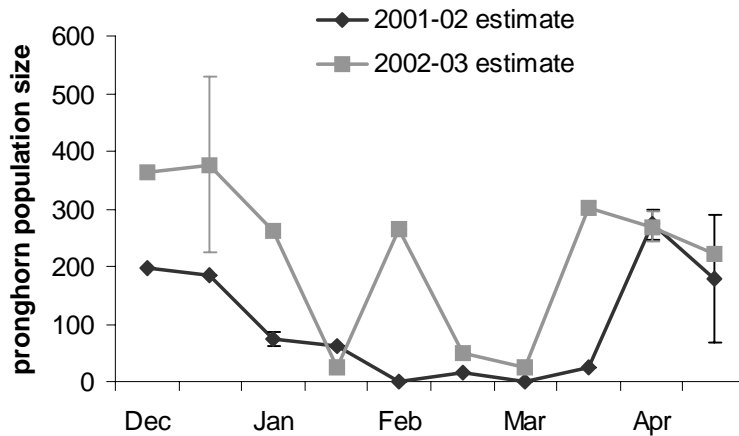


Figure 7. Comparison of 2001-02 and 2002-03 wintering pronghorn populations. Bars= 1 standard error.

spring pronghorn migration began earlier in 2003 than in 2002. Unfortunately, we have not been able to collect reliable information on pronghorn recruitment in the study area due to the distances at which pronghorn are usually observed and our research focus on the more abundant elk population.

of thaw in the grassland, and exemplifies how dependent pronghorn spatial dynamics are on snow conditions (Figure 8). In fact, during this count, pronghorn were present only in the far northern reaches of the open flats, and they moved north to wintering grounds before the next survey period when snow conditions began to worsen in the grasslands. Also notable is that the

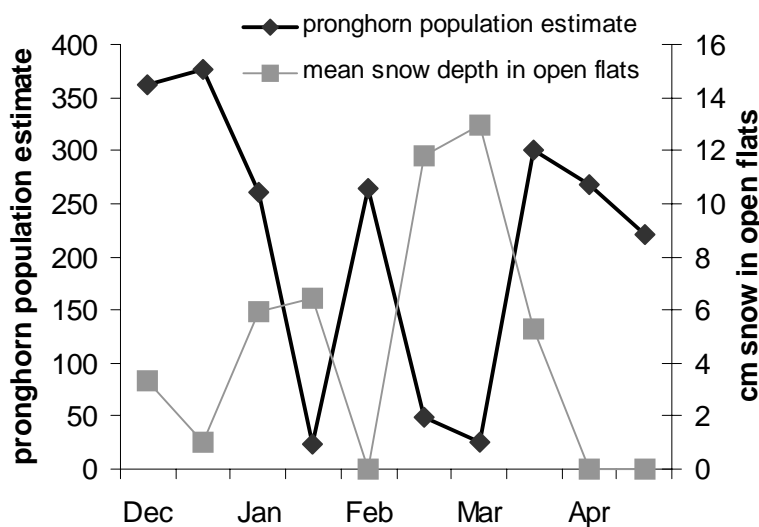


Figure 8. Comparison of 2002-03 Pronghorn population estimates and snow conditions in the open flats. The dependence of pronghorn numbers in the study area on snow conditions is exemplified by the negative relationship between pronghorn numbers and snow depth: as snow melts in the open flats, pronghorn become more abundant.

Unlike pronghorn and elk, mule deer in the study area typically occupy habitats other than the open and sagebrush flats. This habit makes estimates of mule deer numbers less precise because survey efforts are concentrated in the open and sagebrush flats. However, we are still able to obtain an idea of the total mule deer numbers in the study area for each survey period, and numbers in 2002-03 were very similar to numbers in 2001-02, with only minor deviations and a slight difference in the timing of the spring migration period (Figure 9). The wintering population was approximately 150 animals in

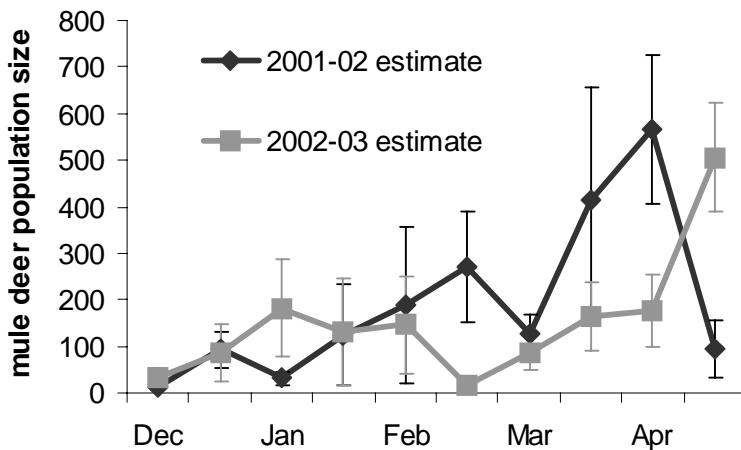


Figure 9. Comparison of 2001-02 and 2002-03 wintering mule deer populations. Bars= 1 standard error

both years, while numbers increased during the migration, which seems to be driven by snow conditions in the forested areas (Figure 10). Mule deer recruitment estimates have been high during all three years of the study (Figure 11). Mule deer recruitment is indexed as the number of fawns per 100 adults, and the 2003 spring value of

47 is similar to the 2001 spring value of 46, while the value dipped to 33 in the spring of 2002. All of these ratios are relatively high, though, and are characteristic of productive populations.

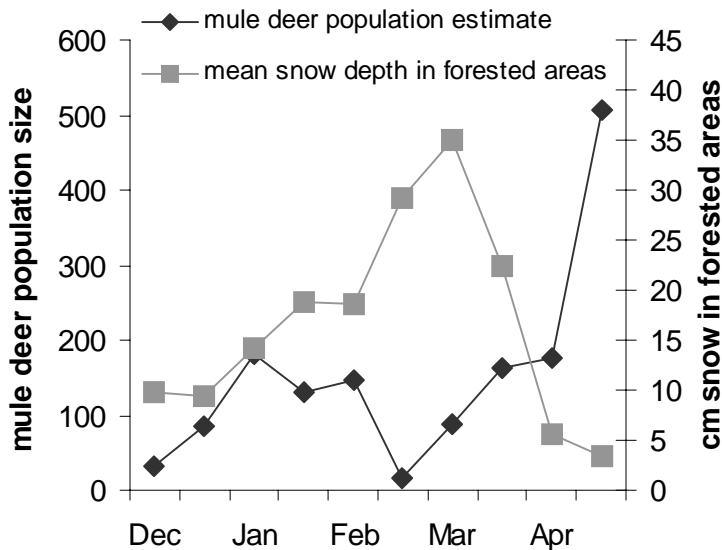


Figure 10. Comparison of 2002-03 mule deer population estimates and snow conditions in forested areas. As the snow melted in the spring, mule deer made their spring migration into the forested areas of the lower Madison valley study area.

White-tailed deer, moose (Figure 12), and mountain goats have also been documented in the study area during the winter months, though all are relatively rare. During survey periods in the last two winters, only 50 white-tailed deer, 7 moose, and 2 mountain goats have been recorded. Further, no predator-induced deaths of these species have been recorded in the area by the research team during the winter study period, so they do not factor into wolf-ungulate dynamics in the study area. Thus, detailed population data on these species is not summarized here.

In summary, the elk population in the lower Madison valley study area dominates the ungulate community. The elk population has been on an increasing trend for approximately 30 years based on Montana FWP trend counts. Elk numbers on the wintering ground in mid-winter have been similar for the last two years, but the elk population in other parts of the winter has been dynamic, with total population estimates ranging from 873 to 5341 over the last two winters.

Recruitment ratios have been relatively high in this elk population compared to other areas over the last three years, and have followed the same trend as other populations being studied in the region. Pronghorn and mule deer population estimates in the study area have also been similar during mid-winter in the last two years, though the timing of migration periods has differed between years. Mule deer recruitment has been relatively high for the last three winters of study. Other ungulates have been seen in the study area and recorded in surveys, but they are rare. Over the last three years, the importance of snow in determining the large-scale spatial distribution of ungulates has become evident.

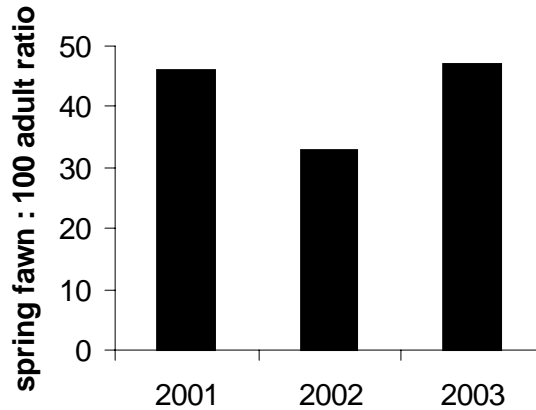


Figure 11. Three-year mule deer recruitment pattern in the lower Madison valley study area.



Examples of the importance of snow conditions in affecting movement across study area boundaries have been illustrated for each of the three dominant ungulate species in the area. Human hunting also seems to affect the distribution of elk between habitat types during the winter months, with fewer elk residing in open areas during hunting seasons.

Figure 12. Moose and calf on Corral Creek Ranch. Moose are present in the lower Madison valley study area, but they are not as numerous as elk, pronghorn, and mule deer.

Wolf Pack history

In the winter of 1999, female wolf #115 was seen with 1 uncollared wolf on the Sun Ranch, and they reproduced in a den along Wolf Creek in the spring of 2000. Not much is known about wolf use of the study area during this time period, nor about other packs that may have used the study area. However, this limited information about an establishing wolf pack in prime ungulate winter range was a major impetus for starting the lower Madison valley wolf-ungulate research project.

By the winter of 2000, this pack had increased to 5 wolves and was named the Taylor Peak pack. A field data collection program that involved intensive wolf monitoring was begun at the site, and beginning with the winter of 2000-01, detailed information about the winter habits and space use of wolves in the area has been collected. This pack denned in the study area in the spring of 2001, but reproduction was unsuccessful, as pups were never seen. In the summer and fall of 2001, this pack was involved in depredation events on domestic sheep and cattle in the Madison valley. After the first depredation event, another collar was deployed in the pack to facilitate increased monitoring, but eventually 2 wolves from the pack were lethally removed after the next confirmed depredation event. This removal left 3 wolves in the pack, 1 of which was uncollared. The uncollared wolf had actually been previously captured, ear-tagged, and collared, as this wolf (#250) carried a drop-off GPS collar in the spring of 2001. Wolf #250 remained in the region after the removal, and was mistakenly shot by a hunter in the 2001 late elk hunting season near Bear Creek. The remaining 2 collared wolves in the pack left the immediate area. Wolf #115 is now the breeding female in the Freezeout Pack, located primarily in the southern and western portions of the Gravelly Mountains, as well as in the Snowcrest range. Wolf # 234, which was collared as a result of the first confirmed depredation event involving the Taylor Peak pack, is now the breeding male in the five-member Sentinel Pack, which has a territory spanning the Madison range into the Taylor Fork and Bear Creek watersheds. This pack has been located north of the study area many times during the winters of 2001-02 and 2002-03, but as of yet they have not been detected within the boundaries of the study area. Most recent reports indicate that this pack has at least three pups in 2003.

The 12-member Chief Joseph pack also occasionally used the study area in the winter of 2000-01, though their primary territory at this time was located in the Gallatin River canyon. The breeding wolves in this pack died in the summer and fall of 2001, and subsequently many of the remaining wolves split up. Most of these wolves have remained uncollared since this time, so the exact fate of the majority of the pack is unknown. Approximately 6-7 uncollared wolves seemed to be traveling together within the typical Chief Joseph pack territory over the 2001-02 winter. This pack successfully denned in Daly Creek in 2002, and had at least 6 pups, though the fate of these pups is unknown. Over the winter of 2002-03, 11 uncollared wolves appeared to be traveling together in the typical Chief Joseph pack territory. This pack again denned in 2003, though the number of pups that have survived is unknown. Additionally, 3-4 uncollared wolves have denned nearby on private land in the Gallatin canyon, within the typical territory of the Chief Joseph pack, and likely are a splinter group from the main pack because of high levels of movement between the two dens.

Collared wolf #198 from the Chief Joseph pack dispersed in 2001 and paired with an uncollared wolf to form the breeding pair of wolves that used the lower Madison valley study area in the 2001-02 winter season. This pack was named the Taylor Peak II pack because they usurped the territory of the disbanded Taylor Peak pack. The activity of this pack was well documented over the course of the 2001-02 winter, and they denned in the study area in the spring of 2002. Three pups were consistently seen by Sun Ranch personnel during the summer and fall of 2002. One of these pups was hit and killed by a vehicle on US Highway 287 in the fall of 2002, and 2 successfully survived to the winter of 2002-03. The Taylor Peak II pack thus consisted of 4 wolves during the latest winter field season, and they again denned in the study area this spring. Latest reports indicate that the pack has 5 pups.

Due to the unstable nature of the wolf population in and around the study area over the last three years, the overall presence of wolves in the study area has been rather variable. Wolf presence is measured in wolf-days, or one wolf spending one day in the study area. The total number of wolf days recorded in 2001-02 was approximately half of the total obtained in 2002-03, at 237 and 466, respectively. Concurrently, the pack using the study area in 2001-02 was half the size of the pack using the study area in 2002-03. At 436, the wolf-day total in 2000-01 was similar to the 2002-03 total, even though monitoring for wolf days did not begin until late January in 2000-01, two months into the first field season. These figures reflect the total potential impact that wolves can have on ungulate populations in the study area, because other than by kill rates, the total number of kills a pack of wolves can make is limited only by the number of wolves present and the amount of time that they spend in the study area. For instance, in the Madison-Firehole region of Yellowstone National Park, the number of wolf-days has been at least four times the wolf-day total in the lower Madison study area in each of the last three winters, making the potential demographic impacts of wolves on ungulates in that system larger than in the lower Madison valley system. In the lower Madison system, the potential demographic impact of wolves on ungulate populations has been dampened by the inability of wolves to form larger packs due to removals related to livestock depredations and poor pup recruitment.

Interesting patterns have also developed relative to wolf space use in the lower Madison valley (Figure 13). One method of determining yearly wolf space use patterns is to create a polygon encompassing all wolf locations obtained over the course of study in order to define wolf territories. Considering wolf location data in this way, wolf use of the study area appears to have been quite variable over the last three winters. In 2000-01 and 2001-02, the territory boundaries of the pack inhabiting the study area extended east of the area into the mountains, but not in 2002-03. In 2001-02, the territory of the resident pack did not include the southern portion of the study area as it did in 2000-01 and 2002-03. Finally, in 2001-02 and 2002-03, the territory boundary of the resident pack included areas west of the Madison River on the Wall Creek WMA, while the resident pack's territory did not extend west of the river in 2000-01.

Another method of considering wolf space use is to determine how frequently wolves used different portions of their territories, or in other words where wolf locations were dense and not dense when plotted on a map. Considering the data in this manner shows that wolf spatial use patterns have been remarkably similar over the last three winters, with activity concentrated on the western slope of the Madison range foothills in

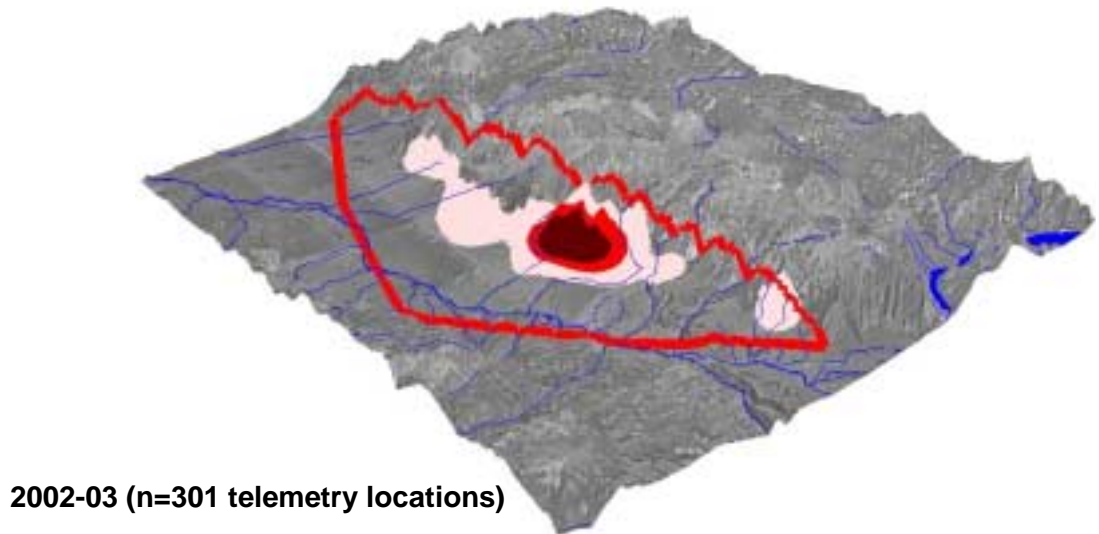
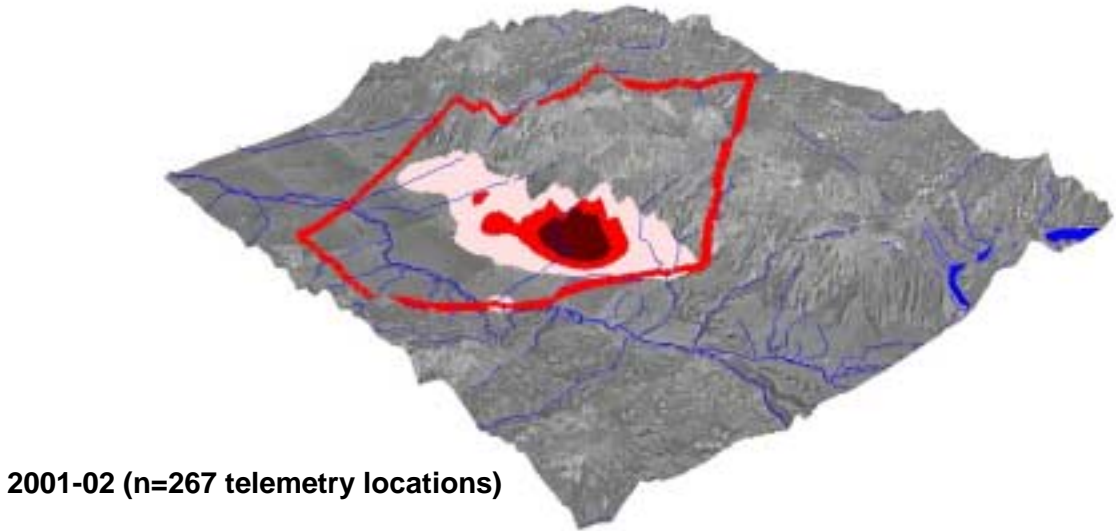
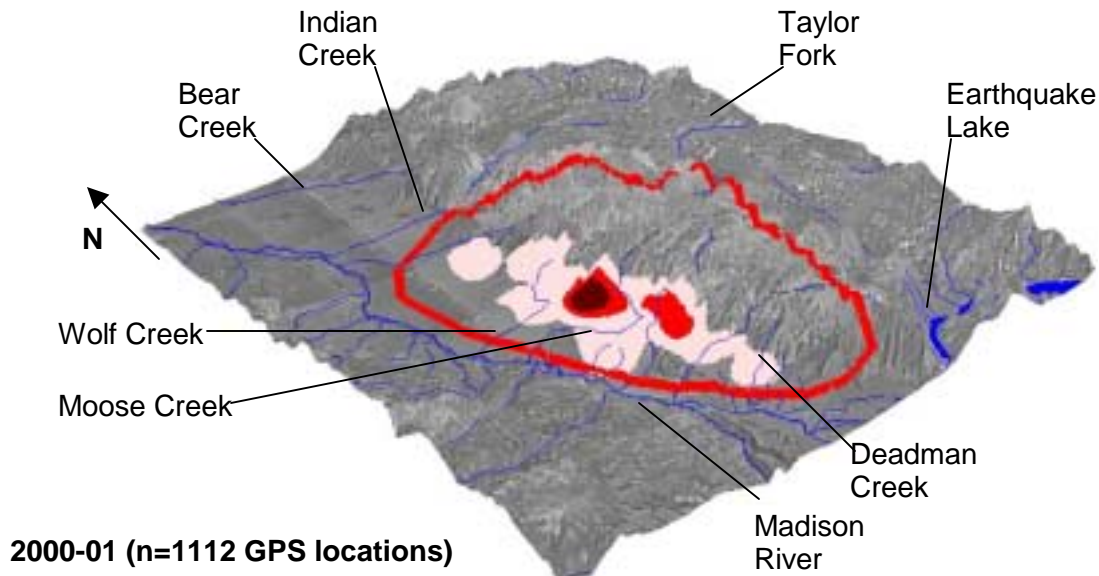


Figure 13. Wolf winter space use patterns in the lower Madison valley study area, 2000-2003. The dark outline represents the entire wolf territory and encompasses all wolf locations for each winter season. The gradation from dark red to pink represents the frequency of wolf use in different parts of the study area; the dark red areas encompass 50% of all wolf locations for each year and represent the wolf core use areas, the lighter red areas encompass 75% of all locations for each year, and the pink areas encompass 95% of the wolf locations for each year.

the area of Wolf and Moose Creeks, an area of high ungulate density (Figure 13). A notable difference between wolf space use patterns, however, is the lack of wolf use of the southern portion of the study area in the 2001-02 winter. Also of note is how much more precisely space use patterns can be defined with an increased number of locations, such as in 2000-01 when a GPS collar was deployed on the resident pack in the study area and generated approximately four times the number of locations obtained in 2001-02 and 2002-03. This increased precision is evident in the smaller areas and more intricate patterns in the contours defining the frequency of wolf use across the study area in 2000-01 as compared to 2001-02 and 2002-03.

Due to an unprecedented growth rate for the wolf population in the GYE and a nearly saturated wolf population inside of park boundaries, the appearance of new packs outside of the park, composed of dispersing wolves from established packs, has been common over the last few years. Consequently, uncollared groups of wolves have shown up in the lower Madison valley study area in each of the last 2 winters. In the 2001-02 winter, 3 uncollared wolves were reported several times in the southern portion of the study area. In 2002-03, 3 uncollared wolves were again repeatedly reported in the region, this time primarily to the south and the west of the study area. In both years, attempts were made to draw the wolves into the open, using bait piles composed of ungulate carcasses donated by the Turner Endangered Species Fund, in order to deploy radio collars. Both attempts were unsuccessful, and the wolves were not reported again after the collaring efforts began. The wolves likely were dispersers from other packs looking for new territories, based on their appearance during the breeding season, when wolf dispersal is common. Such wolves likely will not set up new territories in areas already occupied by established packs. However, given the dynamic pack structure over the last three winters and the dependence of this research on radio-collared wolves, it is best to keep as many wolves in the area collared as possible in case of more restructuring in the SW Montana region and/or colonization of the study area by a new wolf pack. Therefore, all reports of wolf sightings have been useful, and efforts to collar new groups of wolves seen in the area will continue in the future of this research project.

Wolf predation

Wolf kills are searched for daily using tracking methods developed for this study area and described in previous annual reports. Thorough investigations, or necropsies, are conducted on all carcasses located on wolf travel routes in order to accurately determine the cause of death for each animal to the best extent possible (Figure 14). Animals thought to have been killed by wolves are placed into one of three categories: definite kills, probable kills, and possible kills. The kills classified into the definite and probable categories are reported here as wolf kills.

Over the 2002-03 field season, a total of 54 kills were located on wolf travel routes (Table 1). Of these kills, 81% were elk, 11% were mule deer, and 7% were pronghorn, while on average over the course of the winter, elk made up 86% of the ungulate community in the study area, mule deer made up 5% of the community, and pronghorn constituted 9% of the ungulates in the study area. In terms of age and sex classes of ungulates taken by wolves, the majority of wolf predation pressure was focused on elk calves, which tallied 51% of the total number of wolf kills located in 2002-03.



Figure 14.
Necropsy of elk calf found on wolf travel route.
 This calf was classified as a definite wolf kill based on hemorrhaging patterns, puncture wounds, and tracks detailing the chase scene.

Table 1. Wolf-killed ungulates located during the 2002-03 winter season. Numbers in parentheses are probable kills; numbers outside of parentheses are the total number of kills located in 2002-03, including definite and probable kills.

	Elk				Mule Deer				Pronghorn			
	calf	cow	bull	total	fawn	doe	buck	total	fawn	doe	unknown	total
Dec	1	3(2)	0	4	1(1)	0	1(1)	2	0	0	0	0
Jan	6(1)	5(3)	0	11	0	1	0	1	0	0	1	1
Feb	6	3(1)	1	10	0	1	0	1	1	0	0	1
Mar	11(2)	2	1	14	2	0	0	2	0	0	1	1
Apr	4(2)	1(1)	0	5	0	0	0	0	0	1(1)	0	1
Total	27(5)	14(7)	2	44	3(1)	2	1(1)	6	1	1(1)	2	4

In all three winter seasons of this project, wolf selection of prey species has been similar (Figure 15). Concurrent with their dominance of the ungulate community, elk have been the focus of wolf predation pressure, making up 74-93% of animals taken. The lowest percent of elk documented in the wolf diet in the lower Madison study area was in 2001-02, when mule deer constituted 26% of the total kill. The resident pack during this winter was a breeding pair of wolves, thus they may have focused more predation effort on mule deer because of the smaller deer body size compared to elk, hence a smaller threat of injury to wolves making a kill. Pronghorn only showed up in the wolf diet in the study area in 2002-03, though a possible pronghorn kill was also located in 2000-01. Despite the smaller portion of wolf predation pressure directed at mule deer and pronghorn populations, wolf predation might still be important for the population dynamics and behavior of these species in the future. Their small population sizes might make a smaller amount of predation pressure proportionally similar to or greater than the

predation pressure exerted on elk by wolves. Thus, monitoring of predation on these species will continue so that future evaluations of wolf impacts on their populations can be made.

In terms of wolf selection of different age and sex classes of elk, wolf predation was similar in 2000-01 and 2002-03, when approximately 70% and 64%, respectively, of elk predation by wolves was directed at calves (Figure 16). However, in 2001-02, 88% of elk kills were calves, which again

could reflect the fact that calves pose less of an injury threat to a pair of wolves than adult elk do because of their smaller body size. Likewise, the total elk kill contained a more significant proportion of cows in 2000-01 and 2002-03, when pack sizes were larger, than in 2001-02. In the last two winters, elk calves and cows have constituted similar percentages of the total elk population in the study area at approximately 17% and 74%, respectively. Thus, despite the increased focus on elk calves in 2001-02, wolves showed strong selection for elk calves and against elk cows in both 2001-02 and 2002-03, when elk numbers were known with relative certainty in the study area. Bull elk, including yearlings, have not made up a large portion of the total wolf offtake of elk in any of the last three winters.

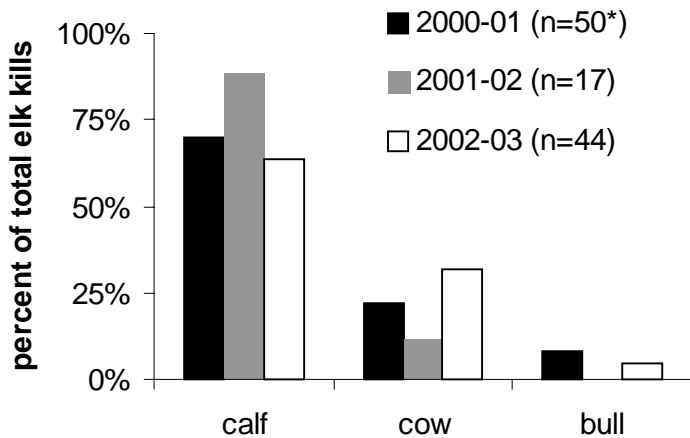


Figure 16. Wolf selection of elk age-sex classes. * Continuous wolf tracking in 2000-01 did not begin until late January; tracking began in early December during both 2001-02 and 2002-03.

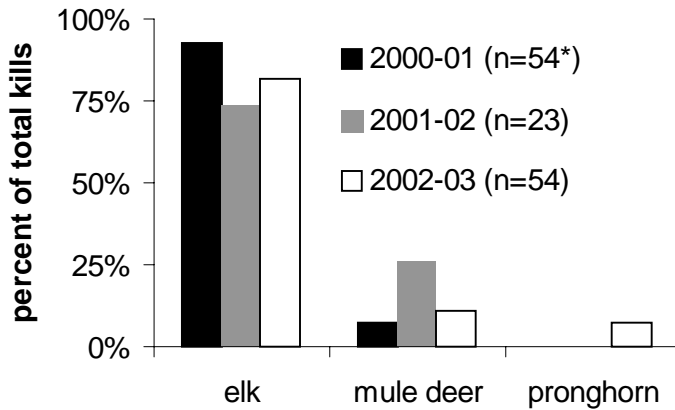


Figure 15. Wolf prey selection by species. *Continuous wolf tracking in 2000-01 did not begin until late January; tracking began in early December during both 2001-02 and 2002-03.

Over the course of a winter, the field crew is not able to track wolf movements with perfect efficiency due to weather and other constraints, making our knowledge of wolf predation incomplete. To this end, Rose Jaffe, John Borkowski, Bob Garrott, and Scott Creel of the Ecology and Mathematical Sciences Departments at Montana State University have developed and validated a method to account for the uncertainty involved in knowledge of wolf

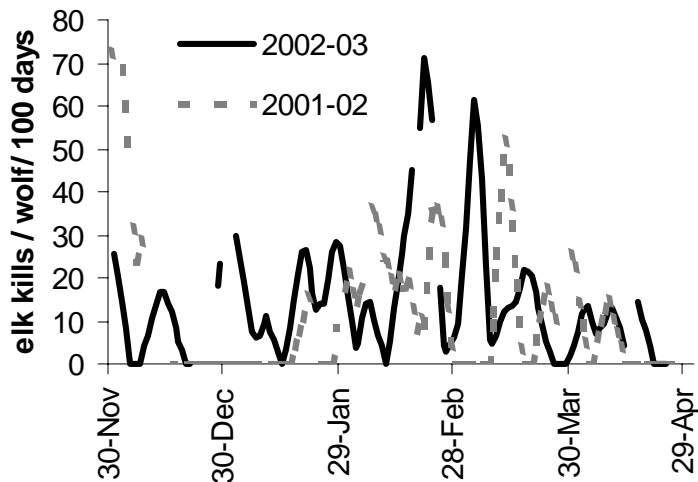


Figure 17. Wolf kill rates in 2001-02 and 2002-03.

movements and the imperfect efficiency of field crews in detecting wolf kills when assessing the impact of winter wolf predation. The method they developed permits assessment of how many kills have been missed during tracking as well as examination of winter wolf kill rates across time, and the method has been applied to the data collected in the lower Madison valley study area. For 2001-02 and

2002-03, when intensive wolf tracking methods were employed for the full winter season, application of this estimation method showed that on average, elk kill rates have been similar at 11.2 and 13.75 elk kills per wolf per 100 days, respectively. In general, these rates are exceptionally high compared to rates reported in the literature, from research conducted on the northern range of Yellowstone National Park and other areas in North America. These rates are also more than twice the rates obtained in the Madison-Firehole study area in Yellowstone National Park, where wolf predation is intensively studied as part of the same larger research program using similar methods as those used in the lower Madison study area. Such variation in wolf kill rates as reported in these different areas leads to curiosity about the cause of variable wolf kill rates. Examination of wolf kill rates over time from the lower Madison study area demonstrates that wolf kill rates are also variable throughout the winter season, as well as among years (Figure 17). Such variation over any given winter season elucidates the fact that the high wolf kill rates in the Madison valley are actually due to very high peaks in the kill rate that occur at short and specific times during the winter. The cause of this variation across time during the winter is the focus of one of the questions being addressed in Justin Gude's MS research. The relative importance of factors that may influence wolf kill rates in the study area will begin to be assessed with this research, and will likely be continued during the research tenure of other graduate students in Bob Garrott's lab group. Knowing what factors influence kill rates would allow insight into what conditions are necessary for high kill rates and low kill rates, and therefore into the effect of each wolf on ungulate populations in future years as conditions change. Combined with knowledge of the number of wolves in a given area, such information would permit estimation of total wolf offtake from ungulate populations, and thus the demographic effects of wolves in variable future winter conditions.

Many quantifiable factors are potentially important in driving the variability in wolf kill rates in winter, including dynamic prey numbers in the study area, changing ungulate nutritional condition, snow conditions, the number of animals dying from other causes and providing meat for wolves to scavenge, and even the loss of animals killed by

wolves to scavengers. These relationships can be complicated, for example the loss of kills to scavengers may depend on the spatial distribution of wolf kills throughout the winter. Most kills in the lower Madison study area are located in the open flats and hills (Figure 18). In the open portions of the study area, scavengers seem to have the ability to locate kills more effectively, as more scavengers are typically seen on fresh wolf kills in open than in forested areas (Figure 19). Due to this pattern, regardless of the amount of a kill eaten by wolves during the first sitting, kills made in the open are usually completely consumed within a couple of days. This loss of meat available to wolves prevents the pack from returning to kills made in the open, thereby necessitating the need to find more food and potentially affecting the kill rate.

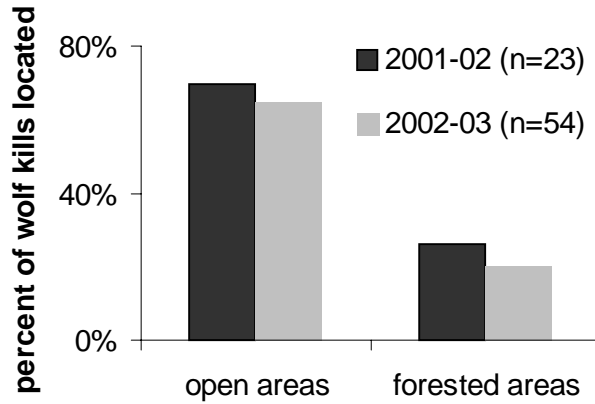


Figure 18. Location of wolf-killed ungulates in 2001-02 and 2002-03.

Information on wolf offtake can be combined with information on ungulate population sizes in order to determine the relative impact of wolves on ungulate demographics. As elk are the current focus of the wolf diet in the study area, summarizing wolf impacts on the elk herd is most informative and useful to wildlife managers at this point in time. This issue is also of great interest to the public, as elk numbers in the GYE have been controversial for some time. Beginning in the 1990's, the controversy over elk numbers has surrounded a perceived overabundance in many areas and the resulting impacts that elk might be having on range conditions and other aspects of the GYE environment. With the reintroduction and growth of the wolf population in the GYE, considerable public focus has shifted to what effects wolf predation might have

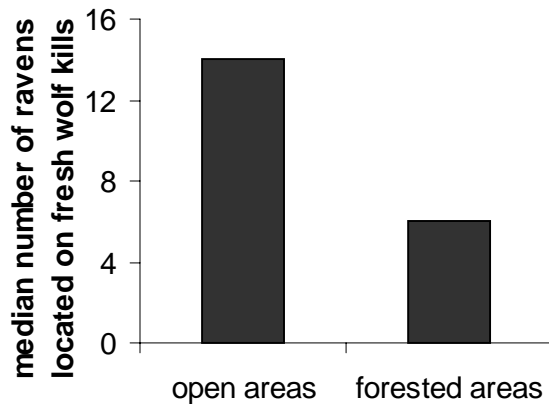


Figure 19. Ravens scavenging on fresh wolf kills (<2 days since kill).

on elk population dynamics and as a result human hunting opportunities. Inasmuch, it is important to summarize the effects of wolf predation on elk along with the effects of human hunting pressure. A January late season hunt has been conducted in the study area for many years, including the last two when detailed wolf offtake information is available for the entire winter. Additionally, Montana FWP and the Madison Valley Ranchlands Group initiated a new A-7 hunt in the study area this past winter, which lasted through mid-February. Significant effort has been

directed at collecting data on hunter harvest from the wintering elk herd in order to consider the effects of both hunter harvest and wolf predation on the elk population in the study area.

Hunter harvest

In 2002-03, we continued collaboration with Fred King and Ken Hamlin of Montana FWP and Gene and Carol Holden of the Sun Ranch, and initiated collaboration with Papoose Creek Lodge personnel and Lane Adamson of the Madison Valley Ranchlands Group to collect information on the antlerless elk harvest in the lower Madison valley study area during the winter months. Collecting data from hunters would not be possible without these cooperators, and this data will be important for understanding elk population dynamics in the study area. We are grateful for the cooperation, and hopefully it will continue into the future.

Hunter data collection consists primarily of monitoring the total harvest and the age of harvested animals in terms of age classes (calf, yearlings, and adults), as well as obtaining more specific age information from harvested adult elk through incisor teeth collected from successful hunters' animals. Cementum is deposited on the roots of mammal teeth every year in bands that can be read in a fashion similar to reading the age of tree using the rings. The tooth-aging process, however, requires use of specialized equipment, necessitating sending the teeth to be processed at a laboratory. The exact age distribution of animals harvested in the 2002-03 winter, therefore, is not yet available, but the full age breakdown of animals harvested in the 2001 and 2002 HD362 late seasons has been determined. As elk calves do not reproduce, yearlings seldom do, and adult cow elk typically do, it is apparent that hunter harvest is focused primarily on the reproductive portion of the elk population, i.e. the prime-aged cows, while wolf predation is not

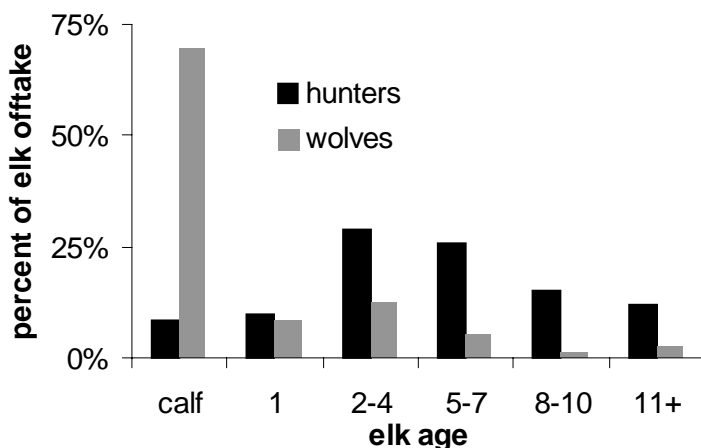


Figure 20. Selection of elk age classes by hunters and wolves, 2000-2002.

also removes all calves that she potentially would have in the future. Reducing population size or limiting population growth is the management-oriented purpose of most antlerless elk hunting seasons. This management goal was augmented in the lower Madison valley study area over the 2002-03 winter with the institution of the A-7 hunt on private lands. Based on our records, this new season led to a 61% increase in

the antlerless elk harvest in the study area boundaries compared to the 2001-02 winter elk harvest.

Over the last 3 winters, data collection from hunter samples has also consisted of taking samples of fecal pellets from harvested cows in order to conduct laboratory assays testing for pregnancy rates. Substantial effort has been put into validating these assays for use with fecal samples collected in January, early in the elk pregnancy period. This work has led us to conclude that one-sample assays are not reliable for samples taken early in elk pregnancy due to inconsistencies in hormone levels between cows in January. Collection of fecal samples from hunters will therefore not continue in future late season hunts.

Total predation impacts on elk

Examination of known hunter harvest and estimated wolf offtake reveals that hunter impacts have been directed at cow elk while wolf impacts have been directed at calves over the last two winter seasons (Figure 21). Not considering uncertainty in these figures, wolves have taken a larger percentage of elk calves than hunters have taken of elk cows. Removing calves has a smaller demographic impact on elk populations than removing cows, but both wolf and hunter offtake combined have not resulted in a large enough elk removal to cause a detectable decline in the size of the population. Two winters, however, is not enough time to document the range of potential impacts of wolves and hunters on the wintering elk population. As data are collected over more winters in the future, we will be able to understand and model impacts of wolves and hunters on elk numbers over a range of plausible scenarios defined by the range of variation in data collected in different field conditions.

Other wolf effects

Because wolves kill ungulates, often the most publicized potential effects of wolves on ungulate populations relate to demographics; in this region the controversy over wolf effects on elk numbers is often discussed in newspapers, for example. However, because wolves pose a threat of mortality to elk populations, individual elk might make changes to their behavioral patterns that reduce the threat of being killed by

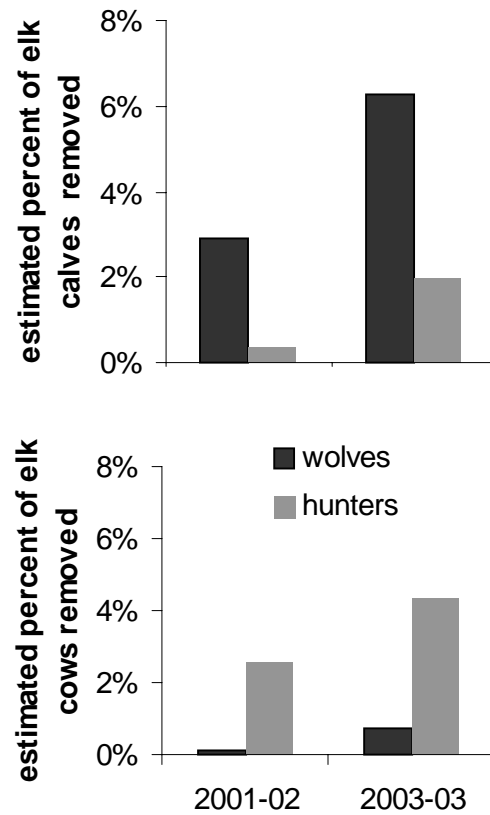


Figure 21. Estimated percent of wintering elk calves and cows removed by wolves and hunters in the 2001-02 and 2002-03 seasons. Winter predation and harvest of bulls has been minimal in both seasons, and is therefore excluded here.

wolves. Such an elk response to the threat of mortality from other predators is well documented, for instance it is normally accepted that elk change their distribution patterns during hunting season in order to reduce the threat of being harvested by hunters. Two of the most commonly cited aspects of behavior that are adapted by animals such as elk in order to reduce the threat of predation are changes in group size and distribution. For example, individual elk in large groups are less likely to be selected by wolves upon an encounter than individual elk in small groups, and smaller elk groups are perhaps less likely to be found by wolves than large elk groups. Elk also might make distributional responses to wolf patterns of landscape use in order to avoid wolf encounters and the associated risk of predation, similar to the response made to human hunting pressure.

Because elk group size and distribution together describe how elk use a particular landscape, changes in these behaviors due to wolf predation pressure might have repercussions for landowners and managers of elk winter range. Changes in these elk behavioral patterns might change elk grazing patterns and thus have implications for range condition and ranchers that depend on elk winter range for cattle production. Such changes might also have implications for state wildlife managers. The state of Montana, for example, owns several WMA's that encompass core elk winter ranges very similar to the one in the lower Madison valley study area, and these WMA's are surrounded by private lands. Changes in elk group size and distribution could affect elk use of WMA's and thus depredation complaints on private lands in the surrounding areas. Also of interest to landowners and wildlife managers is how changes in elk group sizes and distribution might affect hunting opportunities and hunter success rates.

Due to the likelihood of changes in how elk use landscapes with a newly established wolf presence, and the potential implications of such changes, methodology was developed at the lower Madison site to study how elk respond to wolves in terms of group sizes and distribution (Figure 22). As part of this research focus, Fred King of



Figure 22. Scanning to document elk behavior around wolf locations. To determine how wolves affect elk group sizes and distribution, 519 surveys of 1 km² areas around wolf locations and in areas without recent wolf presence have been conducted over the last two winters.

Table 2. Variables shown to influence elk group sizes, as determined using 12 years of data collected by Fred King at Wall Creek state WMA (n= 1228 elk groups).

Variable	Effect
(1) Migration	Smaller groups early and late in the winter, during migratory periods
(2) Time of Day	Larger groups later in day than in early morning
(3) Habitat Type	Larger groups in the open, flat grassland; smaller groups in forested areas; and mid-sized groups in open hills
(4) Temperature	Larger groups in colder temperatures
(5) Season	Smaller groups after onset of spring meltout
(6) Population Size	Larger groups when more elk were present in the count area

Montana FWP has made count data and maps of elk group distribution on Wall Creek WMA available to the research team. Fred’s data dates back to 1986, or 9 years prior to the onset of wolf reintroductions into nearby Yellowstone National Park and 12 full years before colonization of Wall Creek WMA by wolves dispersing from Yellowstone. The usefulness of these data are that they provide information on how elk respond to environmental variables other than wolves, which permits assessment of how elk behavior has changed in the presence of wolves. These data were analyzed in order to determine what factors influenced elk group sizes prior to wolf presence in the region, revealing several important variables (Table 2). Because several researchers studying other ungulates have found that the same factors influence both group sizes and distribution patterns, this analysis provided insight into factors that should be considered when analyzing the effect of wolves on elk group sizes and distribution in the lower Madison study area.

Analyses of wolf effects on elk group size and distribution have begun with data collected at the lower Madison valley site, though only data collected in the 2001-02 winter, when a breeding pair of wolves used the study area, has yet been considered. Interpretations of the results of these analyses are provided here with the caveat that results will likely change in some manner when data from 2002-03 are considered. In terms of elk group size, it appears that wolf effects are minimal compared to the effect of other variables, particularly habitat type (Figure 23). In 2001-02, elk groups in the open flats were on average 60% larger than groups occurring in sagebrush flats, where elk group sizes were the next largest, and 99% larger than groups occurring in forested areas, which had the smallest elk groups. With such a large effect of habitat type on elk group sizes, it was difficult to detect an effect of wolves without considering habitats, even if wolves did affect elk group sizes. The data did contain evidence that wolves affected elk group sizes within each habitat type, though the effect was small compared to the overall effect of habitat.

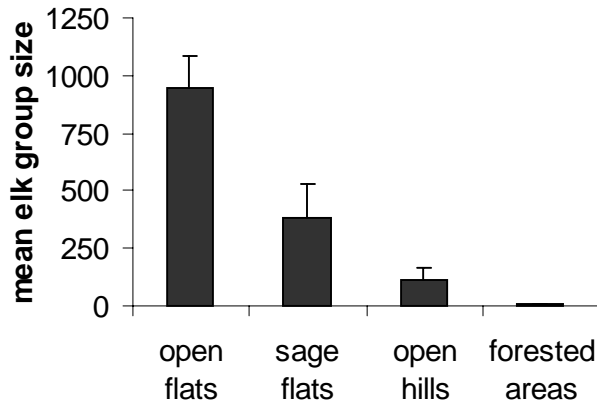


Figure 23. Elk group sizes in the major habitat types in the lower Madison valley study area. Bars= 1 standard error.

infrequently by wolves. The hypothesis of an even more dynamic elk distribution based on a finer breakdown of landscape use by wolves was also well supported by the data (Figure 25). Overall, the 2001-02 data showed that elk distribution was more dynamic in areas used by wolves and less variable in areas not used by wolves. Another important result from this analysis was that the chance of elk presence around wolf locations was initially much higher in areas used more often by wolves than in areas not used by wolves, indicating that wolves centered their activity in areas with a high concentration of elk groups. This result signifies that wolves did not push elk completely out of the area, and that wolves focused their movements in areas with high densities of elk throughout the winter.

Taken as a whole, the implications of the results of analysis with the 2001-02 data on elk group size and distribution for landowners and managers seem to lie mainly in shifted elk grazing patterns. In areas frequented by wolves, elk movement and therefore grazing pressure seems to be more dynamic and perhaps to cover more area on the winter range. The patterns uncovered in the data did not indicate potential problems for state managers in terms of large-scale elk movements out of grassland-dominated areas, such as many WMA's in southwest Montana. Further, an analysis of hunter success in the January late season in the lower Madison study area showed similar success for

The 2001-02 data contained support for hypotheses of wolf effects on elk distribution, however. The data most supported the hypothesis that elk distribution was slightly more dynamic inside the wolf territory boundary than outside of the wolf territory (Figure 24). This pattern is evidenced by a decreasing chance of elk presence around wolf locations inside the wolf territory, indicating some elk movement from areas where wolves were encountered, while the chance of elk presence around wolf locations outside of the wolf territory did not seem to change over time, indicating a static elk distribution in areas used

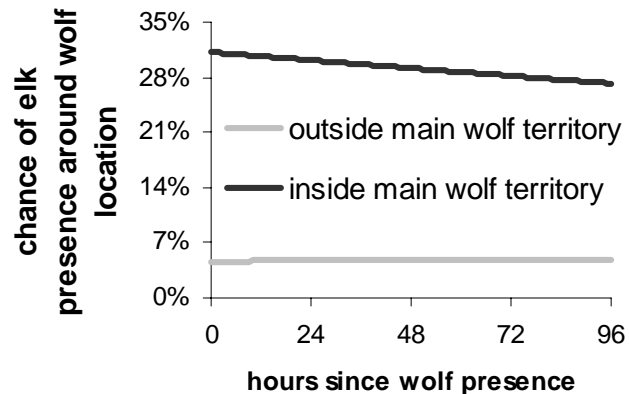


Figure 24. Best model representing elk distribution in relation to wolf movements in the lower Madison valley study area. This model fits the data well (Hosmer-Lemshow Goodness of Fit test P=0.3673).

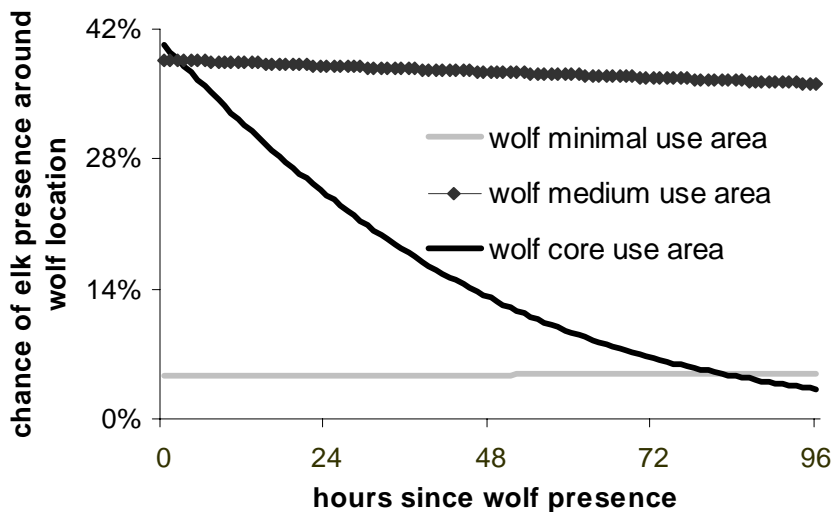


Figure 25. Well-supported model showing dynamic elk movements in areas most frequented by wolves. This model fits the data well (Hosmer-Lemsho Goodness of Fit Test $P=0.8164$).

hunters before and after wolf colonization of the study area. This success was elevated in 2002-03, with the implementation of the new A-7 hunting season.

Environmental condition data

Data on winter conditions can be useful for understanding the dynamics of this system within a given year. For instance, snow conditions were drivers of changes in ungulate numbers and distribution in the study area in 2002-03, as discussed earlier in this report. Snow conditions are also being considered as potential drivers of wolf kill rates. Environmental condition data will also become important for comparisons of system dynamics as data continues to accumulate into the future, permitting analysis of factors driving longer-term processes. For this reason, comparisons of yearly conditions are summarized here.

Scott McClintok of High Valley Ranch has tracked daily high and low temperatures for the last two winter seasons, beginning in January of 2002, and has made these data available to the research team (Figure 26). Temperatures were variable within

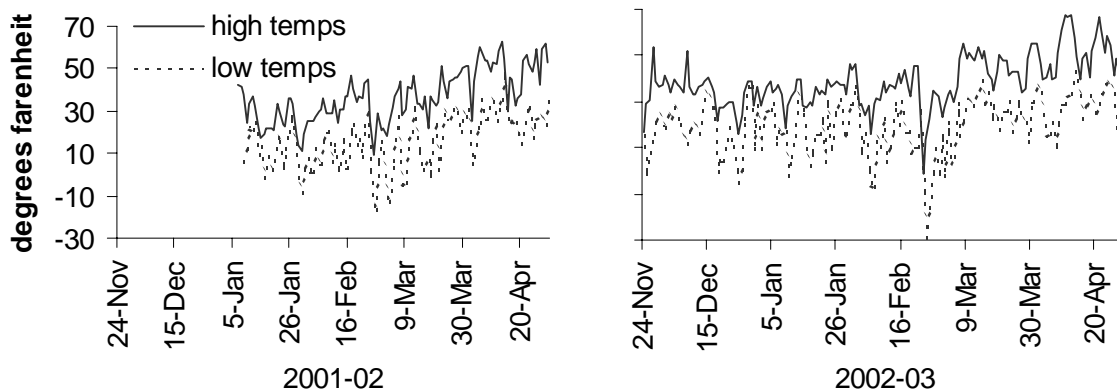


Figure 26. Daily high and low temperatures at High Valley Ranch in the lower Madison valley study area. Data provided by Scott McClintok.

both winters, though visual inspections of the temperature trends suggest that the 2002-03 winter was colder due to the extreme low recorded in early March. However, the average low and high temperatures for the entire winter were slightly lower in 2001-02 (at 15° and 36° F) than in 2002-03 (at 20° and 39° F) simply because it was warmer more often in 2002-03.

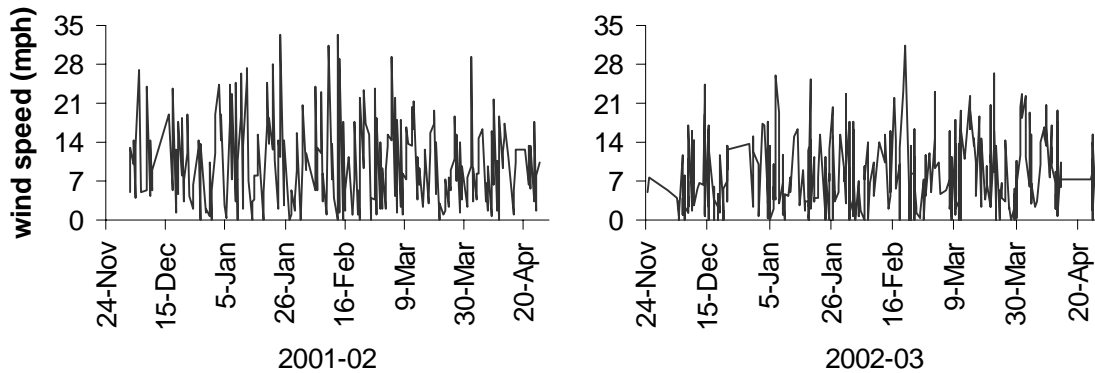


Figure 27. Wind speeds recorded during the 2001-02 and 2002-03 winter seasons.

Wind conditions have also been variable within each of the last two winters, making wind-chill corrected temperatures frigid (Figure 27). The variation in wind speed appears to be more regular than that of temperature, however, as peaks appeared to occur every 10-14 days in both winters.



Figure 28. Measuring snow conditions. Substantial effort has been put into monitoring winter conditions over the last 2 winters, which will be useful for understanding wolf-ungulate interactions in this system.

On average over the entire study area and winter season, snow was deeper in 2001-02 than 2002-03, at 14 and 11 centimeters (5.4 and 4.2 inches) respectively (Figure 28). Patterns of snow accumulation varied between years, however, with the only major similarity between the two years being the onset of spring meltout (Figure 29). Crust conditions in the study area also were different between the two years (Figure 30). More severe crusts are evidenced by a larger difference between penetrability distance and depth, revealing a lack of severe crusts in 2002-03, as penetrability tracked snow depth rather closely. In 2001-02, however, crust conditions

were severe early in the winter and dissipated later in the winter.

Overall, the 2001-02 winter was a little more severe than the 2002-03 winter. A more persistent snowpack, a crust on the snow early in the winter, and lower average temperatures characterized the 2001-02 winter. However, winter conditions were not always easy in the less severe winter of 2002-03, and harsh snow conditions in March of 2003 likely led to an elk exodus from the open flats. Conditions change throughout every winter, and for this reason, documenting the variation in winter conditions within each year will be important over the long term for this research.

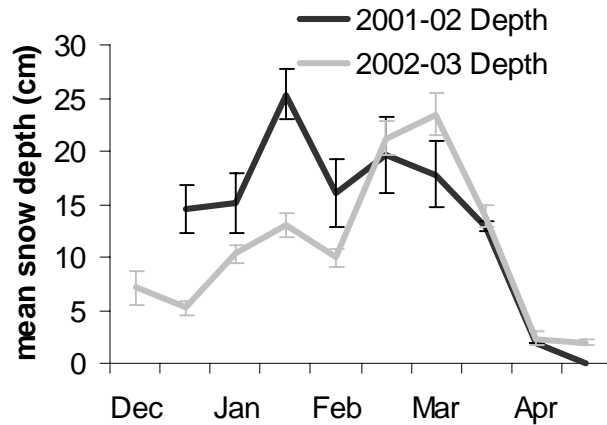


Figure 29. Snow accumulation patterns in the lower Madison study area in 2001-02 and 2002-03. Bars= 1 standard error.

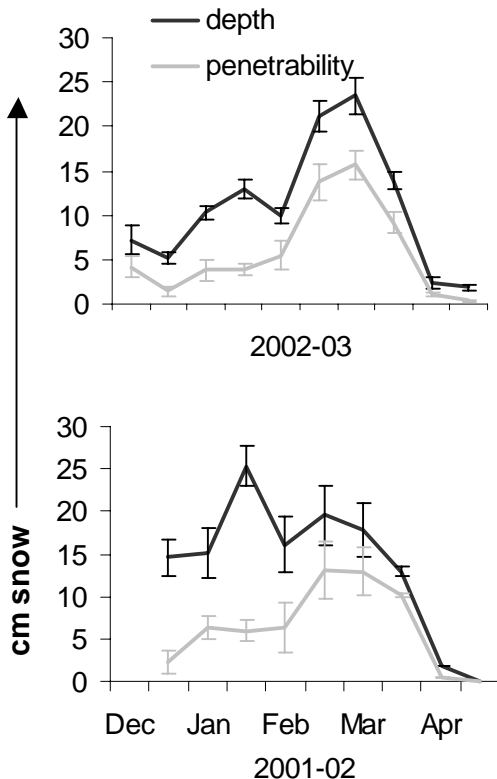


Figure 30. Snow depth and penetrability patterns in 2001-02 and 2002-03. Bars= 1 standard error.

Education and presentations

Just as conducting this research is important to gain insight into how this system operates with wolf presence, sharing what we have done and learned with other scientists, managers, and the public is important to making the research useful. In the winter of 2002-03, the research crew participated in two educational events. On March 21, 2003, Guy Flynn from Ennis High School spent the morning with Justin Gude as part of a career-shadowing program. Guy is interested in field biology, and wanted to learn about field data collection as well as some of the questions we address with this research program. On April 22, 2003, Julie Fuller participated in the Harrison Elementary School Earth Day field trip organized by Chuck Buus of Luzenac America at the Yellowstone Mine. She discussed wolf biology with the students and



Figure 31. Julie Fuller demonstrating radio telemetry to Harrison Elementary School students at Luzenac America's Yellowstone Mine. Photo courtesy of Chuck Buus.

demonstrated some field research techniques (Figure 31).

Over the past year, the research team has also given several presentations about the research program to the public and to professional biologists. In August of 2002, Bob Garrott and Justin Gude participated in a Madison Valley Ranchlands Group field trip to Wall Creek WMA concerning elk, wolves, and cattle in the area, where Bob and Justin gave brief presentations about the lower Madison valley research program.

In February of 2003, Justin presented preliminary results of analyses of elk group size and distributional responses to wolves in winter to managers, research scientists, professors, and students at the annual meeting of the Montana chapter of The Wildlife Society, the professional organization of wildlife biologists, in Lewistown. Justin later presented the same analyses to members of the public, government agency personnel, and to other researchers at the Annual Interagency Wolf Conference at Chico Hot Springs in April. In May of 2003, Justin teamed up with Eric Bergman of the wolf-ungulate research team in the Madison-Firehole region of Yellowstone National Park to give a presentation on the demographic impacts of wolves on the elk populations in the two study areas at the Western States and Provinces Deer and Elk Workshop in Jackson, WY. This meeting was attended by agency personnel and researchers from the western USA and Canada involved in deer and elk management and research.

Conclusions and directions

The 2002-03 field season was successful due to the same cooperative effort between Madison valley landowners and residents, the research team, and agency personnel that also made the previous two field seasons successful. Without such support, the project would not be possible.

Data collected thus far has provided some valuable insights. Ungulate populations have been variable within and between years, as have environmental conditions. Data from the Madison valley have shown how winter conditions can affect large-scale distribution patterns of ungulates as well as finer-scale behavioral patterns such as elk group sizes within and across years. Human hunting pressure and wolf predation pressure also appear to affect elk distribution. The new element in these drivers of ungulate

behavior is wolf predation pressure, and the major impact of the effect of wolf predation pressure thus far appears to lie in altered elk grazing patterns, which might affect range conditions.

Wolf activity and predation patterns have been well documented during this research, especially over the last two years of study. Combined with hunter harvest, wolf predation has not yet led to a detectable effect on elk numbers in the study area. Because kill rates for each wolf have been exceptionally high in the lower Madison valley study area, this appears to be primarily due to the inability of wolves to reach larger pack sizes in order to increase their net offtake. Elk recruitment in the study area has followed a similar pattern to that observed in other study areas, indicating that regional factors might be involved in determining elk recruitment rates.

Justin Gude has finished his tenure collecting data in the field for this research. Currently, labwork is being conducted that will round out the data to be used in Justin's MS thesis project. Final analyses are currently underway, and the thesis will hopefully be completed by December of 2003. As is the case with ecological research, the data collected and insights generated thus far have led to more questions and shown us how little we actually know about this system. To this end, Julie Fuller has signed on to continue this research project as a part of her MS program at Montana State University, beginning in the 2003 fall semester. She will continue to collect data that will be useful over the long term, and she is currently devising questions that she will tackle with her own MS research.

Acknowledgements

Cooperation has been the key to the success of this research. The Madison valley community has provided land access, financial and logistical support, advice, and has generally welcomed us into the valley. Such a partnership between the research team and the community is rare and none of what has been accomplished would be possible without it. This research would also not be possible without the funding and logistical support provided by the National Science Foundation Graduate Research Fellowship Program, Montana FWP, Roger and Cindy Lang, Bob and Annie Graham, and the Rocky Mountain Elk Foundation. Several members of the Madison valley community have helped with data collection, for which we are very grateful. Montana FWP personnel, including Fred King, Ken Hamlin, Mike Ross, and Kurt Alt, have helped with data collection and logistics, and/or given much needed advice and help whenever they could, including providing their own data for this research. Employees of the US Fish and Wildlife Service and Turner Endangered Species Fund have also provided logistical support, namely Val Asher, Joe Fontaine, and Ed Bangs. John Winnie and Scott Creel provided data from the Gallatin canyon study area for comparisons with data from the Madison valley. Patty Hernandez provided data and advice in creating the maps in this report, and many other types of support for this project over the last three years. Finally, the research would not have been possible without enthusiastic help in harsh winter conditions and tedious lab conditions from Thain Cook, Julie Fuller, Gretchen Howard, Terra Scheer, Jon Salerno, and Renee Wulff. Justin Gude would like to thank everyone involved with the project over the last 3 years- it has been a great experience and I am happy to have been part of it.

Contact information

For questions about the study or report, please see

<http://www.montana.edu/ecology/staff/garrott/wolf%20ungulate/index.htm>

or contact us at:

Justin Gude:

jgude@montana.edu

Ecology Department

310 Lewis Hall

Montana State University

Bozeman, Montana 59717

406-994-4573

Bob Garrott:

rgarrott@montana.edu

Ecology Department

310 Lewis Hall

Montana State University

Bozeman, Montana 59717

406-994-2270

Julie Fuller:

jfuller_wbio@hotmail.com

2030 US Highway 287 North

Cameron, Montana 59720

406-682-3122



Winter sunset from the north fork of Squaw creek.

Winter sunset from the north fork of Squaw creek.