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Moose, Caribou, and Grizzly Bear Distribution in Relation to Road Traffic in Denali National Park, Alaska

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ABSTRACT. Park managers are concerned that moose (*Alces alces*), caribou (*Rangifer tarandus*), and grizzly bears (*Ursus arctos*) may be avoiding areas along the 130 km road through Denali National Park as a result of high traffic volume, thus decreasing opportunities for visitors to view wildlife. A wildlife monitoring system was developed in 1996 that used 19 landscape level viewsheds, stratified into four sections based on decreasing traffic along the road corridor. Data were collected from 22 samplings of all viewsheds during May–August in 1996 and 1997. In 1997, nine backcountry viewsheds were established in three different areas to determine whether density estimates for each species in the backcountry were higher than those for the same animals in similar road-corridor areas. Densities higher than those in the road corridor were found in one backcountry area for moose and in two backcountry areas for grizzly bears. None of the backcountry areas showed a higher density of caribou. We tested hypotheses that moose, caribou, and grizzly bear distributions were unrelated to the road and traffic. Moose sightings were lower than expected within 300 m of the road. More caribou and grizzly bears than expected occurred between 601 and 900 m from the road, while more moose and fewer caribou than expected occurred between 900 and 1200 m from the road. Bull moose in stratum 1 were distributed farther from the road than bulls and cows in stratum 4; cows in stratum 1 and bulls in stratum 2 were distributed farther from the road than cows in stratum 4. Grizzly bears in stratum 2 were distributed farther from the road than bears in stratum 3. The distribution of moose sightings suggests traffic avoidance, but the spatial pattern of preferred forage may have had more of an influence. Caribou and grizzly bear distributions indicated no pattern of traffic avoidance.

Key words: Alaska, caribou (*Rangifer tarandus*), Denali, grizzly bears (*Ursus arctos*), moose (*Alces alces*), road traffic, viewsheds

RÉSUMÉ. Les gérants du parc s'inquiètent du fait que l'orignal (*Alces alces*), le caribou (*Rangifer tarandus*) et le grizzli (*Ursus arctos*) pourraient éviter les zones bordant les 130 km de la route qui traverse le parc national Denali, en raison du volume élevé de circulation, ce qui diminue aussi pour les visiteurs les chances de voir la faune. Un système de surveillance de la faune a été mis sur pied en 1996, système qui faisait appel à 19 cabanes d'observation installées de niveau avec le paysage, réparties en quatre sections déterminées selon la décroissance de circulation le long du corridor routier. En 1996 et 1997, on a collecté les données de mai à août provenant de 22 échantillons prélevés à toutes les cabanes. En 1997, neuf cabanes d'arrière-pays ont été installées dans trois zones différentes, afin de déterminer si les estimations des densités pour chaque espèce étaient plus élevées dans l'arrière-pays que dans des zones semblables agissant comme corridors routiers. On a trouvé des densités plus élevées que celles dans le corridor routier pour l'orignal dans une zone d'arrière-pays, et pour le grizzli dans deux zones d'arrière-pays. Aucune des zones d'arrière-pays n'a montré une densité plus élevée pour le caribou. Nous avons testé les hypothèses que les distributions d'orignal, de caribou et de grizzli ne sont pas reliées à la présence de la route ni à la circulation. Les observations d'orignaux étaient moindres que prévu dans la zone s'étendant jusqu'à 300 m de la route. Il y avait plus de caribous et de grizzlis que prévu dans la zone s'étendant de 601 à 900 m de la route, tandis qu'il y avait plus d'orignaux et moins de caribous que prévu dans la zone s'étendant de 900 à 1200 m de la route. Les orignaux mâles dans la strate 1 étaient distribués plus loin de la route que les orignaux mâles et les femelles dans la strate 4; les femelles dans la strate 1 et les mâles dans la strate 2 étaient distribués plus loin de la route que les femelles dans la strate 4. Les grizzlis dans la strate 2 étaient distribués plus loin de la route que les ours dans la strate 3. La distribution des observations d'orignaux suggère que ces animaux évitent la circulation, mais la répartition spatiale de leurs herbes de prédilection pourrait constituer une influence majeure. La distribution du caribou et du grizzli n'a révélé aucun schéma d'évitement de la circulation.

Mots clés: Alaska, caribou (*Rangifer tarandus*), Denali, grizzli (*Ursus arctos*), orignal (*Alces alces*), circulation routière, cabanes d'observation

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INTRODUCTION

Denali National Park and Preserve (Denali) in interior Alaska provides a unique example of the challenge that faces parks: to preserve natural resources while providing visitors opportunities to view and experience these resources. Denali, one of the world's most heavily visited subarctic national parks, offers visitors an exceptional opportunity to view and experience wildlife, tundra ecosystems, and mountain scenery.

Visitor access into the park is provided by the 130 km Denali Park road that runs from the park entrance to Kantishna. Before 1972, park visitation was low, generally limited to those arriving by train and via an arduous overland route on the Paxson-Cantwell road. The completion in 1971 of the Parks Highway linking Anchorage to Fairbanks provided the first direct paved-road access to the park and resulted in a 100% increase in visitor numbers during the 1972 season. Anticipating this increase in visitors, the park initiated a mandatory public transportation system in 1972 to lessen the disturbance to wildlife and minimize congestion along the road corridor. Primary access to the park is by shuttle buses that provide day trips of varying lengths and access to campgrounds and backcountry areas. Buses encountering wildlife in view of the road often stop for several minutes to allow visitors to watch and take photographs.

Moose (*Alces alces*), caribou (*Rangifer tarandus*), grizzly bear (*Ursus arctos*), Dall sheep (*Ovis dalli*), and red fox (*Vulpes vulpes*) are commonly seen along the road corridor, while gray wolves (*Canis lupus*) are less commonly seen. Two previous studies (Tracy, 1977; Singer and Beattie, 1986) were conducted to gain insight into how animals may be affected by vehicle traffic. Both studies focused primarily on observing and quantifying behavioral responses of large mammals to vehicle traffic. Despite efforts to standardize methods, the different techniques and behavioral descriptions used in these studies complicate the interpretation of the data, making useful comparisons difficult.

Determining the direct cause for behaviors displayed by animals along the road corridor is difficult and is complicated by the unknown role that vehicular presence and activity play in eliciting those behaviors. In addition, wildlife observation data collected from the road reveal only a small portion of the actual wildlife distribution: the amount of territory visible from the road is highly variable, as topography and vegetation change along its course (Looney, 1992; Yost and Wright, 1998).

As a result of increasing visitation and the need to better accommodate those visitors, Denali faces continual pressure to permit more tour buses and provide for greater private vehicle use. Because wildlife viewing is a major reason that people visit the park (Miller and Wright, 1998) and because of speculation that increased vehicle traffic may decrease viewing opportunities, the park is confronted with the all too common dilemma of how best to balance use with resource preservation.

The objectives of this study were to determine (1) whether moose, caribou, or grizzly bear densities were higher in backcountry areas than in similar areas transected by the road and (2) whether moose, caribou, or grizzly bears avoided the road and traffic during the summer visitor season.

METHODS

Study Area

The study was conducted on a 130 km section of the road corridor that traverses the north side of a fault valley separating the Alaska Range to the south from the Outer Range to the north (Fig. 1). Elevations range from 540 to 1200 m along the park road as it traverses four passes and five braided glacial rivers.

Vegetation types at lower elevations include open forest stands of white and black spruce (*Picea* spp.) along with ubiquitous shrub (*Betula nana* and *Salix* spp.) tundras. Willow (*Salix* spp.) occurs as understory in the spruce forests, and green alder (*Alnus crispa*) and willows are common along streams. The treeline occurs at approximately 800 m. At higher elevations, open dwarf shrub tundra (*Dryas* spp. and *Vaccinium* spp.) and alpine sedge tundra (*Carex* spp. and *Eriophorum* spp.) predominate.

The abundance of alpine sedge and shrub tundra along the road corridor provides good visibility of animal use of the large, relatively open landscapes, particularly from elevated observation points**.** To take advantage of this situation, 19 plots, termed viewsheds (mean size = 3037, SE = 360 ha), were established in 1996 along the entire length of the road corridor (Fig. 1). Each viewshed was observed from a single location. Viewsheds were stratified into four sections based on traffic volume during the visitor season (Table 1). In 1997, nine backcountry viewsheds in three separate areas were established to compare animal densities between strata 1, 2, and 3.

Techniques

Each road-corridor viewshed was sampled 11 times in 1996 and 11 times in 1997 from May through August. Backcountry viewsheds were sampled seven times each in 1997. A sample consisted of arbitrarily selecting one of the four road strata and systematically observing each viewshed in that stratum for two hours. The entire area visible from the observation point was scanned immediately upon reaching that point and every 15 minutes thereafter, using binoculars and spotting scopes. The time needed to observe all 19 viewsheds ranged from four to six days. Backcountry viewsheds were sampled during the time intervals between road corridor viewshed samplings.

Because animals often occurred in groups of more than one individual, each sighting of any number of individuals was treated as a group. The size of a group was the number

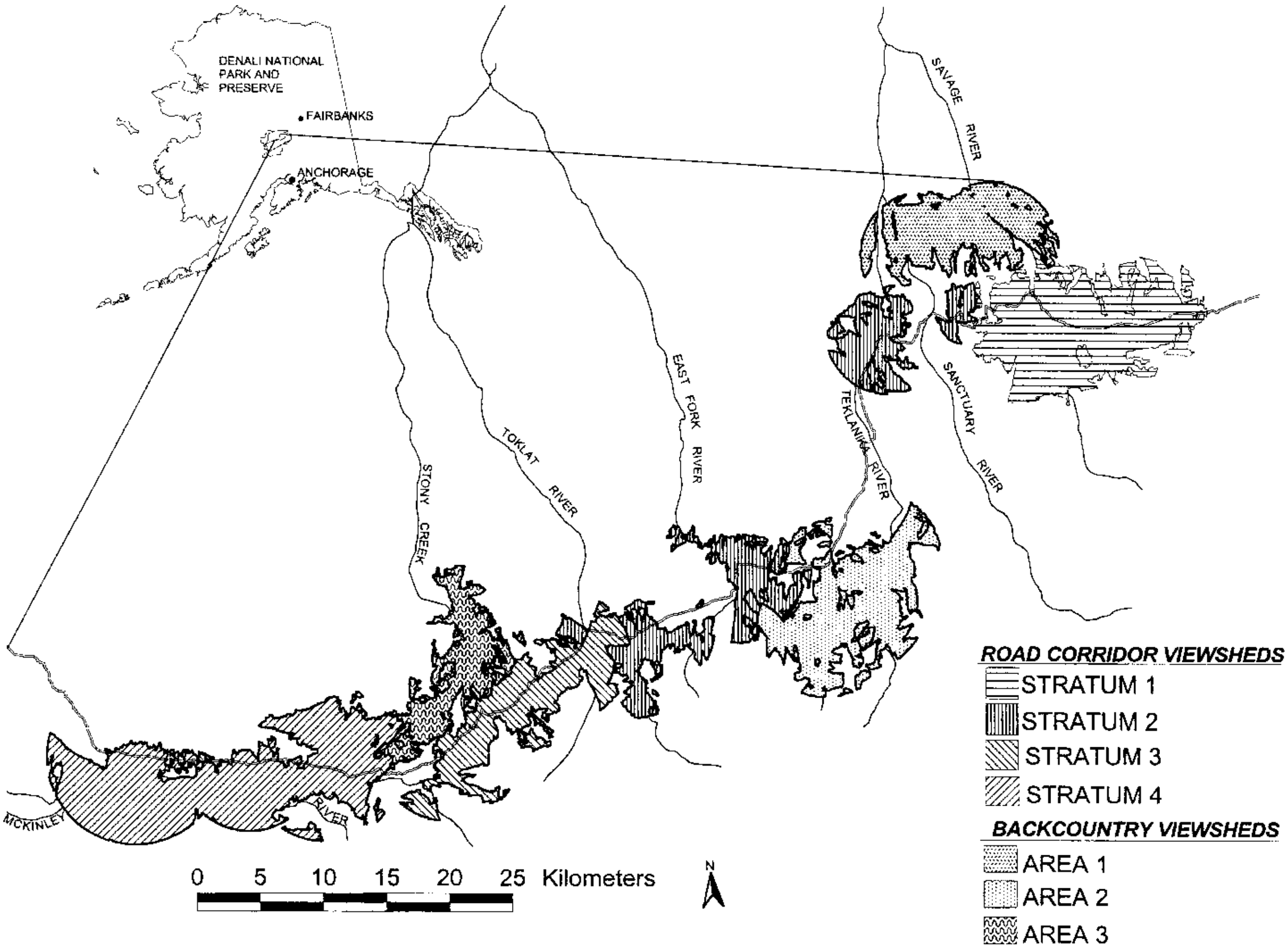

FIG. 1. Denali National Park and Preserve, showing the four road-corridor strata and the three backcountry areas. Stratum outlines represent the combined area of all viewsheds in a stratum.

TABLE 1. Total number of buses passing through each stratum of the study area during the visitor season, along with the total area and number of viewsheds in each stratum.

Stratum	Location	Number of Viewsheds	Viewshed Area, hectares	Total Number of Buses	
				1996	1997
1	Mile 5 (km 8) to Mile 18 (km 29) (Savage River Bridge)	5	18880	7132	7108
2	Mile 18 to Mile 54 (km 87) (Toklat River Bridge)	5	11941	5314	5610
3	Mile 54 to Mile 66 (km 106) (Eielson Visitor Center)	4	8058	2682	2811
4	Mile 66 to Mile 84 (km 135) (Wonder Lake)	5	18832	1013	1165

of independent animals that moved, foraged, or interacted as a common unit or aggregation (Bergerud and Manuel, 1969). Data recorded for each moose, caribou, or grizzly bear sighting included time, species, age, and sex of all animals within a group. Points were placed on 1:63 360 topographic maps in the field for each group sighting and were used to generate point coverages in ARC/INFO® (Environmental Systems Research Institute, Redlands California). Although many sightings were of the same animals among subsequent samplings, completing the observation periods for all viewsheds in a stratum in one day minimized repeat sightings during an individual sampling. At least three days were allowed to pass between samplings to maintain independence of observations (Swihart and Slade, 1985).

Density estimates for each species were calculated to explore the hypothesis that wildlife abundance might be higher in areas of no traffic. Estimates were calculated for each of the four road-corridor strata for both 1996 and 1997 and for each backcountry area for 1997. Distances from the road at which groups of animals were first sighted from each observation point were determined with the NEAR command in ARC/INFO. The conversion from distance values to density estimates was accomplished using the program DISTANCE (Laake et al., 1994), which allows each viewshed observation point to be treated as a point transect. Sampling effort for each viewshed required by the program was calculated as the ratio between the irregular viewshed area and the circular area defined by a radius from the observation point within which at least 90% of all animals were sighted. Three major assumptions are critical to achieving reliable estimates of density from point transect sampling: 1) objects on the point are detected with certainty; 2) objects are detected at their initial location; and 3) measurements are exact.

DISTANCE produces estimates of animal density and 95% confidence intervals from a detection function (the probability of detecting an object given its distance from the observation point) in a two-step modeling process. The first step is establishing a "key function" (one of four statistical distributions: uniform, half-normal, hazard-rate, or negative exponential) that roughly conforms to a histogram of the distance data. The second step is adjusting the key function with a "series expansion" (cosine, simple polynomial, or hermite polynomial) to improve the fit of the model to the data. The model with the lowest Akaike's Information Criterion (AIC) is selected for the detection function. AIC attempts to identify a model with the fewest parameters that fits the data well (Buckland et al., 1993).

Analysis

The chi-square goodness-of-fit test was used to test the null hypothesis that each species used four zones within 1200 m of the road in proportion to their occurrence (Neu et al., 1974; Byers et al., 1984). Distance intervals of 300 m were chosen for analysis because Tracy (1977) and Singer and Beattie (1986) found alert reactions of wildlife decreased when animals were located more than 300 m from the road and traffic. The analysis was limited to the area within 1200 m of the road because we assumed that the effect of road traffic on wildlife distributions beyond this distance was undetectable. The area of each zone was determined by buffering the line graph of the park road using ARC/INFO® and summing the area of each zone that overlapped with the road corridor viewsheds. The Bonferroni Z statistic was used to calculate 95% confidence intervals around the observed proportion of sightings within each interval. The expected proportion of wildlife sightings was calculated by multiplying the total number of groups observed by the relative area of the zone in which they occurred. If a value for an expected proportion was not contained within the 95% confidence interval for the proportion observed, then the number of groups observed was significantly lesser or greater than expected. Traffic volume and the vehicle types are relatively constant from year to year, so we assumed that their effect on wildlife should remain constant as well. Therefore, we combined data for both years to increase sample sizes for each species.

A second analysis used the distances from the park road at which animal groups were first sighted to test the null hypothesis that there was no stratum effect. Only those animal groups within 1500 m of the road were included in the analysis to remove bias from areas where the road corridor narrows to less than 3 km. Group sightings from both years were combined for the analysis. A two-way analysis of variance for each species was performed on the ranks of the data, following Conover and Iman (1981). For moose and caribou, the main effects tested were stratum and sex. For grizzly bears, determination of sex in lone bears is almost impossible; therefore, a one-way ANOVA was conducted on the distances from the road at which all bear groups were sighted in the various strata. Multiple comparisons were calculated for pairwise comparisons using Tukey's Honestly Significant Difference for unequal sample sizes. All analyses were conducted using STATISTICA for Windows (Statsoft, 1998).

RESULTS

Density Estimates

For moose, estimates of density decreased from stratum 1 to stratum 3 but then increased in stratum 4 for both years (Table 2). The largest increase in moose density (from 5 animals per 50 km^2 in 1996 to 13 in 1997) occurred in

TABLE 2. Density estimates and 95% confidence intervals for moose, caribou and grizzly bears in 1996 and 1997 in the four road corridor strata and the three backcountry areas.

		Moose		Caribou		Grizzly Bears	
Year	Location	Groups/50 km^2	Animals/50 km^2	Groups/50 km^2	Animals/50 km^2	Groups/50 km^2	Animals/50 km^2
1996	Stratum 1	1 < 6 < 28	2 < 9 < 38	4 < 9 < 22	8 < 18 < 40	0 < 1 < 2	0 < 1 < 2
1997	Stratum 1	3 < 7 < 18	4 < 10 < 26	3 < 7 < 15	8 < 18 < 40	1 < 1 < 2	1 < 1 < 2
1997	Backcountry	2 < 7 < 22	2 < 7 < 24	0 < 1 < 1	< 1 < 1	0 < 1 < 1	0 < 1 < 1
1996	Stratum 2	3 < 4 < 17	1 < 4 < 17	4 < 11 < 31	10 < 27 < 74	1 < 4 < 15	1 < 4 < 16
1997	Stratum 2	1 < 4 < 12	2 < 5 < 15	5 < 11 < 25	13 < 29 < 67	1 < 3 < 10	1 < 3 < 10
1997	Backcountry	0 < 1 < 7	0 < 1 < 7	2 < 9 < 34	5 < 16 < 56	1 < 4 < 13	1 < 4 < 13
1996	Stratum 3	0 < 1 < 2	0 < 1 < 2	13 < 36 < 100	60 < 150 < 376	2 < 10 < 38	3 < 11 < 39
1997	Stratum 3	0 < 1 < 4	0 < 1 < 4	20 < 40 < 80	79 < 158 < 313	2 < 5 < 11	3 < 6 < 11
1997	Backcountry	3 < 7 < 16	5 < 10 < 21	3 < 15 < 67	8 < 25 < 80	3 < 8 < 17	3 < 8 < 17
1996	Stratum 4	1 < 4 < 26	1 < 5 < 28	4 < 17 < 69	10 < 40 < 155	0 < 2 < 8	0 < 2 < 10
1997	Stratum 4	5 < 9 < 18	7 < 13 < 26	5 < 15 < 42	14 < 38 < 104	1 < 2 < 5	1 < 3 < 6

TABLE 3. Results of the chi-square goodness-of-fit test for the hypothesis that each species used four distance zones within 1200 m of the road in proportion to occurrence.

Distance Zone	Total Hectares	Proportion of Total Hectares	Moose: Number of Groups Observed	Moose: Number of Groups Expected	Moose: 95 % Confidence Interval	Caribou: Number of Groups Observed	Caribou: Number of Groups Expected	Caribou: 95 % Confidence Interval	Grizzly Bears: Number of Groups Observed	Grizzly Bears: Number of Groups Expected	Grizzly Bears: 95 % Confidence Interval
0–300	4417.7	0.267	13	29	.041 < .118 < .195	73	76	.192 < .257 < .322	13	19	.066 < .178 < .290
301–600	4386.3	0.265	23	29	.112 < .209 < .306	84	75	.228 < .295 < .363	21	19	.155 < .288 < .420
601–900	4041.7	0.244	36	27	.215 < .327 < .439	93	69	.258 < .327 < .397*	29	18	.254 < .397 < .540*
901–1200	3694.3	0.223	38	25	.232 < .345 < .458*	34	63	.072 < .120 < .168*	10	16	.036 < .137 < .238

* indicates a difference at the 0.05 level of significance.

stratum 4. Moose density in the first and second sets of backcountry viewsheds was lower than in the respective road-corridor strata. Moose density in the third set of backcountry viewsheds, however, was much higher than that estimated for stratum 3.

For caribou, estimates of density grew progressively higher from stratum 1 to stratum 3 then decreased in stratum 4 for both years (Table 2). There were fewer caribou groups and individual animals per 50 km^2 in all three backcountry areas than in each of the corresponding road strata.

For grizzly bear, estimates of density were lowest in stratum 1, increased in strata 2 and 3, but then decreased in stratum 4 in both years (Table 2). Densities in each stratum show little change from 1996 to 1997, except for a decrease in stratum 3 from 11 animals per 50 km^2 to 6. Grizzly bear density was identical in both the road and backcountry areas of stratum 1. However, estimates were slightly higher in the second and third set of backcountry viewsheds than in road strata 2 and 3 respectively.

Use vs. Availability

Moose were sighted within 300 m of the road in significantly smaller numbers than expected. The numbers of groups sighted in the 301–600 m zone and the 601–900 m zone were not different from expected, but in the 901–1200 m zone numbers were significantly higher than expected (Table 3).

Caribou were sighted in the closest two zones in expected numbers. However, there were significantly more caribou than expected in the 601–900 m zone, but significantly fewer than expected in the farthest zone (Table 3).

For grizzly bears, the numbers sighted within the 601–900 m zone was significantly higher than expected, but the numbers sighted in other zones were close to expected numbers (Table 3).

Two-Way Analysis of Variance

For moose, there was a significant effect by stratum (F = 11.59, d.f. = 2, $p < 0.001$) and sex (F = 7.183, d.f. = 1, $p = 0.008$) (Fig. 2) on the distances from the road at which animals were sighted. The interaction between sex

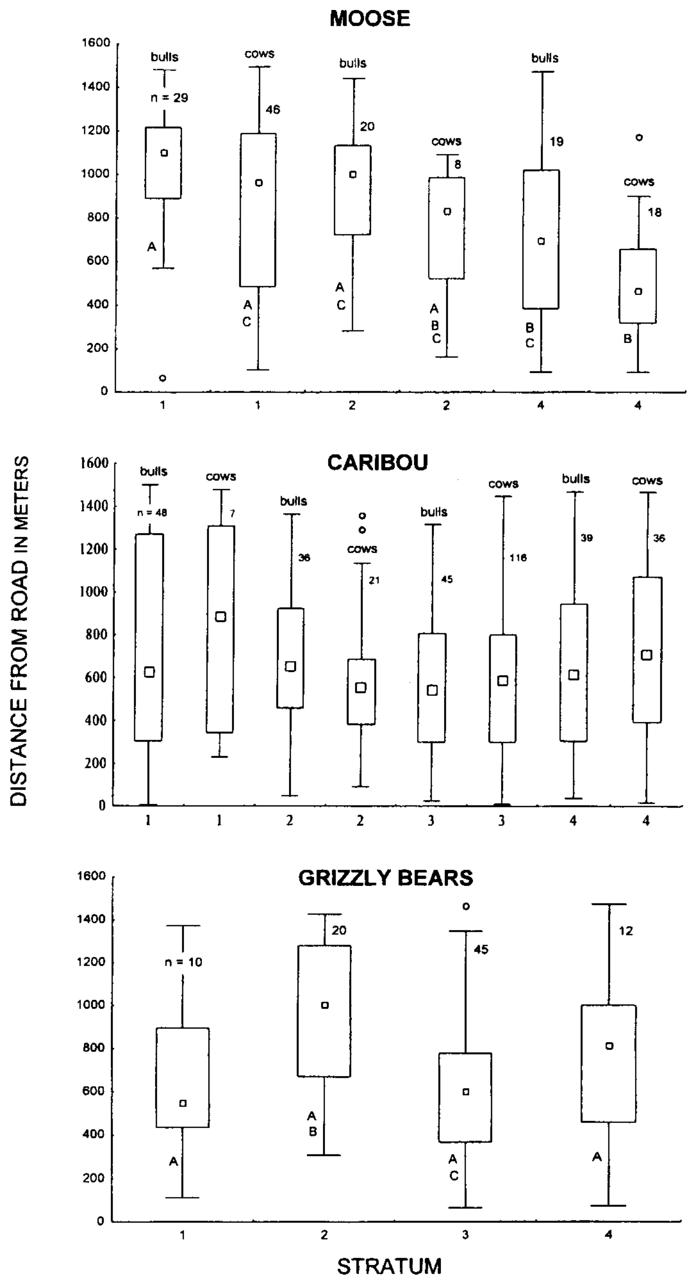

FIG. 2. Distributions of actual distances from the park road at which moose, caribou, and grizzly bear groups were sighted in each stratum. Each range of distances includes only those groups within 1500 m of the road. The number of animals is shown for each category of stratum and sex. Categories with the same letter were not different ($p < 0.05$).

and stratum was not significant (F = 0.01, d.f. = 2, p = 0.990). Groups of bulls sighted in stratum 1 were significantly farther from the road than both groups of bulls (p = 0.015) and cows ($p < 0.001$) sighted in stratum 4. Bulls in stratum 2 were significantly farther from the road than cows sighted in stratum 4 (p = 0.005). Cows sighted in stratum 1 were significantly farther from the road than those sighted in stratum 4 (p = 0.004).

For caribou, the effects of stratum and sex on the distances from the road at which animals were sighted were not significant (F = 2.01, d.f. = 3, p = 0.11) (F = 0.37, d.f. = 1, p = 0.54) (Fig. 2).

For grizzly bears, the effect of stratum on the distances from the road at which animals were sighted was significant (F = 4.219, d.f. = 3, p = 0.007). Groups of bears in stratum 2 were significantly farther from the road when first sighted than those in stratum 3 (p = 0.010). No other comparisons were significant (Fig 2).

DISCUSSION

Moose

Interpreting the analysis in terms of sighting distance and traffic level alone suggests that moose were distributed farther from the road than expected in areas of high traffic volume. However, a more plausible explanation may be the spatial pattern of preferred forage. For example, moose were consistently sighted in large patches of habitat dominated by diamondleaf willow (*Salix planifolia*) in the first viewshed of stratum 1. These patches were located approximately 600 m from the road. Thus, the distance from the road at which preferred forage and cover occurred may have had a greater influence on moose distribution than traffic volume did.

The differences in moose density between backcountry and road strata can also be accounted for by the availability of forage and cover. As elevation rises above 1100 m, preferred forage species decline significantly, and the lack of cover where cows with calves could hide to avoid predation precludes their use of these areas (Miquelle et al., 1992). The patchy nature of available habitat and the elevation changes along the road corridor resulted in a spatially structured distribution of moose sightings. Although few moose were sighted within 100 m of the road during samplings of the road-corridor viewsheds, moose can often be seen on or near the road at other times, for example, while driving from the park entrance to km 24.

Caribou

Most of the Denali herd is not near the road during summer, and those animals that are there encounter traffic for only short periods of time (Layne Adams, pers. comm. 1996). Caribou disperse in mid-July after insect harassment abates and then start returning to lower elevations (Boertje, 1981). A seasonal transition to higher elevations occurred during May and June each year of this study and was followed by a return to lower areas in August. Consequently, the majority of caribou were sighted in the road and backcountry viewsheds of stratum 3 and the higher elevations of stratum 4.

Caribou did not appear to avoid the road corridor at the viewshed scale since the backcountry density estimates were much lower than their road-corridor analogues. Nevertheless, simply because caribou density in these three backcountry areas was lower than what was observed in the road corridor does not mean that caribou density was not higher in other, unsampled backcountry areas of the park.

Tracy (1977) also reported no evidence that caribou were avoiding the vicinity of the road. She observed caribou using areas near the road more intensively than other areas with similar habitat and reasoned it to be a result of the road's being built in the same east-west fault valley traditionally used by caribou as a migration route.

Summer distribution is largely dependent upon where spring calving occurs. The low number of caribou sightings in stratum 1 is most likely a result of low population numbers, distance from the calving area (> 90 km), and seasonal movements to higher elevations. The post-calving movements of cows with calves and accompanying individuals from the nearby calving grounds most likely account for the large caribou groups sighted in stratum 3.

Cronin et al. (1998) found that caribou were abundant in the Prudhoe Bay oil field and did not avoid oil field infrastructure. Bergerud et al. (1984) provide several examples of caribou resilience to high levels of human disturbance. They argue that caribou are as adaptable to the presence of human activity as other North American ungulates but that they need a great deal of space to maintain their "ultimate adaptation—mobility, to seek space to cope with an ever-changing extrinsic environment" (Bergerud et al., 1984:19). Even though a few individual animals in our study displayed cautious behavior when encountering the road there was no strong evidence of avoidance.

Grizzly Bears

The emerging green vegetation causes bears to distribute themselves in higher areas in midsummer. Sighting frequencies indicate that bears were consistently more abundant between km 62 and km 106, where summer food items are also more abundant than they are in the lower east and west sections of the park.

Albert and Bowyer (1991) hypothesized that bears not habituated to humans are displaced into backcountry areas by high levels of human activity in the front country. Similarly, Mattson et al. (1987) reported reduced grizzly bear occupancy of habitat near human facilities as the more dominant cohorts displaced subordinate and security-conscious bears into these habitats. In 1997, grizzly bear densities in the backcountry areas of Denali did not appear to be appreciably higher than those found in their road corridor analogues. The pattern of grizzly bear distribution with respect to different traffic levels along the road corridor is inconsistent. Thus traffic along the road appeared to have little influence on bear distribution.

CONCLUSIONS

There was no evidence that moose abundance was higher in backcountry areas than in similar areas in the road corridor. The distribution of moose sightings relative to traffic levels along the park road suggests that moose may have avoided the vicinity of the road where traffic levels were highest. While many animals appeared habituated to traffic and were observed foraging near the road, others showed behaviors that indicated fear or intolerance and distributed themselves at greater distances. However, the spatial pattern of preferred forage and vegetation appears to have had a much larger influence than traffic on moose distribution.

This study produced little evidence to support the hypothesis that caribou avoid the vicinity of the road and traffic. The distribution of caribou is largely influenced by where the herd spends the winter, where calving occurs, weather, and insect harassment. Many caribou do show uneasiness when encountering the road and traffic, which suggests that the effect is limited to the immediate vicinity.

Grizzly bear densities in backcountry areas were not appreciably higher than densities in similar road-corridor areas. Road traffic appeared to influence grizzly bear distribution less than forage availability, abundance, and phenology did. While some bears might have been intolerant of road activity and avoided its vicinity, many were clearly habituated and carried out daily activities in close proximity to traffic and human onlookers.

Traffic on the Denali Road, concentrated as it is in a three-month period, is significant—particularly for a park set in an Arctic wilderness. This is especially true in the first two strata of the study area. Although in general the animal species we studied displayed no overt avoidance of the road, this might not be the case in the future, particularly if the traffic volume or the patterns of road use change. Accordingly, the data collection and analytical methods were designed to provide Denali with an effective protocol for monitoring wildlife densities and distributions in the road corridor. The program DISTANCE is an effective tool for providing best estimates of population change and redistribution over the years. The sampling protocol and the use of GIS technology do not violate the major assumptions of the program. This monitoring, when carried out on a routine basis, allows ready detection of changes in wildlife abundance, distribution, composition, and productivity (Yost, 1998). The goal of this monitoring program would be to provide the park with an “early warning” of a potential ecological problem and to alert the park that corrective management might be necessary.

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