

The Effect of Vehicle Traffic on Wildlife in Denali National Park

S.L. BURSON III,¹ J.L. BELANT,^{1,2} K.A. FORTIER¹ and W.C. TOMKIEWICZ III¹

(Received 17 December 1998; accepted in revised form 29 November 1999)

ABSTRACT. We recorded observations of caribou (*Rangifer tarandus*), grizzly bear (*Ursus arctos*), Dall sheep (*Ovis dalli*) and moose (*Alces alces*) along the Denali National Park and Preserve road corridor during 1995–97. We compared these observations to similar data from previous studies to evaluate the effect of an increase in traffic on the number of animals sighted and their behavior. Between 1972 and 1997, annual visitation to Denali National Park increased from about 45 000 to 350 000, with attendant increases in traffic on the park road. The mean number of caribou, grizzly bear, and Dall sheep observed did not decline ($p > 0.301$) from 1973 to 1997. The number of moose observed declined by more than 50% ($R^2 = 0.529$, $p < 0.001$). The estimated population of moose also declined over the same period ($R^2 = 0.374$, $p = 0.002$). The distance from the park road at which caribou and grizzly bears were sighted did not change ($p > 0.787$), but fewer moose ($p < 0.031$) were observed within 100 m of the road and fewer sheep ($p < 0.011$) were observed between 400 and 500 m from the road. Adverse behavioral responses to traffic (e.g., running from vehicles) occurred in less than 1.3% of observations for each species. Increased traffic on the park road apparently has not caused significant changes in abundance, distribution, or behavior of caribou, grizzly bear, Dall sheep, and moose in the park road corridor.

Key words: Alaska, behavior, caribou (*Rangifer tarandus*), Dall sheep (*Ovis dalli*), Denali National Park, grizzly bear (*Ursus arctos*), human disturbance, moose (*Alces alces*), traffic, visitation

RÉSUMÉ. De 1995 à 1997, on a rapporté des observations du caribou (*Rangifer tarandus*), du grizzli (*Ursus arctos*), du mouflon de Dall (*Ovis dalli*) et de l'orignal (*Alces alces*) dans le corridor routier de la réserve et du parc national Denali. On a comparé ces observations à des données similaires recueillies au cours d'études antérieures visant à évaluer l'impact d'une augmentation du trafic sur le nombre d'animaux aperçus et sur leur comportement. Entre 1972 et 1997, le nombre annuel de visiteurs au parc national Denali est passé d'environ 45 000 à 350 000, ce qui a amené une augmentation de la circulation sur la route du parc. De 1973 à 1997, le nombre moyen de caribous, de grizzlis et de mouflons de Dall observés n'a pas diminué ($p > 0,301$). Le nombre d'originaux observés a décliné de plus de 50 p. cent ($R^2 = 0,529$, $p < 0,001$). La population d'originaux estimée a aussi baissé durant cette période ($R^2 = 0,374$, $p < 0,002$). La distance, mesurée depuis la route du parc, à laquelle ont été aperçus les caribous et les grizzlis n'a pas changé ($p > 0,787$), mais on a observé moins d'originaux ($p < 0,031$) à moins de 100 m de la route et moins de mouflons de Dall ($p < 0,011$) entre 400 et 500 m de la route. Des réactions comportementales négatives au trafic (p. ex., fuite à l'approche de véhicules) ont eu lieu dans moins de 1,3 p. cent des cas observés pour chaque espèce. L'augmentation du trafic sur la route du parc ne semble pas avoir causé de changements notables dans l'abondance, la distribution, ou le comportement du caribou, du grizzli, du mouflon de Dall et de l'orignal dans le corridor routier du parc.

Mots clés: Alaska, comportement, caribou (*Rangifer tarandus*), mouflon de Dall (*Ovis dalli*), parc national Denali, grizzli (*Ursus arctos*), perturbation anthropique, orignal (*Alces alces*), circulation, visiteurs

Traduit pour la revue *Arctic* par Nésida Loyer.

INTRODUCTION

Annual visitation to Denali National Park and Preserve (formerly Mt. McKinley National Park) has increased from fewer than 45 000 people before 1972 (Dalle-Molle and Van Horn, 1989) to the current level of 350 000 people (National Park Service [NPS], unpubl. data). The National Park Service's mandate is to protect park resources while providing access and viewing opportunities for the public. Balancing these needs becomes more difficult with increased visitation.

The ease of viewing caribou, grizzly bear, Dall sheep, and moose along the 147 km park road is an important visitor attraction. A permit system implemented to maintain wildlife viewing opportunities along the park road limited the number of private vehicles in 1972 and the total number of vehicles in 1986. Buses in use since the 1930s (Brown, 1993) have been the primary means of transport for visitors since 1972. Between 26 May and 13 September, 10 512 vehicles are permitted to pass the check station at km 24 (NPS, 1986). Outside of this restricted period, noncommercial traffic can travel the first 50 km as road conditions allow.

¹ Denali National Park and Preserve, Division of Research and Resource Preservation, P.O. Box 9, Denali Park, Alaska 99755, U.S.A.

² Corresponding author: Jerry_Belant@nps.gov

In response to increased visitation, Tracy (1977) and Singer and Beattie (1986) studied wildlife abundance and behavior along the park road. Both studies concluded that some animals were adversely affected by road-related disturbances (e.g., loud unexpected noises, people getting off buses at wildlife sightings), especially those animals within 100 m of the road. Other studies have documented the abundance, distribution, or behavior of large mammals along the park road (Dalle-Molle and Van Horn, 1991; Looney, 1992; Taylor et al., 1997; Putera and Keay, 1998). However, there has been no synthesis of studies to determine the long-term effect of traffic disturbance on these animals. To address this need, we recorded the number of sightings of individual large mammals and their distribution and behavior along the road corridor during 1995–97 and compared our observations to the findings of earlier studies.

STUDY AREA

Denali National Park was established in 1917 to protect wildlife from hunting (Brown, 1993). The 2.4 million ha park is located in interior Alaska, between Anchorage and Fairbanks. Mt. McKinley (Denali) at 6194 m is its most prominent feature. The park road, completed in the 1930s, connects Alaska Highway 3 in the east to the private inholding town of Kantishna 147 km to the west. The road follows a valley between the Alaska Range on the south and the Outer Range on the north. This valley (road corridor) varies in width from 1 to 10 km, and the elevation of the road varies from 484 m to 1230 m. The climate is subarctic: only June, July, and August have an average maximum temperature greater than 17°C and an average minimum temperature greater than 0°C (NPS, unpubl. data). Snow usually covers the road from October to April or May. Average annual precipitation was 38 cm during 1973–97, with an average of 26 cm during May–September (NPS, unpubl. data). Daylight varies during the year from over 20 hr in June to 4 hr in December.

The road transects forests dominated by spruce (*Picea* spp.), shrub tundra dominated by birch (*Betula* spp.) and willow (*Salix* spp.), and higher-elevation tundra characterized by *Dryas* (spp.) and other short-stature plants. The road crosses five braided rivers and many streams. It is paved for the first 24 km, but the remaining 123 km is gravel.

METHODS

Data Collection

Two observers in a pickup truck drove the 100 km between park headquarters (5.6 km) and Eielson Visitor Center (105.6 km) at 40–48 km/hr on 1–4 days per week ($\bar{x} = 3.3 \pm 1.38$ SD). These trips were distributed approximately evenly from May to September in 1995–97 and

throughout the day. Passable road conditions determined the starting and ending dates each year. Observers searched opposite sides of the road corridor and recorded sightings of caribou, grizzly bear, Dall sheep, and moose. Only one trip was made per day, and data were collected travelling in one direction only to avoid counting individuals twice. We stopped the vehicle when animals were sighted and recorded the time, location, species, number of individuals, their distance from the road, and, for animals within 500 m of the road, behavior. (We could not accurately classify the behavior of animals at distances greater than 500 m). We estimated distances from the road visually or with rangefinders. We randomly selected a focal adult in each group to characterize behavior at first sighting. We classified the response as adverse if animals were startled or moved at a gait faster than a walk in reaction to human disturbance.

The number of animals observed is defined as the annual mean number of sightings of individual animals per trip. We compared our counts to those made between 1973 and 1997 by Tracy (1977), Singer and Beattie (1986), Looney (1992), Taylor et al. (1997), and Burson et al. (1999). Bus drivers collected wildlife observation data for Looney (1992), Taylor et al. (1997), and Burson et al. (1999), while observers in buses recorded wildlife observations for Tracy (1977). Singer and Beattie (1986) collected wildlife observation data from a pickup truck. The numbers of caribou, grizzly bear, Dall sheep, and moose observed in the road corridor were recorded over approximately the same months and road section in each of these studies. We divided the number of sightings reported by Tracy (1977), Singer and Beattie (1986), and Looney (1992) by two because they recorded data for daily round trips. We compared our own data on the animals' behavior and their distance from the road when observed to data recorded by Tracy (1977).

Population estimates of moose in the eastern portion of the park were obtained from late fall–early winter aerial surveys during the past 25 years (Meier et al., 1991; V. Van Ballenberghe, pers. comm. 1998). Sixty-eight percent of our sightings of moose along the road occurred within the area covered by aerial surveys.

Data Analyses

We calculated the annual mean number of each species seen per trip for our study and other studies (Tracy, 1977; Singer and Beattie, 1986; Looney, 1992; Taylor et al., 1997; Burson et al., 1999) and used simple linear regression (Zar, 1984) to test for temporal change.

We tested for trends in the estimated moose population from 1973 to 1997 (Meier et al., 1991; V. Van Ballenberghe, pers. comm. 1998) with simple linear regression. We then compared the change in the number of moose sighted from the park road to the change in the estimated moose population over the same time period, using correlation analysis (Zar, 1984) to determine whether the decline in sightings

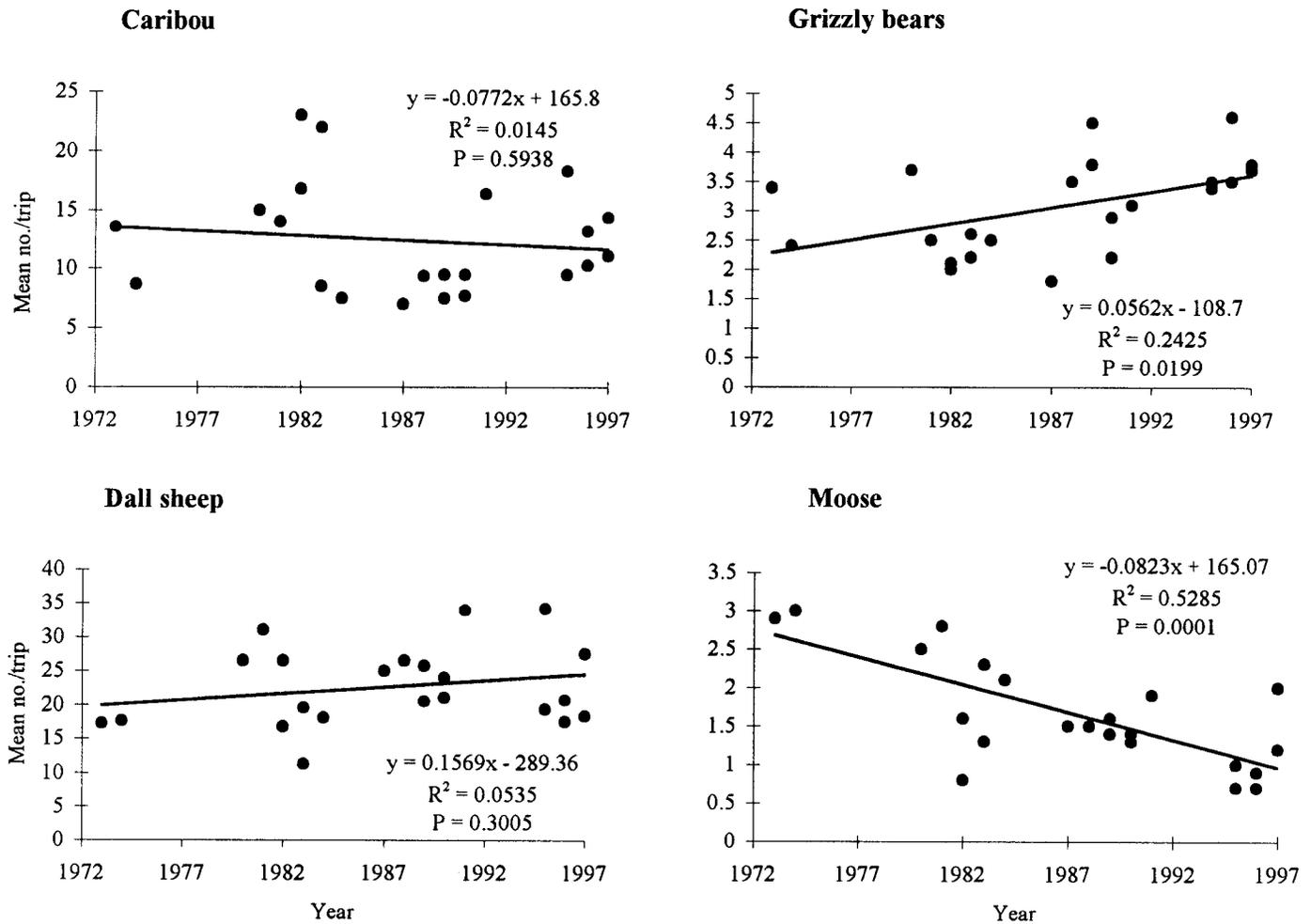


FIG. 1. Annual mean numbers of caribou, grizzly bears, Dall sheep, and moose observed per trip along the park road corridor, Denali National Park and Preserve, Alaska, 1973–97.

from the park road was associated with a population decline.

To determine whether the animals' distance from the road when observed had changed, we compared the proportion of animals sighted at 100 m intervals from the park road to the 1973–74 counts from Tracy (1977), using chi-square contingency tests (Zar, 1984:69–70). We also qualitatively compared behavior observed for each species during 1995–97 with behavior recorded by Tracy (1977) to assess changes in responses over the years.

RESULTS

On 171 trips (48 in 1995, 64 in 1996, and 59 in 1997), we recorded 2544 caribou, 604 grizzly bears, 3785 sheep, and 163 moose. Between 1973 and 1997, the annual mean number of moose observed per trip declined by more than 50% ($R^2 = 0.526$, $n = 22$, $p < 0.001$; Fig. 1). There was a small increase in the number of bears observed per trip, ($R^2 = 0.243$, $n = 22$, $p = 0.020$), but numbers of sheep ($n = 22$, $p = 0.301$) and caribou ($n = 22$, $p = 0.594$) did not change across years (Fig. 1).

The number of moose observed from the road declined ($R^2 = 0.526$, $n = 22$, $p = 0.001$), as did the moose population in the eastern portion of the study area ($R^2 = 0.373$, $n = 24$, $p = 0.002$). There was a direct association $R^2 = 0.257$, $n = 16$, $p = 0.045$) between the number of moose observed from the road and the estimated moose population.

The proportion of caribou ($\chi^2 = 2.430$, 5 df, $p = 0.787$) and grizzly bear ($\chi^2 = 1.288$, 5 df, $p = 0.936$) observed by 100 m intervals did not change between 1973–74 (Tracy, 1977) and 1995–97 (Fig. 2). Fewer Dall sheep ($\chi^2 = 14.918$, 5 df, $p = 0.011$) were observed at 400–500 m from the road and fewer moose ($\chi^2 = 12.274$, 5 df, $p = 0.031$) were observed within 100 m of the road during 1995–97 than during 1973–74 (Tracy, 1977).

Overall, 1.3% of caribou, 0.5% of grizzly bear, 0% of Dall sheep, and 1.3% of moose exhibited adverse responses to traffic. We observed no adverse responses when animals were more than 100 m from the road. When animals were within 100 m of the park road, we recorded adverse responses in 4% or less of the observations for each species. In contrast, Tracy (1977) recorded adverse responses in more than 30% of all observations within 100 m

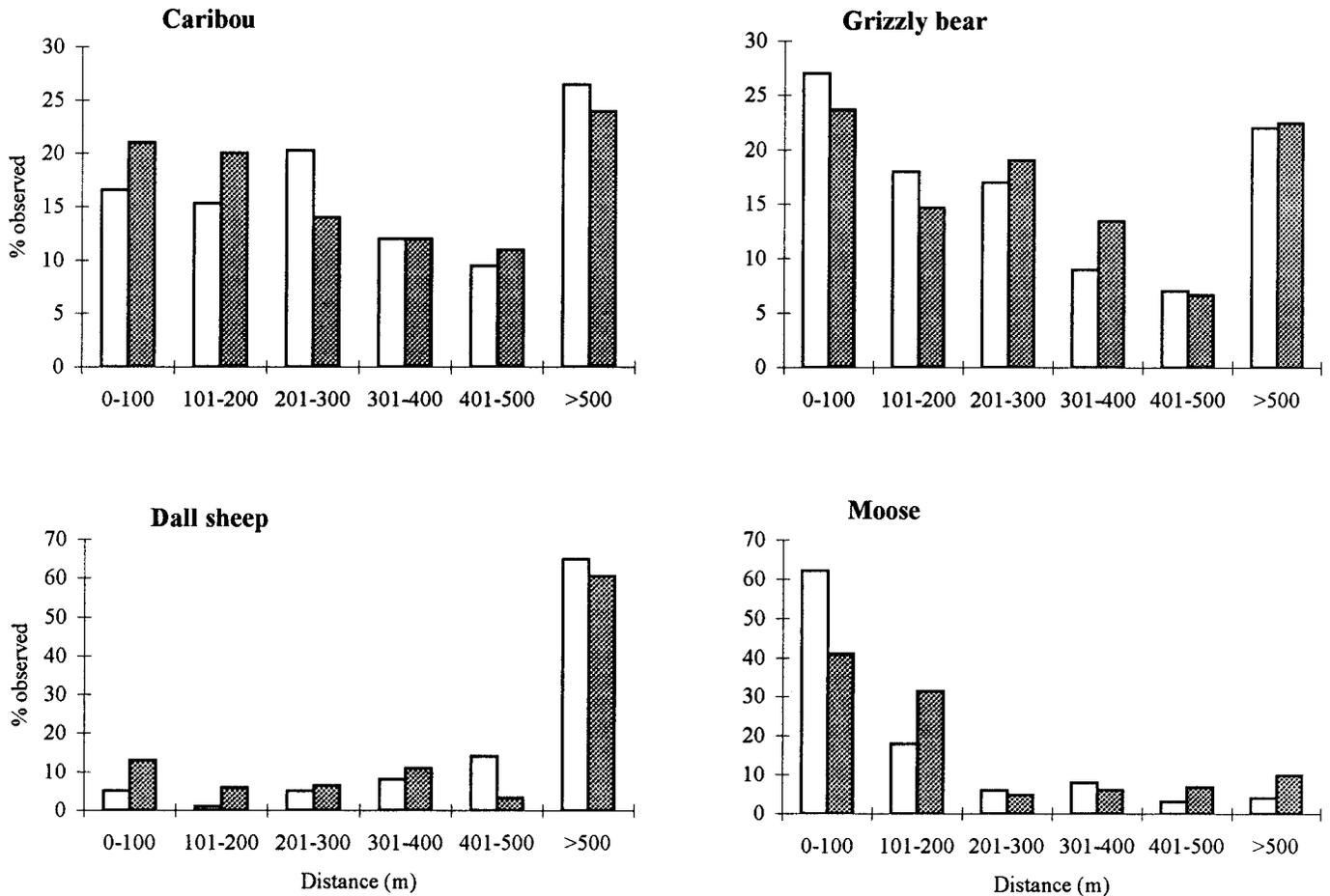


FIG. 2. Percent of individual caribou, grizzly bears, Dall sheep, and moose observed at various distances from the park road, Denali National Park, Alaska. White bars show data from Tracy (1977); shaded bars show data from this study.

of the road during 1973–74. Although the two studies used different definitions for behavioral responses, this fact does not fully explain the decline in adverse responses.

DISCUSSION

Although there was no trend in the number of caribou sighted along the park road over the last 25 years, there has been annual variation. From 1973 to 1997, the Denali caribou herd fluctuated between 1000 and 3100 individuals (Adams et al., 1989; Adams, 1996; L.G. Adams, pers. comm. 1998). Caribou have annual movements that extend beyond the road corridor and vary among years (L.G. Adams and J.L. Belant, unpubl. data). We recorded few adverse behavioral responses to traffic, and there was no change in the distance at which caribou were seen from the road. Annual variation in the number of caribou sighted from the park road is likely explained by changes in population size and seasonal movements that vary among years, not by factors related to traffic on the park road.

The number of bears observed along the park road increased from 1973 to 1997. Grizzly bear population densities in the park appear to have remained relatively

stable during 1983–95 (Dean, 1987; J. Keay, pers. comm. 1998). The increase in sightings may result from consistent observations of females with young near the road in recent years (see Mattson et al., 1987; McLellan and Shackleton, 1988). We observed few adverse responses to traffic, and there was no change in the distance at which bears were seen from the road.

Dall sheep regularly cross the road during seasonal movements between the Alaska Range and the Outer Range (Murie, 1944). Although traffic may affect sheep during seasonal movements (Dalle-Molle and Van Horn, 1991; Putera and Keay, 1998), our observations and those of Singer and Beattie (1986) suggested no change in the number of sheep sighted since 1973–74. Fewer sheep were observed at 400–500 m from the road during 1995–97 than in 1973–74 (Tracy, 1977). It is unlikely that this change is related to disturbance along the road corridor. The variation among years in the number of sheep observed was likely affected by sheep movement in relation to suitable habitat, by timing of observations, and by changes in population size, not by traffic disturbances.

The decline in the number of moose observed is partly explained by the decline in the moose population, which is probably due to emigration (Haber, 1977) and low

recruitment resulting from high calf mortality (Van Ballenberghe, 1987; Bowyer et al., 1999). Vegetative growth near the road also may have obscured visibility in areas of high moose density (F. Dean, pers. comm. 1998; V. Van Ballenberghe, pers. comm. 1998), which could have contributed to the decline in observations. Proportionally fewer moose were seen within 100 m of the park road than in 1973–74 (Tracy, 1977). Traffic may have had a slight effect on moose adjacent to the road; but it is also possible that new vegetation obscured visibility near the road, so that moose present in this area were not seen. There was no difference in the proportion of moose observed in any area beyond the first 100 m. Additionally, in an analysis of moose distribution along the eastern section of the road corridor (where 68% of our sightings occurred), radio-collared moose did not appear to avoid the road during May–September 1995–97 (J.L. Belant, unpubl. data).

Habituation to traffic on the park road could explain the reduction in adverse responses of animals between 1973–74 and 1995–97. Mammals exposed to stimuli typically habituate if the stimuli do not provide negative reinforcement (Denniston, 1956; Altman, 1958; Belant et al., 1998). The dramatic increase in vehicle traffic in the early 1970s likely contributed to the high number of adverse reactions recorded during Tracy's 1973–74 study (1977). Additionally, in recent years fewer people have been getting off buses at wildlife stops, and drivers have attempted to minimize human noise.

Some believe the number of animals that use the road corridor may have declined with the increase in traffic (F. Dean, pers. comm. 1998). The number of sightings could be independent of the number of animals if fewer, but habituated, individuals were seen more frequently than individuals had been seen prior to habituation. Unfortunately, no data are available to allow accurate assessment of the number of different individuals observed from the road.

Denali National Park is apparently maintaining opportunities to view wildlife along the road corridor while meeting the demands of increased visitation. We do not claim that there was no effect of traffic disturbance on caribou, Dall sheep, grizzly bear, and moose behavior, only that we have been unable to measure an adverse effect. Likewise, we are not suggesting that disturbance along the road could not increase to a level that would adversely affect these species. The number of vehicles permitted on the park road is limited between 26 May and 13 September, but traffic volume on the first 50 km continues to increase outside this period (Fortier and Olson, 1996). Park managers must continue to be attentive to these and other changes in human activity along the park road.

ACKNOWLEDGEMENTS

We thank the park road bus drivers for information and support, but especially T. Parry, M. Boyce, and R. Coliani. V. Van Ballenberghe and F. Dean provided insight and helpful information.

Three reviewers also improved an earlier draft of this manuscript. We are grateful to J. Balay, P. Sousanes, and J. Paynter for their assistance. S. Carwile, C. Loeb, and J. Van Horn maintained an interest in this project to its completion.

REFERENCES

- ADAMS, L.G. 1996. Calf production and survival in the Denali caribou herd, Alaska. Ph.D. thesis, University of Minnesota, St. Paul. 152 p.
- ADAMS, L.G., DALE, B.W., and SHULTS, B. 1989. Population status and calf mortality of the Denali caribou herd, Denali National Park and Preserve, Alaska, 1984–1988. Alaska Region National Resources Progress Report: AR-89/13. Anchorage, Alaska: United States National Park Service. 131 p.
- ALTMAN, M. 1958. The flight distance in free-ranging big game. *Journal of Wildlife Management* 22(2):207–209.
- BELANT, J.L., SEAMANS, T.W., and TYSON, L.A. 1998. Comparison of three frightening devices as white-tailed deer deterrents. *Proceedings of the Vertebrate Pest Conference* 18:107–110.
- BOWYER, R.T., VAN BALLEMBERGHE, V., KIE, J.G., and MAIER, J.A.K. 1999. Birth-site selection by Alaskan moose: Maternal strategies for coping with a risky environment. *Journal of Mammalogy* 80(4):1070–1083.
- BROWN, W.E. 1993. Denali, symbol of the Alaskan wild: An illustrated history of the Denali-Mt. McKinley region, Alaska. Denali Park: Alaska Natural History Association. 223 p.
- BURSON, S.L., III, BELANT, J.L., FORTIER, K.A., and TOMKIEWICZ, W.C., III. 1999. Suitability of bus drivers for monitoring large mammal abundance. In: Harmon, D., ed. *On the frontiers of conservation: Proceedings of the Tenth Conference on Research and Resource Management in Parks and on Public Lands*, 22–26 March 1999, Asheville, North Carolina. 102–106.
- DALLE-MOLLE, J., and VAN HORN, J. 1989. Bear-people conflict management in Denali National Park, Alaska. In: Bromley, M., ed. *Bear-people conflicts: Proceedings of a Symposium on Management Strategies*. Yellowknife, Northwest Territories: Department of Renewable Resources. 121–128.
- . 1991. Observations of vehicle traffic interfering with migration of Dall's sheep, *Ovis dalli dalli*, in Denali National Park, Alaska. *Canadian Field-Naturalist* 105(3):409–411.
- DEAN, F.C. 1987. Brown bear density, Denali National Park, and sighting efficiency adjustment. *International Conference of Bear Research and Management* 7:37–43.
- DENNISTON, R.H., II. 1956. Ecology, behavior and population dynamics of the Wyoming or Rocky Mt. Moose, *Alces alces shirasi*. *Zoologica* 41(14):105–118.
- FORTIER, K., and OLSON, G. 1996. Park road traffic: 1979 to 1995. Unpubl. report. Available from the Division of Research and Resource Preservation, Denali National Park and Preserve, P.O. Box 9, Denali Park, Alaska 99755, U.S.A. 20 p.
- HABER, G.C. 1977. Socio-ecological dynamics of wolves and prey in a subarctic ecosystem. 2 vols. Ph.D. thesis, University of British Columbia, Vancouver. 786 p.

- LOONEY, B. 1992. Interpretive aspects of visitor observations of wildlife along the Denali National Park road corridor 1980–1990. M.Sc. thesis, Humboldt State University, Arcata, California. 41 p.
- MATTSON, D.J., KNIGHT, R.R., and BLANCHARD, B.M. 1987. The effects of developments and primary roads on grizzly bear habitat use in Yellowstone National Park, Wyoming. *International Conference on Bear Research and Management* 7:259–273.
- McLELLAN, B.N., and SHACKLETON, D.M. 1988. Grizzly bears and resource extraction industries: Effects of roads on behavior, habitat use, and demography. *Journal of Applied Ecology* 25:451–460.
- MEIER, T.J., KEAY, J.A., VAN HORN, J.C., and BURCH, J.W. 1991. 1991 Aerial moose survey, Denali National Park and Preserve. Alaska Region Natural Resources Survey and Inventory Report AR-91/06. Anchorage, Alaska: United States National Park Service. 18 p.
- MURIE, A. 1944. The wolves of Mount McKinley. *Fauna Series 5*. United States National Park Service. Seattle: University of Washington Press. 283 p.
- NPS (NATIONAL PARK SERVICE). 1986. The Denali National Park and Preserve General Management Plan, Land Protection Plan, Wilderness Suitability Plan. Denali National Park and Preserve, National Park Service. D-96A. Denver: Denver Service Center. 244 p.
- PUTERA, J., and KEAY, J.A. 1998. Effect of vehicle traffic on Dall sheep migration in Denali National Park and Preserve. Unpubl. report. Available at Denali National Park and Preserve, Research and Resource Protection Division, P.O. Box 9, Denali Park, Alaska 99755, U.S.A.
- SINGER, F.J., and BEATTIE, J.B. 1986. The controlled traffic system and associated wildlife responses in Denali National Park. *Arctic* 39(3):195–203.
- TAYLOR, D.L., VOGT, K.D., and WARBURTON, J. 1997. A system for monitoring impact of Denali National Park road traffic on wildlife. *Biological Sciences Report: USGS/BRD/BSR-1997-0001*. Anchorage, Alaska: United States Geological Survey, Biological Resources Division, Alaska Biological Sciences Center. 260 p.
- TRACY, D.M. 1977. Reactions of wildlife to human activity along Mount McKinley National Park road. M.Sc. thesis, University of Alaska Fairbanks. 260 p.
- VAN BALLEMBERGHE, V. 1987. Effects of predation on moose numbers: A review of recent North American studies. In: *Proceedings of the Second International Moose Symposium*. Swedish Wildlife Research, *Viltrevy Supplement* 1(2):430–460.
- ZAR, J.H. 1984. *Biostatistical analysis*. 2nd ed. Englewood Cliffs, New Jersey: Prentice Hall. 718 p.