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The Controlled Traffic System and Associated Wildlife Responses in Denali National Park

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ABSTRACT. Wildlife observability and responses and visitor attitudes were sampled after a mandatory visitor shuttle bus transportation system was in operation for 10 years in Denali National Park, Alaska. Visitor approval of the park transportation policy increased from 80% to 89% from 1972 to 1982-83. Vehicles per day increased 50% from 1973-74 to 1982-83. Moose sightings per trip declined 72%, grizzly bear sightings declined 32%, while Dall sheep and caribou sightings remained constant over the same period. Allowing unlimited private vehicle access during the falls of 1982 and 1983 had little influence upon the numbers of wildlife seen. However, more wildlife were put to flight, flight distances increased, more grizzlies were thwarted from crossing the road, and visitors stopped near and approached wildlife afoot more often. Wildlife responses were significantly influenced by pre-stimulus wildlife behavior for all four species, the type of human behavior for moose and grizzlies, sex/age class for moose and caribou, group size for caribou, number of vehicles present for grizzlies, and the presence or absence of vegetation screening for moose and grizzlies ($p<0.05$). Moose were alert four times as often ($32\pm21\%$) when close to the park road than when >1 km away ($4.8\pm5.1\%$), and when close to the road they were alerted to $37\pm21\%$ of all road stimuli, while caribou were alerted to only $21\pm11\%$ ($p<0.03$) of road stimuli.

Key words: wildlife viewing, visitor attitudes, wildlife response to traffic, Denali National Park, moose (*Alces alces*), Dall sheep (*Ovis dalli*), grizzly bear (*Ursus arctos*), caribou (*Rangifer tarandus*)

RÉSUMÉ. Les possibilités d'observation de la faune, les réactions de la faune et les attitudes des visiteurs furent échantillonnées après la dixième année d'opération d'un service de navette obligatoire par autobus pour les visiteurs dans le parc Denali en Alaska. Entre 1972 et 1982-83, le pourcentage de visiteurs en faveur de la politique de transport augmenta de 80% à 89%. Le nombre de véhicules par jour augmenta de 50% entre 1973-74 et 1982-83. Les observations d'orignaux par voyage diminuèrent de 72%, celles d'ours bruns (grizzlys) baissèrent de 32%, tandis que celles de mouflons de Dall et de caribous demeurèrent constantes durant cette même période. L'accès non contrôlé de véhicules privés permis durant les automnes de 1982 et 1983 produisit peu de différence dans le nombre observations de faune. Il entraîna cependant la fuite d'un plus grand nombre d'animaux ainsi qu'une augmentation des distances de fuite de ces derniers. Les véhicules empêchèrent aussi à plus d'ours bruns de traverser la route et les visiteurs s'arrêtaient tout près de la faune ou s'en approchaient à pied plus souvent. Les réactions de la faune chez ces quatre espèces étaient influencées de façon importante par leur comportement habituel pré-stimulus, c'est-à-dire par le type de comportement des humains chez les orignaux et les ours bruns, par classe de sexe et d'âge chez les orignaux et les caribous, par le nombre de véhicules présents chez les ours bruns, et par la présence ou l'absence d'un couvert végétal chez les orignaux et les ours bruns ($p<0.05$). Les orignaux étaient quatre fois plus vigilants ($32\pm21\%$) lorsqu'ils se rapprochaient de la route du parc que lorsqu'ils se déplaçaient à >1 km de celle-ci ($4.8\pm5.1\%$). De plus, lorsqu'ils se trouvaient à proximité de la route, ils étaient en état d'alerte face à $37\pm21\%$ des stimulus de la route tandis que caribous n'étaient mis en état d'alerte que face à $21\pm11\%$ ($p<0.03$) de ces mêmes stimulus.

Mots clés: observation de la faune, attitudes des visiteurs, réactions de la faune face à la circulation, parc national Denali, orignal (*Alces alces*), mouflon de Dall (*Ovis dalli*), ours brun (*Ursus arctos*), caribou (*Rangifer tarandus*)

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INTRODUCTION

A pervasive challenge in the management of national parks is to balance protection of resources while at the same time making them available for people to enjoy (Everhart, 1972:80-98). At times the two objectives may be contradictory. The management challenge is nowhere greater than in Denali (formerly Mt. McKinley) National Park, which has become one of the most heavily visited subarctic national parks in the world. Here the opportunity to view the wildlife, tundra ecosystems, and mountain scenery, including the highest peak in North America (Mt. McKinley), must be balanced against protection of those same sensitive northern resources. We report here on a reevaluation conducted in 1982-83 of both visitor attitudes (Harrison, 1975) and wildlife viewing opportunities (Tracy, 1977) after 10 years of operation of a mandatory shuttle bus system for visitor access along the Denali Park road.

The opportunity to view and conserve highly visible wildlife, particularly moose (*Alces alces*), Dall sheep (*Ovis dalli*), grizzly bear (*Ursus arctos*) and caribou (*Rangifer tarandus*), was one of the major reasons that Denali National Park and Preserve was originally created in 1916 (Mt. McKinley National Park Establishment Act 39, Stat. 938) and then greatly expanded in 1980 (Public Law 96-487). In 1936, a 130 km unpaved road was completed into the park with no restrictions on its use. Visitation initially was low, since all private vehicles had to be shipped to the park by rail; even after 1957, when the 256 km, arduous, unpaved Denali Highway was built from Paxson to the park, few visitors drove to the park. In 1971, however, the paved George Parks Highway was completed between Anchorage and Fairbanks, making the park accessible to all motorists. Visitation subsequently rose from 58 342 in 1971 to 306 027 in 1972. In anticipation of the increase in access, the National Park Service (NPS) in 1973 instituted a mandatory system of free shuttle buses along the park road with the following objectives: 1) to minimize disturbances to wildlife and scenery, 2) to minimize road hazards, and 3) to maximize wildlife and scenery viewing with the least resource impact and energy consumption (U.S. Department of Interior, 1982).

Visitation to Denali Park has greatly expanded since 1972, along with demands on the park road and shuttle bus system. From 1972 to 1982-83, the number of shuttle bus trips per day increased from 27 to 36, the number of other vehicles increased 40% and the number of shuttle bus boardings ($\bar{x}=2.3$ boardings per visitor) increased about 11% annually. The current bus system operates near capacity, with all seats occupied on most buses. Increasing the number of buses is a questionable solution because of the quality of the park road base and surface (U.S. Department of Transportation, 1978).

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STUDY AREA

The Denali Park road traverses the north side of a fault valley that separates the Alaska Range and the Outer Range. This valley is 2-3 km wide near the NPS headquarters at the eastern end, but steeper and only 1 km wide 100 km farther west near Eielson Visitor Center. All wildlife observations were confined to this 100 km section of the park road. The road climbs from 520 m asl through four passes over 1070 m, travels through one rocky canyon and crosses five braided glacial rivers. Climate is subarctic, with short, cool and rainy summers. Annual precipitation is only 38 cm.

Open white spruce (*Picea glauca*) and tall willow (*Salix* spp.) stands predominate in the first 50 km of the park road. At higher elevations and along the western half of the road open dwarf shrubs (*Dryas* spp., *Vaccinium* spp.) and herbaceous tundra (*Carex* spp., *Eriophorum* spp.) predominate (Dean and Heebner 1982).

Dall sheep numbers may have increased from 1978 to 1981, although increased survey efficiency likely accounted for a higher aerial count in 1981 (Singer, 1984). Grizzly bear densities were similar in 1973 and 1983 along the park road (Dean, 1976, 1986). Moose numbers apparently declined 32% in the eastern half of the park road but were stable or more likely increased in the western half 1974-76 to 1984 (Singer and Dalle-Molle, 1985). Caribou numbers increased about 60% since about 1980 (Singer and Dalle-Molle, 1985). Most moose were observed close to the road in the partially forested first 50 km. Dall sheep were usually sighted at greater distances from the road on the steep slopes of the mountain ranges, but sheep were adjacent to the road at Igloo Creek Canyon and Polychrome Pass, where the road enters sheep habitat, and also when sheep crossed the park road during seasonal migrations (Murie, 1944). Some caribou, particularly bulls, reside all along the road corridor during the summer, but larger groups of cows and calves migrating to and from calving grounds approached the western half of the road for brief periods (Murie, 1944; Troyer, 1981).

The first 21 km of the park road is paved and open to all vehicles. Beyond that point, beginning on Memorial Day and through Labor Day of each year, all visitors must travel on the shuttle buses. The only exceptions are fee tour buses, NPS administrative and road construction vehicles and private vehicles with special permits. Special permits are given to miners operating beyond the far end of the road at Kantishna and to park visitors using one of the five campgrounds located along the road. The next 26 km is improved gravel and is 7.9 m wide. The remaining 53 km of the study road section is only 5.5 m wide and sinuous.

Shuttle buses depart from the park entrance every half hour 0600-2000 h. Visitors may exit or board at any point along the road, assuming a seat is available. Drivers exercise some control near wildlife by moving on if passengers begin to disturb animals and not allowing visitors to exit any closer than 0.8 km from a grizzly bear.

METHODS

Observations of moose, Dall sheep, grizzly bear and caribou were made in 1982 and 1983 from May to early September by driving round-trip from park headquarters to Eielson Visitor Center in an inconspicuous government truck or van. We completed 53 round trips in 1982 and 72 in 1983; Tracy (1977) completed 70 trips in 1973-74 (N = 195 total trips). Vehicle restriction effects were sampled with 16 trips both during four days before and four days after *lifting* of restrictions on 6 September 1982, 12 trips before and 19 trips after 5 September 1983, and 13 trips before and 13 trips after *placement* of restrictions on 27 May 1983. During these periods, four different observers traveled the road each day beginning at 0600, 0800, 1200, and 1400 h respectively. We continued to observe the paved first 21 km section during these before and after tests, since this section was always open to private vehicles and their number also increased here during the open periods.

Each time a group of animals was observed, the vehicle was stopped as close as possible to the animal, the engine turned off and the animal and stimuli observed for 5 min. A 20-40 × spotting scope and 7 × 35 binoculars aided observations. At each observation site we recorded the time, weather, vegetation type (Level III of Viereck *et al.*, 1982), slope, elevation and estimated mean dominant canopy height of vegetation. We recorded the number of animals, their sex/age composition, their distance at first response irrespective of angle to the road, their perpendicular distance from the road and whether or not they were partially screened by vegetation. We estimated the angle between the animal and the stimulus at first response and the total distance moved by the animal in a response. Stimuli were the number of buses, private cars or pedestrians and their activity. Pre-stimulus and post-stimulus or response behavior of wildlife included: bed, feed, stand, stand up, brief glance, alert, drift away, walk away, startled, trot away, run away, group bunch up and group reverse direction. Species specific excitation or aggressive responses included: stott, excitation jump, head high-spring trot, tail erect and hind leg up-urination alarm for caribou (Pruitt, 1960; Lent, 1966); erect mane, stiff-legged walk and antler threat for moose (de Vos, 1958; Geist, 1963); and bluff charge, woof and lateral threat for grizzlies (Stonorov and Stokes, 1972). Distances in 1983 were measured with a range-finder (MKS, Ranging Inc.), visual estimates were made in 1982 combined with pacing tests, and these data were compared to the mid-points of Tracy's (1977) distance groupings. Similar data were collected on caribou responses to vehicles from the little-used Stampede Road 1-6 March 1982, during typical winter conditions of about 0.3 m snow depth and −10° to 0°F.

Longer observations were made of caribou and moose groups from inside a parked vehicle to record their alert reactions to a number of different stimuli. Data collection was similar to that for the round trips, but each animal(s) was observed for as long as it was visible and the duration of each behavior was timed to the nearest minute. Moose were more difficult to keep under observation in tall brush, and the observer often left the vehicle on foot to keep the animal in sight. Although efforts were made not to alert the moose to the observer, some such disturbances were unavoidable.

We contacted 400 visitors in both 1982 and 1983: 200 at intermediate rest stops during their shuttle bus trip, 100 car drivers each fall after travel restrictions were lifted, another 100 car drivers in 1983 in mid-summer, while in 1982 another 100 visitors were contacted at the termination of their 200 km round-trip bus ride. Selection of parties was random and only one person in each party was interviewed. We asked the same questions as Harrison (1975) did in 1972, the difference being that he used questionnaire forms, not interviews. Visitors who agreed to the contact (none declined) were asked for: 1) party

size, 2) number of days on bus, 3) length of stay in park, 4) residence, 5) sightseeing, backcountry or campground activities, 6) opinion of NPS transportation policy — strongly approve, approve, neutral, disapprove, or strongly disapprove, and 7) opinion of shuttle bus service — excellent, good, fair, poor, very poor. In 1983, we also asked visitors whether they would desire a greater number of shuttle buses. During both falls, we asked car drivers if they had purposely scheduled their trip to avoid travel restrictions. We attempted not to prompt or react to visitor responses.

Only the probability levels are presented for t-test and Chi-square tests. We used the Mann-Whitney U Test (Siegel, 1956) for comparisons involving individual animals, for comparisons to distances that were categorical (Tracy, 1977) or where distance measurements likely increased disproportionately in error, or for comparisons between wildlife numbers likely influenced by groupings. The effects of several variables on wildlife response categories were tested with the nonparametric Kruskall-Wallis 1-way ANOVA (Siegel, 1956), or one- and two-way ANOVA with multiple runs comparing each response category in turn against all the others pooled (Subprogram. ONEWAY, Nie *et al.*, 1975). Acceptance levels (p) vary based upon our judgment of sample sizes and test power.

RESULTS

Visitor Attitudes

Residency of visitors interviewed was 32% Alaskan, 62% other 49 states, 4% foreign (primarily western Europe), and 2% Canadian. Party size averaged 2.9 ± 1.7 ($\bar{x}$ + s.d.), length of visit in the park was 2.3 ± 1.9 days (range 1-23), and the number of days riding the bus was 1.3 ± 0.7 (range 0-7). Alaska residents were more common among both car drivers in the uncontrolled fall period and in car drivers commuting to campgrounds in mid-summer ($p<0.001$). Twenty-four (24%) of 101 fall car drivers in 1982 had purposely scheduled their trip to avoid road travel restrictions, but this preference was not associated with residency ($p=0.75$). Nineteen percent of the fall car drivers did not know of the lifting of travel restrictions and would have preferred to ride a shuttle bus. Harrison (1975) also found nearly double the proportion of Alaskans in cars than in buses.

Approval for the NPS mandatory transportation system increased 17% from 1972 to 1982 and further increased 4% in 1983 ($p<0.001$; Table 1). Approval by car drivers increased from 1982 to 1983. Alaskans approved less than did other residents ($p<0.002$). Shuttle bus riders in 1983 approved more than summer car drivers and fall car drivers ($p<0.05$; Table 1). Thirty-four percent of the fall car drivers who approved of the transportation policy also preferred to drive their own vehicles. The typical round-trip shuttle bus trip to Eielson Visitor Center takes 7-10 h over a rough road, but apparently fatigue does not alter visitor opinion. There were no differences in opinion between mid- and end-trip interviews ($p<0.05$).

TABLE 1. Attitudes of park visitors toward the shuttle bus system in Denali National Park

	Approve		Neutral		Disapprove	
Year: Group	N	%	N	%	N	%
1972[1]	251	71	33	9	67	20
1982	287	87*	34	10	10	3
1983	360	91*	14	4	21	5
a) shuttle bus	191	96	5	2	5	2
b) summer car drivers	88	89	3	3	8	8
c) fall car drivers	81	81*	8	8	10	10

*Indicates significant difference from the value directly above it using t-tests ($p<0.05$).
[1]From Harrison (1975).

We pooled the approve-strongly approve and disapprove-strongly disapprove categories, since strongly approve: approve ratios were 2.5:1 in 1972, but only 1.2:1 in 1982 and 0.6:1 in 1983; we suspect survey techniques varied or perhaps distinction between the categories was not meaningful.

Denali Park visitors who provided reasons for their approval of the NPS transportation policy ($n=702$) strongly identified the system with a reduction in both traffic congestion ($n=205$) and environmental impacts ($n=174$), such as wildlife protection and reductions in litter and air pollution. Other reasons provided for approval of the system included: enhances viewing of wildlife and scenery ($n=109$), improves safety ($n=81$), more control on visitor activity ($n=51$), promotes access and convenience ($n=32$), no costs ($n=28$), saves wear on personal vehicles ($n=15$), and saves energy ($n=7$).

Only 35 (5%) of the parties interviewed in 1982-83 disapproved of the transportation system: 22 complained of losses to personal convenience, 7 gave no reason, 5 complained of hampered wildlife viewing from the bus, 1 found the bus uncomfortable and 1 objected to his loss of personal freedom.

Wildlife Observations

A total of 656 ($n=451$ groups) moose, 5609 ($n=662$ groups) Dall sheep, 897 ($n=556$ groups) grizzly bears, and 3801 ($n=762$ groups) caribou observations were recorded during four years of data collection in 1973-74 ($n=70$ trips; Tracy, 1977), 1982 ($n=53$ trips), and 1983 ($n=72$ trips). In March 1982 we recorded an additional 404 ($n=46$ groups) caribou observations along the Stampede Road.

Bull ratios for moose in 1982-83 (41 ♂:100 ♀) were similar to 1973-74 (38 ♂:100 ♀), as were caribou bull ratios between 1982-83 (124 ♂:100 ♀) and 1973-74 (136 ♂:100 ♀, $p>0.95$). Roadside sex/age ratios were apparently representative of the park's population of moose (W. Troyer, pers. comm. 1981), but caribou bulls were three times as abundant along the road (130 ♂:100 ♀) when compared to aerial surveys of the population as a whole (45 ♂:100 ♀; Troyer, 1981).

Moose sightings declined 72% per road trip 1973-74 to 1982, grizzlies declined 32% ($p<0.05$), while vehicles per day increased 50% (Table 2). Like Tracy (1977), we observed more moose on the first trip of the day (0600 h) in 1982.

Seasonal migrations and seasonal habitat preferences affected wildlife observations. More moose and fewer caribou were observed during fall than summer, more sheep were observed during spring than summer. Grizzly sightings peaked during fall (Mann-Whitney U tests, $p<0.05$). Weather had no effect on the number of grizzlies seen per trip, but more caribou were seen on clear days and fewer moose, sheep and caribou when it was snowing (Kruskall-Wallis 1-way ANOVA, $p<0.05$). Dall sheep often fed closer to the road on lower snow-free slopes in spring, and more were observed crossing the road during fall.

Caribou and grizzlies were significantly closer to the road in 1982 than 1973-74 ($p<0.05$). A similar trend was suggested for moose. The number of moose groups <75 m from the park road increased from 46% in 1973-74 to 70% in 1982. Grizzlies <75 m

TABLE 2. Moose, sheep, grizzlies and caribou observed per round trip on the Denali Park road during the visitor seasons, 1973-74, 1982, 1983, before and after placement of vehicle restrictions spring 1983, and before and after lifting restrictions fall 1982 and 1983

Period		Vehicles per day[1]	Moose		Dall sheep		Grizzly bear		Caribou	
			$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.	$\bar{x}$	s.d.
1973-74[2]		77	5.8	4.7	34.5	19.7	5.9	4.2	33.1	63.6
1982		112	1.6	0.4*	33.4	6.2	4.0	0.9*	33.5	12.6
1983		121	2.6	2.7*	22.7	29.3	4.3	3.4*	43.9	61.6
Fall 1982:	before	115	2.0	2.6	42.5	28.3	4.0	2.1	18.4	9.8
	after		2.4	2.2	46.7	23.9	5.4	3.1	17.9	40.3
Fall 1983:	before	115	2.1	1.7	6.0	9.5	6.3	3.0	10.0	7.1
	after	144	2.2	3.1	9.6	9.4	4.8	2.8*	14.2	10.5
Spring 1983:	before		3.8	3.0	40.7	32.2	4.0	3.3	103.2	98.6
	after	93	2.8	2.5	39.0	30.5	2.3	2.8	84.1	48.4

*Indicates a difference from the mean directly above using Mann-Whitney U tests, $p<0.05$.
[1]Data not available for all periods.
[2]From Tracy (1977) for 1973-74.

TABLE 3. Percentage of groups put to flight and flight distances ($\bar{x}$ + s.d.) for moose, Dall sheep, grizzly bears and caribou from the Denali Park road in 1973-74, 1982 and 1983, and before and after lifting of travel restrictions during fall 1982 and 1983

Period		Moose			Dall sheep			Grizzly bear			Caribou		
			Distance (m)			Distance (m)			Distance (m)			Distance (m)	
		% fleeing	$\bar{x}$	s.d	% fleeing	$\bar{x}$	s.d	% fleeing	$\bar{x}$	s.d	% fleeing	$\bar{x}$	s.d
1973-74		14	44	63	5	77	111	12	111	144	14	99	121
1982		26*	43	47	0*			8*	28*	37	17	104	77
1983		30	79*	122	17*	79	73	21	70	85	31	110	100
Fall 1982:	before	13	52	32	0			18	42	39	35	81	84
	after	30	46	51	4*	57	6	14	95	97	94*	174*	171
Fall 1983:	before	54	57	121	0			17	59	62	0		
	after	42	164*	163	24*	49	31	24	96*	104	0		

*Indicates a difference in the proportion of groups put to flight in comparison to the value directly above, Chi-square tests, $p<0.10$ or difference from the mean distance directly above, Mann-Whitney U tests, $p<0.05$.

from the park road increased from 25% to 65%, while caribou groups <200 m from the park road increased from 70% to 90%.

Lifting vehicle restrictions on the Denali Park road in the fall had little influence upon numbers of wildlife seen. However, flight distances increased, proportionately more wildlife were put to flight and there were more visitor disturbances (Table 3). Only grizzly bear sightings were reduced ($p<0.05$; Table 2). More vehicles aggregated near wildlife groups each fall, visitors left their vehicles and approached wildlife more often, more wildlife groups were alerted and put to flight, more caribou performed excitation jumps and more grizzlies were temporarily thwarted from crossing the park road ($p<0.05$; Table 4). Other flight responses, however, were less consistent and suggest annual variations in observers or in wildlife distribution or responses. For example, moose and sheep were more responsive during fall in 1983 than 1974-75, but less responsive in 1982.

TABLE 4. Visitor and wildlife behavior compared before and after lifting of vehicle restrictions in Denali National Park, fall of 1982 and 1983 (n = 122 wildlife observations before and 154 after, 15 grizzly crossing attempts before and 17 after, 22 caribou group sightings before and 16 after)

Behaviors	Before	After
Visitors leaving roadside	10	25*
Vehicle jams	35	104*
Visitors threatened by wildlife	2	6
Caribou excitation jumps	0	11*
Wildlife alerts	75	131
Wildlife groups fleeing	25	65*
Grizzly road crossings thwarted	2	9*
$\bar{x}$ + s.d. Vehicles near a wildlife group	3.6±2	6.2±5*
$\bar{x}$ + s.d. Visitors out of vehicles near wildlife	6.3±12	10.1±9

*Significant differences $p<0.05$ using Chi-square and t-tests. Chi-square tests based upon comparisons of total numbers of wildlife observations both before and after or, in the case of grizzly crossings, the number of crossing attempts both before and after were compared to the number thwarted.

Denali Park caribou were more sensitive when wintering along the Stampede Road March 1982. The wintering caribou were subjected to 1-4 vehicle passes per day at random intervals in contrast to 200-250 vehicles passing at more regular intervals along the park road. More caribou groups (27%) were put to flight on the Stampede Road ($p<0.05$), and increases in flight distance approached significance ($p<0.10$), but mean distance of caribou groups from the 2 roads did not differ and the number of excitation jumps per (4 per 100 fleeing caribou) was identical.

Wildlife Responses

Larger caribou groups or groups with calves first reacted when closer to the park road ($p<0.05$; Table 5). Moose reacted less when screened by vegetation, but grizzlies reacted more when screened by vegetation ($p<0.05$). Number of vehicles present and grizzly bear reaction distance correlated at $p<0.10$.

Moose groups within 400 m of the park road alerted (75%) or fled (38%) more than grizzlies (51% alerted, 21% flight) or caribou (51% alerted, 28% flight). Dall sheep were very responsive within 400 m of the road (alert 80%, flight 38%), when they were often far from security habitat and crossing the road. Four running retreats by sheep of 0.4-2.0 km were

TABLE 5. Regression analysis of factors (Xi) suspected of influencing perpendicular distance (Y) and reaction distance from (Y) from the Denali Park road for responses by moose, Dall sheep, grizzly bears and caribou in 1983; independent variables were number of vehicles, group size, screened:not screened and young of the year present:absent

	Moose (n = 43 groups)		Sheep (n = 17)		Grizzly (n = 60)		Caribou (n = 99)	
	r^2	F	r^2	F	r^2	F	r^2	F
First reaction distance:								
Perpendicular	0.57	55.54*	0.90	161.33*	0.84	300.4*	0.73	269.18*
No. vehicles	0.003	0.19	0.007	0.12	0.02	1.16	0.006	0.54
Group size	0.0003	0.01	0.001	0.01	0.02	1.05	0.08	7.97*
Screened	0.12	5.73*	0.005	0.08	0.11	7.70*	0.005	0.48
Young of year present	0.003	0.13	0.005	0.08	0.03	1.55	0.012	1.27
Perpendicular reaction distance:								
No. vehicles	0.001	0.05	0.01	0.17	0.05	2.9	0.004	0.41
Group size	0.00005	0.002	0.003	0.05	0.01	0.71	0.08	8.58*
Screened	0.01	0.44	0.0009	0.01	0.14	9.67*	0.005	0.50
Young of year present	0.02	0.86	0.03	0.56	0.02	1.06	0.06	6.27*

* Significant correlation, $p<0.025$.

observed. Another group remained near the road for three hours attempting to cross. However, when distant sheep sightings were considered they were the least responsive species (14% reacted, 7% fled). Percentage of extreme responses (running, excitation, alarm) was higher for caribou (18% of all sightings), followed by moose (14%), grizzlies (10%) and sheep (5%). Caribou also moved farther during a response (117±73 m, $\bar{x}$ ±sd), followed by sheep (105±95 m), grizzlies (81±79 m) and moose (72±72 m).

Distance from Denali Park road influenced behavior responses in all four species ($p<0.0001$; Table 6). Moose, sheep, and caribou responses suggested the following order of increasing intensity of responses with decreasing distance from the road: no response > stare, stand up > walk away > startle, trot, run > excitation.

Group type of caribou significantly influenced behavioral reactions to the road. Using the response ranks above (Kruskall-Wallis one-way ANOVA, $p<0.05$), the influence of group type on a trot or run response was: cow/calf groups (35%) > mixed (30%) > cows (10%) > bulls (8%). Increasing numbers of vehicles present near a group increased caribou responses ($H=14.9$, $p<0.05$) and grizzly bear responses ($H=39$, $p<0.05$). Human activity influenced moose and grizzly responses, pre-stimulus wildlife behavior affected responses of all four species, while sex/age class influenced moose reactions (Table 7). Travelling wildlife were the most likely to respond. Pre-stimulus behavior for grizzlies influenced reactions in the following order: walking (71% reacted) > bedded (33%) > standing (12%); the order in 1983 was very similar: walking (79%) > bedding (67%) > feeding (33%). For caribou, however, the 1982 pre-stimulus behavior rank was: travelling (77% reacted) > bedding (33%) > standing (12%). Cow moose with calves were more responsive to road stimuli; 80% of cows with calves reacted to the road, 65% of cow only groups, 50% of mixed sex groups, and 48% of bull only groups.

Alert Response of Individual Groups of Moose and Caribou, 1983

Moose alert time was negatively correlated with distance from the road (Spearman rank correlation, $r_s=-0.53$, $p<0.05$), and caribou alert time was negatively correlated at the $p<0.10$ level. Moose were more responsive than caribou and alerted to 37±21% ($\bar{x}$ ±sd) of all road stimuli (8.6 alerts·h), compared to only 21±11% for caribou (3.2 alerts·h, $p<0.03$). Moose and caribou differed in the stimuli they alerted to (Table 8), with no correlation between their respective rankings of alert stimuli ($r_s=0.36$, $p=0.25$). Both species alerted highly to the combined stimuli of cars and buses, and cars and pedestrians. Moose alerts varied for different stimuli ($p<0.03$; Table 8), and differences in alerts for caribou approached significance ($x^2=10.1$, $p<0.10$).

For comparative purposes, an additional five moose groups (4 bull, 1 cow groups) were observed for 969 min (194±108 min per session) in undisturbed situations more than 11 cm from the park road. Moose were alert four times as often (alert 32±2% of

TABLE 6. Perpendicular distance ($\bar{x}$ + s.d. m) from the Denali Park road for 6 behavioral responses by moose, Dall sheep, grizzly bear and caribou, 1982-83; differences in mean distances between response categories were tested by one-way analysis of variance

Behavioral response	Moose			Sheep			Grizzly bear			Caribou		
	N	$\bar{x}$	s.d.	N	$\bar{x}$	s.d.	N	$\bar{x}$	s.d.	N	$\bar{x}$	s.d.
None	128	182	217A	202	570	321A	271	189	205A	217	418	349A
Stare, stand up	99	110	106B	116	135	105B	62	76	68B	266	143	101B
Walk	51	94	193B	13	125	106B	100	120	102B	72	131	111B
Startle, run, trot	38	55	83B	11	73	69B	39	89	106B	78	104	90B
Excitation	7	8	5B	8	98	75B	11	50	68B	44	11	99B
Antler, head low, or other threat	1	15	B				2	2.5	3.5B	1	12	B
ANOVA Results: (df = 5) F value		7.6*			65.40*			9.95*			65.96*	

A, B — Distances followed by the same letter are not different ($p<0.05$) according to the least-significant difference procedure.
* $p<0.001$ for F value.

TABLE 7. Analysis of variance for behavioral responses of wildlife to the categories of visitor presence, pre-stimulus of wildlife behavior and wildlife sex/age class

Independent variable	Dependent response	Moose		Sheep		Grizzlies		Caribou	
		F	P=	F	P=	F	P=	F	P=
Visitor presence[1]	react	1.69	0.19	0.64	0.20	1.32	0.25	0.72	0.54
	alert	0.60	0.52	0.82	0.44	4.94	0.03*	1.46	0.22
	walk	2.52	0.08	0.32	0.73	5.73	0.02*	0.29	0.84
	alarm	13.25	0.001*	0.19	0.96	1.31	0.27	1.09	0.36
Pre-stimulus behavior[2]	react	0.80	0.54	0.54	0.66	2.72	0.04*	3.59	0.02*
	alert	0.61	0.66	1.15	0.35	1.10	0.38	4.37	0.006*
	walk	28.84	0.001*	6.48	0.002*	4.84	0.003*	7.87	0.001*
	alarm	0.002	0.99	0		0.33	0.57	0.02	0.96
Sex/age	react	5.14	0.002*	0.15	0.93	1.76	0.18	0.97	0.38
	alert	1.86	0.14	0.68	0.57	0.13	0.87	0.17	0.83
	walk	0.47	0.71	0.25	0.86	1.58	0.21	0.04	0.95
	alarm	2.05	0.11	0.28	0.84	0.50	0.61	0.02	0.75

*Indicates significance at $p<0.05$.
[1]Visitor presence = none, cars and buses but no pedestrians, pedestrians alone or with cars and buses also present.
[2]Pre-stimulus behavior = bed, feed, stand, walk; sex/age = male, female, mixed sex, female with young.

TABLE 8. Alert responses by moose and caribou to various road stimuli during longer observation sessions along the Denali Park road in 1983[1]

Stimuli	Moose			Caribou		
	No. stimuli	No. alerts	% alerts	No. stimuli	No. alerts	% alerts
Cars and buses	13	8	62	57	16	28
Cars and pedestrians	10	6	60	27	8	30
Pedestrians only	28	11	39	13	3	23
Cars only	98	25	26	350	86	25
Buses only	46	12	26	416	72	17
Heavy equipment				17	5	29
Cars, buses, pedestrians				12	1	8
Buses and pedestrians				12	0	0
Other	12	1	8			
TOTAL	207	63		904	191	

[1]Sample size included 35 caribou groups observed for 4762 min ($\bar{x}$ ±s.d. = 217 ± 109 min·session), and 23 moose groups observed for 1345 min (120 ± 90 min·session). The caribou groups included 14 bull, 4 cow, 4 cow with calf, and 3 mixed groups. The moose groups included 8 cow, 8 cow with calf, 6 bull, and 1 mixed group.

observation time) when close (186±158 m) to the park road (8.6 alerts·h) than when observed more than 1 km from the road (alerts 4.8±5.1% of observation time, 2.6 alerts·h, $p<0.0001$). Some alerts were to the observers, but this was a consistent factor both close to and distant from the road. We also observed cows with calves to alert to other stimuli such as magpies or other moose.

DISCUSSION

Visitor Attitudes

There were positive biases toward the bus system in our survey methods, but less so than for the 1972 survey (Harrison, 1975). Like Harrison (1975), we did not survey any visitors who had impatiently left the park due to an overcrowded bus and would likely have had more negative responses. We did not mail questionnaire forms to a random sample of Alaska residents, some of whom may not have visited the park because of disapproval of the transportation policy. Harrison (1975) verified that this latter group was more negative about the bus system. However, we eliminated three other possible positive biases of Harrison (1975): 1) the shuttle bus system was no longer in an experimental setting, which might have caused visitors to be less critical of it in 1972; 2) bus drivers distributed questionnaires in 1972 and may have been more helpful and courteous on those trips; 3) we provided no explanation or justification of the policy, as the questionnaire in 1972 did, which could have introduced a positive bias. The ratio of strongly approve:approve in 1982 was only half that of 1972, and we received many pragmatic statements concerning the policy, such as "the buses are the only way to handle all these people" or "the service was good considering these are just school buses." This less enthusiastic approval than in 1972 further suggested our survey had less positive bias.

Ratings of bus service and policy approval increased from 1982 to 1983 and fewer complaints were heard. In 1982, we recorded 16 complaints of bus maintenance and 25 of schedule, but zero for either in 1983. Fifty-two percent of bus riders voiced complaints in 1982, but only 28% in 1983. We attribute the decrease in complaints to a change in the bus contractor in 1983 and an improvement in service.

Wildlife Observability

We documented a large degree of variability in the numbers of wildlife observed per trip, in the distances wildlife were observed from the park road and in flight distances. Factors that greatly affect wildlife observability include weather — particularly fog, rain and snow, which obscure visibility — diurnal activity fluctuations in wildlife (de Vos, 1958; Roby, 1978) and seasonal migrations of wildlife. We restricted our observations

to four days before and after travel restriction changes in order to reduce these influences. Tracy (1977) observed wildlife from shuttle buses, while we primarily used pickup trucks. However, a comparison of 12 bus and 15 pickup truck trips during four days in 1982 suggested no difference in wildlife observability ($p<0.05$). Distances were measured by us and estimated by Tracy (1977). In spite of these sources of variation, we propose our data reflect major trends in wildlife observability and responses.

Moose and grizzly bears may have been displaced from the park road since 1973-74 or a major change in bear distribution or population size occurred. A grizzly population decline is unlikely (Dean, 1976, 1986), but moose apparently declined about 32% in the east end of the road corridor but not in the west (Singer and Dalle-Molle, 1985). Moose, grizzlies and caribou were observed closer to the road in 1982-83, suggesting habituation by at least some individuals. Van Ballenberghe (1978) observed that certain radio collared moose exhibited more fear and avoidance of the trans-Alaska pipeline than did other collared individuals. Fewer declines in wildlife sightings after the first trip of the day in 1982-83 further suggested habituation. In contrast, ungulate sightings in Elk Island National Park declined by two-thirds after the first passes by Nordic skiers in a day (Ferguson and Keith, 1981), and elk in a national park left open meadows after the first vehicle passes in the morning (Schultz and Bailey, 1978).

Wildlife Response

Moose: Moose observations declined along the road more since 1973-74 in comparison to the other three species, although a portion of the drop may have been due to a population decline. They alerted more to stimuli than caribou did, but they responded less by fleeing than the other three species after the lifting of vehicle restrictions. Moose often exhibit a delayed escape response (de Vos, 1958; Altman, 1958; Geist, 1963, 1975). Moose responded less than elk or deer (*Odocoileus hemionus* and *O. virginianus*) and more than bison (*Bison bison*) and were more likely to remain still or walk away than flee, but were displaced more from ski trails (Ferguson and Keith, 1981).

Moose responded less when screened by vegetation. Similarly, elk screened themselves from logging or road building by topographic features and lived within 300 m of a heavily traveled interstate when hidden from passing motorists by trees (Ward *et al.*, 1973).

Alert responses by moose in 1982-83 increased 29% over 1973-74 and flight responses increased 11%, although moose sightings declined. We suspect that some conditioned moose remained close to the park road in 1982-83, but they responded when at similar distances to the road. Caribou moved closer to the Trans-Alaska Pipeline haul road (Roby, 1978) after conditioning to it.

Dall sheep: The greater sensitivity of Dall sheep attempting to cross the road was predicted by higher mean heart rate elevations in bighorns when disturbed on flat terrain or closer than 200 m from a road (MacArthur *et al.*, 1979).

Sheep showed evidence of habituation in areas where the road passed through steep terrain. Numbers of sheep observed since 1973-74 have remained fairly consistent. Migrating Dall sheep, however, were rarely recorded, and any road crossing avoidance could go undetected and might have serious biological consequences (Dean and Tracy, 1979).

Grizzly bears: Grizzlies were observed closer to the road than the other three species, exhibited fewer flight responses and were observed closer to the road in 1982-83 than 1973-74. However, grizzlies were the most responsive species in terms of increased flight distances after lifting vehicle restrictions, and fewer bears were observed 1982-83. Grizzly bears are more sought for viewing and therefore subjected to more active human disturbances (Tracy, 1977). Grizzlies apparently felt less secure when screened by vegetation from the road than when they were not, which may be a consequence of poor eyesight and ability to focus on the human shape (Craighead and Craighead, 1966), or a result of greater security when they have the source of human disturbance located (Servheen, 1983).

Caribou: Caribou are considered among the most sensitive of all arctic wildlife species (Geist, 1975; Miller and Gunn, 1979; Klein, 1980), yet our data do not entirely support this conclusion. Caribou sightings did not decline 1982-83, and caribou were observed closer to the road. Caribou alerted to the roadway less than moose and showed less variability in their alert responses to different stimuli than moose (range 0-30% versus 8-62%). Unquestionably, the high proportion of resident bull caribou close to the park road contributes to these findings, since in all studies they are less responsive than cow or mixed groups. Also, we sampled many resident, conditioned caribou — flight distances of caribou rapidly migrating through Highway Pass in 1984 were almost two times what we observed along the entire road corridor (J. Beattie, unpubl. data). Flight distances were also slightly longer for Denali caribou along the Stampede Road, where we observed proportionately two-thirds fewer bulls (46 ♂:100 ♀). Flight distances for caribou were longer in winter in other areas (Bergerud, 1974; Horejsii, 1981) than for the Denali road in summer, so that greater winter responsiveness of caribou (Lent, 1966; McCourt and Horstman, 1974; Shank, 1979) might explain the greater caribou sensitivity along the Stampede Road. We recommend caution when comparing our caribou response data to other areas because of differences in caribou responses with respect to season and insect harassment (Cameron and Whitten, 1979) and because of the high proportion of bull and resident, conditioned caribou in our sample. However, we know of no differences in sex and age ratios of caribou, seasonal migration patterns or distributions along the road in the years 1973, 1974, 1982 or 1983.

In agreement with other workers, we found caribou groups with calves to be more sensitive to disturbances (Calef *et al.*, 1976; Miller and Gunn, 1979; Shank, 1979; Klein, 1980), larger groups to be more sensitive (Calef *et al.*, 1976; Horejsii, 1981) and traveling caribou to be more sensitive (Surrendi and DeBock, 1976; Fischer *et al.*, 1977; Shank, 1979). We observed the order of sensitivity for pre-stimulus behavior for caribou to be travel > bed > stand > feed, but Shank (1979) ranked the order travel > feed > bed > stand.

Effects of Lifting Vehicle Restrictions

Visitor disturbances to wildlife increased when vehicle restrictions were lifted each fall. These brief comparisons represent only partial tests of the lifting of vehicular restrictions, since the number of vehicles increased only 50% but 300-500% increases are predicted if a mid-summer lift of restrictions occurred. Also, four-day test periods were probably too brief for any observable wildlife avoidance to occur. Visitors leaving vehicles accounted for much of the increased wildlife disturbances. Dean and Tracy (1979) reported the park shuttle buses tend to keep people in vehicles, and they observed a doubling in strong reactions in caribou when people got out of a bus. Similarly, elk (Ward *et*

al., 1973; Schultz and Bailey, 1978), bighorn sheep (MacArthur *et al.*, 1979) and deer (Kucera, 1976) respond more to skiers or hikers approaching afoot.

MANAGEMENT IMPLICATIONS

Our data indicate the NPS policy of a mandatory public transportation system has been highly successful in Denali National Park relative to its original goals. Visitors' opinions of the policy is high and has increased from 1972 to 1982-83. Caribou and Dall sheep sightings are nearly identical, and grizzly bear sightings decreased only a minor amount in spite of a 50% increase in vehicles. Evidence points to wildlife habituation since 1973-74. Caribou, grizzlies and, to a lesser extent, moose are seen closer to the park road and flight distances for grizzlies declined. No sex/age ratio changes have been detected. There are fewer reductions in sightings after the first trip of the day. The drop in moose sightings over the eight-year period may be partially explained by a decline in numbers in part of the road corridor and may not have serious ecological implications if moose are only moving short distances from sight into heavy cover or if summer habitat is not limiting. Human activity along roads and trails in other national parks in North America results in much greater wildlife avoidance.

We caution, however, against any expansion in road use. The drop in moose sightings is much larger than any possible decline in numbers. A higher proportion of moose were disturbed by road travel than in 1973-74. Grizzlies were persistently sought after for viewing when close to the road. Dall sheep were highly sensitive during migrations across the road corridor, and any drop in migrational crossings might have been undetected by our data. Denali caribou herd numbers were extremely low, and disturbance to them should be minimized.

Any management measures that reduce the proportion of visitors leaving vehicles will reduce wildlife disturbance rates. Most of the increased wildlife responses after fall lifting of travel restrictions were due to visitors leaving vehicles. More sheep and caribou responses occurred during summer when visitors were out of vehicles than when vehicles alone were present. Regular spacing of vehicles may promote closer approach by wildlife to a road (Roby, 1978; Geist, 1978). However, for species highly sensitive during crossings, such as Dall sheep, or persistently pursued by humans in vehicles, such as grizzlies, clumping of vehicles or caravans may provide longer openings for crossings (Dean and Tracy, 1979).

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