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EFFECTS OF SNOWMOBILES ON WHITE-TAILED DEER[1]

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Abstract: The effects of snowmobiles on white-tailed deer (*Odocoileus virginianus*) were studied in Minnesota during 1973 and 1974. Study areas were in St. Croix State Park, where numbers of snowmobiles per day averaged 10 on weekdays and 195 on weekends, and in Mille Lacs Wildlife Management Area, where snowmobiling was prohibited except by project personnel. Home range size, movement, and distance from radio-collared deer to the nearest trail increased with snowmobile activity at Mille Lacs, but remained unchanged at St. Croix. Numbers of deer along a 10-km trail decreased as snowmobile traffic increased at St. Croix. Light snowmobile traffic caused the displacement of deer from areas immediately adjacent to trails at St. Croix; thereafter, increased snowmobile traffic caused no additional response. Deer returned to areas along trails within hours after snowmobiling ceased at St. Croix. Deer responded to very low intensities of intrusion by man and vehicles.

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The impact of snowmobile activity on white-tailed deer has been of concern since snowmobiling became a major winter sport in Minnesota in the late 1960's. This paper reports the effects of snowmobile traffic on home range size, daily activity, and movement of white-tailed deer during the winters of 1972–73 and 1973–74.

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STUDY AREAS

We selected study areas in St. Croix State Park, near Hinckley, and Mille Lacs Wildlife Management Area, near Ogilvie, in east-central Minnesota. St. Croix State Park is approximately 12,600 ha in size. Topography is flat to gently rolling. Dominant vegetation types in the study area were jackpine (*Pinus banksiana*), aspen (*Populus tremuloides*), jackpine-aspen, and jackpine-northern pin oak (*Quercus ellipsoidalis*). Common woody shrubs included willow (*Salix* spp.), American hazel (*Corylus americana*), *Prunus* spp., and sweetfern (*Comptonia peregrina*). St. Croix State Park was selected for the following reasons: (1) snowmobile traffic was known to be extremely heavy on weekends but relatively light on weekdays; hence, deer response could be contrasted during periods of light and heavy snowmobile traffic; (2) the Park has approximately 192 km of established, well-groomed, and well-marked snowmobile trails with snowmobiling restricted to established trails; and (3) the Park is a wintering area for large numbers of deer, although no estimates are available.

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Deer concentrate in coniferous stands in the central portion of the Park (Fedkenheuer and Hansen 1971). In general, areas with the greatest snowmobile traffic coincided with the heaviest concentrations of deer. No hunting season has been held in the Park since 1969.

Mille Lacs Wildlife Management Area is approximately 15,400 ha in size. Topography is flat to gently rolling. Dominant vegetation was aspen with northern pin oak. Major woody shrubs included maples (*Acer* spp.), willows, dogwoods (*Cornus* spp.), and American hazel. Except for project personnel, snowmobiling was prohibited on this Area. Thus, location of trails and duration of snowmobile activity could be closely controlled. The area was open to deer hunting during state-wide firearms and archery seasons.

METHODS

Deer were captured in wooden box traps and instrumented with radio transmitters fitted on a collar. Transmitters operated at frequencies between 164.0 and 165.0 MHz. Tracking was accomplished with portable receivers, hand-held three-element Yagi antennas, and eight-element Yagi antennas mounted on 9-m-high towers. Electronic equipment was designed and built by personnel of the University of Minnesota, Cedar Creek Natural History Area Laboratory.

The location of each deer was determined every 4 hours for 48 hours on weekdays and again every 4 hours for 48 hours the following weekend at St. Croix State Park during 10 January–26 February 1973 and 9 January–11 February 1974. Radiolocations were made at 0300, 0700, 1100, 1500, 1900, and 2300, CST. Radiolocations were initiated at 0700 Wednesday and repeated every four hours until 0700 the following Friday. On weekends, locations were initiated at 0700 Saturday and repeated every four hours until 0700 Monday. Hereafter, the radiolocation of a deer every 4 hours for 48 hours on weekdays and again every 4 hours for 48 hours the following weekend will be termed "one trial." Five adult does and one adult buck were monitored for two to six trials in 1973; two adult does and two doe fawns were monitored for one to five trials in 1974.

Numbers of snowmobiles registered at park headquarters were used as an index to snowmobile traffic at St. Croix State Park. Numbers per day averaged 10 on weekdays and 195 on weekends during 1973 and 1974. Hereafter, the term "weekdays" will be used to designate periods of light snowmobile traffic and the term "weekends" will be used to designate periods of heavy snowmobile traffic at St. Croix State Park.

Numbers of deer instrumented with radio collars at Mille Lacs Wildlife Management Area were four adult does, one adult buck, and one doe fawn in 1973, and three doe fawns in 1974. One trial was run at Mille Lacs during 1–4 March 1973, and three trials were run during 13 February–4 March 1974. The experimental design was the same as that used at St. Croix, except that radiolocations were not taken at 0300 during 1–4 March 1973. A snowmobile trail was established through each animal's home range after the initial 48-hour non-snowmobile period. Between four and six snowmobiles were operated on this trail during 1000–1200 and again during 1300–1500 each day during snowmobile periods. Numbers of snowmobiles passing through each home range varied between 44 and 154 per day.

A 10-km length of trail was driven on a snowmobile at St. Croix State Park on 26 days during 23 January–22 February 1973. Numbers of deer along the route were used as an index to deer activ mediately adjacent to si The survey was initiated l 1400. A constant speed o maintained.

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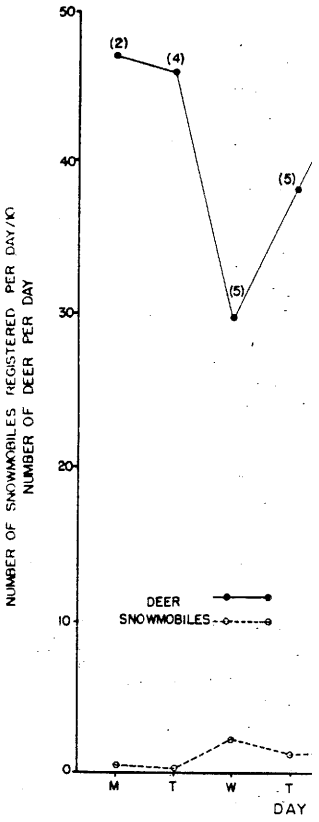

Fig. 1. Mean numbers of deer obs ing to day of week, along a 10-k St. Croix State Park, 1973. Number

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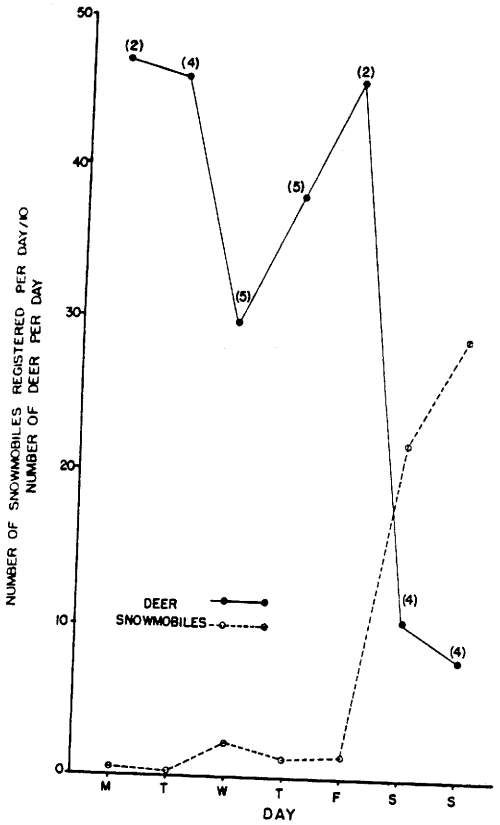

Fig. 1. Mean numbers of deer observed per day, according to day of week, along a 10-km snowmobile trail in St. Croix State Park, 1973. Number of days in parentheses.

as an index to deer activity on areas immediately adjacent to snowmobile trails. The survey was initiated between 1200 and 1400. A constant speed of 6–10 km/h was maintained.

Home range area was calculated by the minimum area method (Mohr 1947). Each 2-day home range was estimated from 13 radiolocations. Distances from the nearest trail to radiolocations taken at 1100, 1500, and 1900 reflected daytime movement and were pooled into the interval 1100–1900; distances from the nearest trail to radiolocations taken at 2300, 0300, and 0700 reflected nighttime movement and were pooled into the interval 2300–0700. Distances between radiolocations were pooled into the intervals 0700–1900 and 1900–0700 to reflect daytime and nighttime movement, respectively. Home range and movement data were tested with analysis of variance. Tests of significance are at $P < 0.05$ unless otherwise indicated. Areas and distances are given with standard error.

RESULTS AND DISCUSSION

Mean number of deer per day along the 10-km trail in St. Croix State Park was 39 on weekdays and 9 on weekends. A significant, negative correlation was obtained between numbers of deer along the trail and numbers of snowmobiles registered ($r = -0.653$, 24 df, $P < 0.001$), suggesting that deer responded to relatively low intensities of snowmobile traffic. Numbers of deer observed along the trail were lowest on Saturdays and Sundays, but were higher, or as high, on Mondays and Tuesdays than during any other day of the week (Fig. 1) Hence, deer became more visible adjacent to trails less than 24 hours after periods of heavy snowmobile traffic.

The area of 2-day home ranges did not differ significantly between weekdays and weekends at St. Croix in 1973 (10 ± 3 vs. 9 ± 2 ha) and 1974 (11 ± 2 vs. 8 ± 1 ha), and no trends were obvious. The area of 2-day home ranges did not change significantly between non-snowmobile ($\bar{x} = 12 \pm 2$ ha) and snowmobile ($\bar{x} = 20 \pm 6$ ha) periods at Mille Lacs in 1974 ($P = 0.13$). However, there was an obvious trend toward larger home ranges during snowmobile periods; 2-day home ranges of the 3 doe fawns averaged 6 ± 1 and 11 ± 1, 13 ± 4 and 20 ± 8, and 15 ± 3 and 30 ± 17 ha during non-snowmobile and snowmobile periods, respectively.

Distance between radiolocations (Table 1) did not differ significantly between

Table 1. Mean distance (m) between deer radiolocations, 1973 and 1974.

Study area	Year	No. radio-locations	0700–1900		1900–0700	
			Weekdays[a]	Weekends[b]	Weekdays	Weekends
St. Croix	1973	153	179 ± 12[c]	193 ± 12	133 ± 12	129 ± 11
	1974	78	185 ± 12	176 ± 12	182 ± 14	152 ± 12
Mille Lacs	1973	24	253 ± 24	263 ± 33		
	1974	54	218 ± 20*	315 ± 44*	156 ± 16	170 ± 20

[a] Light snowmobile traffic at St. Croix; no snowmobile traffic at Mille Lacs.
[b] Heavy snowmobile traffic.
[c] SE.
* Significantly different ($P < 0.05$).

weekdays and weekends at St. Croix. Thus, movement and activity of deer, as reflected by distance between radiolocations, were not measurably affected by snowmobile traffic in St. Croix State Park during 1973 and 1974.

A radio-collared doe (No. 300) and doe fawn (No. 200) moved out of the Mille Lacs study area on 2 March 1973. Consequently, movements of this doe and fawn were not included in the analysis. Distance between radiolocations did not differ significantly between non-snowomobile and snowmobile periods for the four instrumented deer remaining on Mille Lacs study area during 1–4 March 1973 (Table 1). However, mean distance between radiolocations during the day (0700–1900) increased significantly from 218 m during non-snowmobile periods to 315 m during snowmobile periods for 3 doe fawns at Mille Lacs in 1974; distance between radiolocations at night (1900–0700) remained essentially unchanged between non-snowmobile and snowmobile periods for these 3 fawns (Table 1).

Table 2. Mean distance (m) between deer radiolocations on the first and second day of snowmobile and non-snowmobile periods, Mille Lacs, 1974.

Day	No. radio-locations	Non-snowmobile		Snowmobile	
		0700–1900	1900–0700	0700–1900	1900–0700
1st	27	194	146	211	185
2nd	27	242*	167*	420*	155*

* Significantly different ($P < 0.05$).

Distance between radiolocations increased significantly between the first and second day of non-snowmobile and snowmobile periods at Mille Lacs in 1974 (Table 2). We drove a pickup truck through the study area once every four hours, stopping only twice to obtain radiolocations. This activity was sufficient to cause increased movement during 0700–1900 on the second day of non-snowmobile periods. However, mean distance between radiolocations on the second day was markedly higher during snowmobile periods than during non-snowmobile periods (Table 2). These data suggested that (1) deer responded to very low intensities of vehicular traffic, (2) the response of deer to vehicular traffic changed with time, and (3) movement of deer increased sharply when snowmobiles were operating on this study area.

Distance from radiolocations to the nearest trail did not differ significantly between weekdays and weekends at St. Croix during 1973 and 1974. However, deer were significantly farther from trails during days than during nights in 1973 ($P < 0.001$): distance from deer to the nearest trail averaged 97 and 79 m on weekdays and 107 and 75 m on weekends, 1100–1900 and 2300–0700, respectively (Table 3). Radiolocations at distances greater than 100 m

Table 3. Mean minimum distance

Study area	Year	N obser
St. Croix	1973	15
	1974	7
Mille Lacs	1973	2
	1974	5

[a] Differences between weekdays differences between 1100–1900 a $P < 0.05$).
[b] Light snowmobile traffic at St
[c] Heavy snowmobile traffic.

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Radio-collared deer te to trails on the first nigl weekdays and weekends 1973 (Table 4). These significant. Deer return mediately adjacent to t night, but not on the secc tracking. These data su were responding to our 1973, radiolocations we marily with hand-held distances no greater than from deer to the nearest significantly between da 1974. Radiolocations we element Yagi antennas distances ranging from 6(Home ranges tended to trails in 1974 than in 19 radiolocations to the nea 89 m in 1973 and 206 m response of deer was when deer were immed trails in 1973; the effect chines were not apparen farther from trails in 19

	1900–0700	
	Weekdays	Weekends
	133 ± 12	129 ± 11
	182 ± 14	152 ± 12
*	156 ± 16	170 ± 20

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Table 3. Mean minimum distance (m) from deer radiolocations to the nearest trail, 1973 and 1974.

Study area	Year	No. observations	Mean ± SE[a] 1100–1900 Weekdays[b]	1100–1900 Weekends[c]	2300–0700 Weekdays	2300–0700 Weekends
St. Croix	1973	153	97 ± 5	107 ± 5	79 ± 5	75 ± 4
	1974	78	222 ± 19	205 ± 21	190 ± 19	209 ± 20
Mille Lacs	1973	24	104 ± 23	200 ± 38		
	1974	54	145 ± 12	212 ± 38	111 ± 9	152 ± 20

[a] Differences between weekdays and weekends are significant at Mille Lacs 1973 ($P < 0.05$) and 1974 ($P < 0.05$); differences between 1100–1900 and 2300–0700 are significant at St. Croix 1973 ($P < 0.001$), and Mille Lacs 1974 ($P < 0.05$).
[b] Light snowmobile traffic at St. Croix; no snowmobile traffic at Mille Lacs.
[c] Heavy snowmobile traffic.

from the nearest trail were most numerous during 1100–1900, whereas radiolocations within 60 m of trails were most numerous during 2300–0700 (Fig. 2). Deer probably cannot be seen at distances much greater than 60–100 m in most vegetation types in St. Croix State Park.

Radio-collared deer tended to be closest to trails on the first night (2300–0700) of weekdays and weekends at St. Croix in 1973 (Table 4). These differences were significant. Deer returned to areas immediately adjacent to trails on the first night, but not on the second night of radiotracking. These data suggested that deer were responding to our presence. During 1973, radiolocations were obtained primarily with hand-held Yagi antennas at distances no greater than 365 m. Distances from deer to the nearest trail did not differ significantly between days and nights in 1974. Radiolocations were made with 8-element Yagi antennas on 9-m towers at distances ranging from 60 to 600 m in 1974. Home ranges tended to be farther from trails in 1974 than in 1973; distance from radiolocations to the nearest trail averaged 89 m in 1973 and 206 m in 1974. Thus, the response of deer was most pronounced when deer were immediately adjacent to trails in 1973; the effects of man and machines were not apparent when deer were farther from trails in 1974.

Minimum distance from radiolocations to the snowmobile trail was significantly different between non-snowmobile and snowmobile periods for the 4 deer that remained on Mille Lacs study area during 1–4 March 1973, i.e., 104 and 200 m, respectively (Table 3). We did not travel on the site of the snowmobile trail during the non-snowmobile period. Thus, these deer apparently moved away from the trail in response to snowmobile traffic.

Adult doe No. 300 and doe fawn No. 200 left Mille Lacs study area on 2 March 1973, this being a gradual shift over a 24-hour

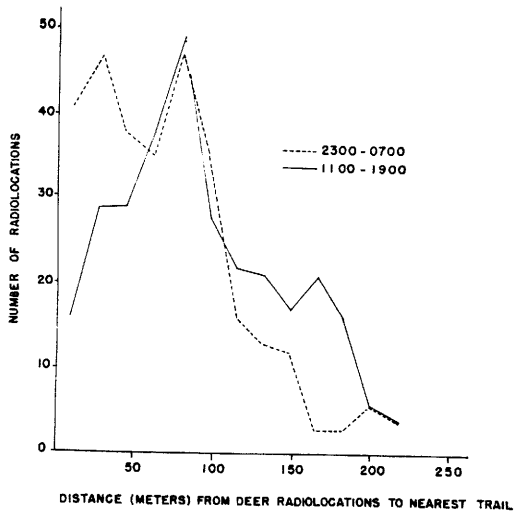

Fig. 2. Distance from deer radiolocations to the nearest trail, St. Croix State Park, 1973.

Table 4. Mean minimum distance (m) from deer radiolocations to the nearest trail on the first and second day of week day and weekend test periods, St. Croix 1973 and Mille Lacs 1974.

Study area and year	Day	No. radio-locations	Mean[a]			
			Weekdays[b]		Weekends[c]	
			1100–1900	2300–0700	1100–1900	2300–0700
St. Croix 1973	1st	75	101d	67d,e	115f	62f,g
	2nd	75	95	90e	99	87g
Mille Lacs 1974	1st	27	127	107	167h	179
	2nd	27	163	114	258h	125

[a] Values having the same letter are significantly different ($P < 0.05$).
[b] Light snowmobile traffic at St. Croix; no snowmobile traffic at Mille Lacs.
[c] Heavy snowmobile traffic.

period. Number 200 was probably the fawn of doe No. 300 since they moved together. Our activity on the study area during the non-snowmobile period was confined to two men walking back and forth on a fire lane once every four hours. The fire lane was not part of the snowmobile trail. Doe No. 300 and fawn No. 200 remained at least 0.8 km from the snowmobile trail and fire lane during 3–4 March 1973. Radiolocations again were obtained on this doe and fawn during 8–9 March. Distance from the firelane averaged 102 m during 1100–1900, 8 March. By 1500, 9 March, these deer were at least 1.6 km from the fire lane and tracking was discontinued. We believe that these deer moved from the area in response to our presence.

Minimum distance from radiolocations to the trail differed significantly between non-snowmobile and snowmobile periods and between 1100–1900 and 2300–0700 for three doe fawns at Mille Lacs in 1974 (Table 3). Deer moved away from trails when snowmobiles were operating on the area. Movement away from trails during 1100–1900 (non-snowmobile periods) probably resulted from our presence.

Mean minimum distance from deer to the trail during 1100–1900 increased significantly from 167 m on the first day to 258 m on the second day of snowmobile periods at Mille Lacs in 1974. There appears to have been a trend toward movement away from trails on the second day of non-snowmobile periods as well (Table 4). Here again, these data suggested that deer responded to very low intensities of disturbance, and that the response of deer increased with the duration of the disturbance.

The effects of snowmobile traffic on white-tailed deer were subtle in St. Croix State Park; snowmobile traffic resulted in the displacement of deer from areas immediately adjacent to snowmobile trails. We hypothesize that during severe winters on poor ranges, the displacement of deer from even small segments of their home range is detrimental. During less severe winters, any effects of snowmobiles on white-tailed deer may be negligible at St. Croix State Park.

The effects of snowmobile traffic on deer were more pronounced at Mille Lacs Wildlife Management Area than at St. Croix State Park. Snowmobile traffic resulted in increased home range size, increased movement, and displacement of deer from areas along trails. Some deer were particularly sensitive to intrusion by man and vehicles and changed their home ranges to entirely different locations. We believe that these effects could cause

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changes in the energy budget that could be detrimental, especially during severe winters.

Results from St. Croix State Park suggested that deer do become habituated to snowmobile traffic. However, we hypothesize that deer that are hunted annually would never become as habituated to snowmobile traffic as deer that have not been hunted for several years, such as those in St. Croix State Park.

There are two simple methods for reducing disturbance of white-tailed deer by snowmobile traffic: (1) route trails away from areas where deer concentrate in winter, and (2) avoid use of a particular trail on consecutive days.

LITERATURE CITED

FEDKENHEUER, A. W., AND H. L. HANSEN. 1971. Winter cover type use by white-tailed deer (*Odocoileus virginianus*) in St. Croix State Park, Minnesota. Minnesota For. Note 223. 4pp.

MOHR, C. O. 1947. Table of equivalent populations of North American small mammals. Am. Midl. Nat. 37(1):223–249.

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