REGIONAL COPPER-NICKEL STUDY

WHITE-TAILED DEER

(Odocoileus virginianus)

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Minnesota Environmental Quality Board

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Introduction

White-tailed deer are the most widely distributed and numerous large mamal in Minnesota and have, in recent years, been found in all 87 counties (Erickson, et al. 1961). Prior to logging in the state in the late 1880's to 1920, deer were largely excluded from this northern forest which is often considered the "traditional range" of this species (Erickson et al. 1961). Deer were unknown along Minnesota's North Shore in 1870. The estimated deer population in the entire Superior National Forest (SNF) in 1914 was only 900 animals, building to over 7,000 in 1929 (Siderits 1976).

Distribution and Importance of Species

The welfare of the deer herd in Minnesota is important from the standpoint of tourism, asthetics, as well as for the sport hunting and the revenues so granted. Deer are a renewable resource that have dramatically fluctuated in numbers, gauged from harvest records, as the age and composition of our state forest have changed. Records since 1918 show that year totaled 23,893 and the harvest was estimated at 9,000 animals (Longley and Knudson 1974). From this begining, a peak harvest of 127,000 deer was reached in 1965, while deer hunting license sales reached a maximum of 327,596 in 1975.

In 1975, money generated through the sale of all types of Non-Commercial licenses totaled 9.81 million dollars in Minnesota, of which 4.50, 2.53. and 1.66 million dollars were from the sale of fishing, deer, (deer, bear), and small game licenses, respectively (MDNR Statistics). At an average expenditure of $50.00 per hunter per season for lodging, ammunition, gas, restraunts, clothing, and etc., the 327,596 hunters in 1975 would have added over 16 million dollars to the state's economy. This $50.00 multiplier is probably a serious underestimation of the actual expenditures.

Deer harvest in Minnesota has declined dramatically since the peak numbers of 95-127,000/year estimated for 1960 to 1968 (Longely and Knudson 1974).

The peak harvest since that period was only 73,448 deer in 1972, while the lowest was 27,834 in 1976 during a summer and fall plagued by fires in our state. The season was closed in 1971 for the first time since a closure in 1950. Maturing habitat, especially aspen (<u>Populus</u> spp) and aspen-birch (<u>Betula</u> spp.) types (Mooty 1971), and a series of severe winters that began in 1964 and lasted through 1971 have been cited as the main reasons for the decline of the deer herd in Minnesota, as well as the decline in the Great Lakes states in general (Mech and Karns 1977). Although statewide firearm deer license sales declines only slightly from 1960-68 ($\bar{x}$ = 272,097) to the 1969-76 period ($\bar{x}$ = 235,369), the percent of successful hunters declined from a mean of 40.5 percent to 18.3 percent, respectively. An all-time low of 10.5 percent success was recorded in 1976 (MDNR Statistics).

Within the principal deer range in Minnesota, the northeastern portion of the Arrowhead Region (especially the SNF) has had a history of low harvest rates and generally low deer densities, especially in recent years. Ideally this could be tested by comparing spring pellet census data from other regions of the state with the northeast. Differences within various portions of the northeast could also be tested in this way. Regrettably pellet census data are not available for much of the Study Area.

Lacking the above census estimates we have compiled harvest figures by MDNR kill blocks (each block is approximately 16 townships in size, Figure 1) for the region and our specific Study Area for the 1972-1975 period (Rutske 1975). Discussion of these data is intended to compare the effect of development in portions of each of these areas with the potential of that area to provide deer accessible to hunters. In this restricted sense these regional comparisons are valid. Harvest data do not directly lend themselves to comparing deer populations from one site to another unless similar road access and hunter densities are present at each location. This is not the case in northeastern Minnesota.

Eighteen census blocks were selected to compare regional trends (Figure 1). Nine of the above blocks were used to evaluate our Study Area. We purposely omitted blocks along the Canadian border which are largely inaccessible. Exceptions include blocks No. 22, 23 and 24 which were deemed necessary to include to characterize our Study Area, but are not used in the regional discussion.

Regional comparisons used block data organized into three tiers running from north to south (Table 1) and west to east (Table 2). The mean harvest rates for the north ($.38/km^2$), middle ($.38/km^2$) and south $0.35\ km^2$) were not significantly different (Table 1). A comparison of six tiers from west to east, however, showed that the means were significantly different (Table 2). Harvest decreased from $.63/km^2$ in the west to only $.16/km^2$ in the east.

The same trend held true for the Study Area when compared separately. North to south groupings showed no significant differences, even though the northern, largely inaccessible area, had a mean harvest rate of only $.19/km^2$ compared to .28 and $.26/km^2$ for the middle and south, respectively (Table 3). The harvest from west to east across the Study Area was far greater in the west ($\bar{x} = .41/km^2$), intermediate in the center ($\bar{x} = .21/km^2$) and lowest in the east ($\bar{x} = .14/km^2$, Table 4). These means were significantly different.

These findings strongly suggest that under current hunting pressure and road access, the number of deer harvested in northeastern Minnesota decreases from west to east in a somewhat concentric pattern. The implications of this relative to development are discussed in the impact section.

The general decline of deer on the SNF is largely attributed to servere winters, maturing forest and recently elevated levels of wolf (Canis lupus) predation. Drive census recorded 6-7 deer/km^2 in the 1930's (Olson 1938), with inly 2-3/km^2 seen in 1948 (Stenlund et al. 1952) and 1976 (Rogers 1976).

A winter deer and moose census was conducted during the winter of 1977-1978 on the eastern portion of the Study Area. (Appendix A). The aerial census estimated an average population of 2.3 deer/km^2, with 3568 for the entire 1542 km^2 census area. Only 16 percent of the census area was included in the "high density" strata.

High density is a relative term used when randomly statifying an area and by no means indicates a high deer population on this portion of the Study Area. For example, pellet census strata in Minnesota use four categories: 0-1.9 deer/km^2; 2.0-5.8/km^2; 5.9-9.6/km^2; and 9.7 plus/km^2 (J. Mooty, MDNR, pers. comm. June 1978). The first two are considered low populations, the third is medium, and 9.7 plus/km^2 are high densities. Management goals by the MDNR (spring, prior to fawning) for Deer Management Unit (DMU) 3 within the Rainy River and Itasca units near our area are 7.3 and 7.7 deer/km^2, respectively (J. Mooty, MDNR, pers. comm. June 1978). It is obvious from these figures that the highest density areas within out Study Area are near the low population extremes for deer in Minnesota.

The importance of our Study Area to the total harvest of deer in Minnesota is presented in Table 5. Calculations from MDNR harvest data suggest that between 1131 to 1952 deer ($\bar{x}$ = 1523) were taken on the Study Area from 1972-1977. This was 1.7 to 3.2 ($\bar{x}$ = 2.4) percent of the total state kill. The forested portion of the Study Area represents 6.2 percent of the state's total of 78585 km^2 of deer habitat as calculated in 1961 by Erickson et al. (1961).

Habitat Requirements

The current, severely depressed deer density over most of the Study Area has affected our interpretation of the literature pertaining to habitat and food shortages that may not be true if populations were to increase substantially. High deer densities in this area, however, are not expected in the near future.

The trembling aspen (Populus tremuloides) and trembling aspen-birch (Butula papyrifera) forest are the most important ecosystems for maintaining high densities of white-tailed deer in this northern region of Minnesota. The carrying capacity of a mixture of age classes of aspen forest 25 years of age or younger is at least twice as large (9 to 13 deer per km^2) as forests 25 years or older (4 to 6 deer per km^2) (Mooty 1971). In Michigan, Byelich (1972) found a significant correlation ($P < 0.01$) between the average buck kill per county and the acreage of aspen in that county. In Minnesota and Wisconsin both aspen and aspen-birch forests are preferred by deer during the snow-free period (Kohn and Mooty 1971, McCaffery et al. 1969). Grassy openings and roads created by logging operations are used in early summer, while recent clearcuts and young conifer plantations are used most heavily in July (Kohn and Mooty 1971). Aspen-birch-fir (Abies spp.)-spruce (Picea spp.) types are used during the majority of most winters on the Study Area (USFS 1976, Mooty 1972, Wetzel 1972). Conifer-dominated stands are used in late winter (usually late February and March) and include white cedar (Thuja occidentials). black spruce (Picea mariana), red pine (Pinus resinosa) and jack pine (Pinus banksiana) (Wetzel 1972).

Mixtures of deciduous-coniferous tree species near recently disturbed areas containing large quantities of preferred deer browse should be considered prime wintering areas worthy of preserving. Figure 2 depicts sites that are currently known to be used by deer primarily within the Minesite (a term used by the MDNR to describe a 1456 km^2 area of high copper-nickel development potential). It is apparent that winter concentrations of deer are greatest in the northern, western, and southern portions of this area, with the central and eastern portions relatively less important during this season. Two of these areas (the northern and southern) also had the highest densities of deer hunters in November, 1976 (Appendix B), while the central area is on mining company land and largely inaccessible to hunters.

Conifer stands within deer wintering areas provide both reduced snow depths which allow increased mobility, and decrease body heat loss otherwise radiated to the open sky under pure deciduous stands (Ozaga 1968). Of 202 winter deer beds examined near or on our Study Area, 46 percent were associated with balsam fir (Abies balsamea) trees, 17 percent with white cedar, 13 percent with black spruce and 13 percent with white spruce (Picea Glauca) (Wetzel 1972). Pines were relatively unimportant and combined amounted to only 10 percent. In a hypothetical situation where mining pollutants would seriously reduce the conifer cover on a deer wintering area, one might expect this factor alone would cause abandonment of the site in the future.

White cedar is often mentioned when white-tailed deer wintering yards are discussed. The Jonvik Yard on Minnesota's North Shore is the major white cedar dominated yard in northeastern Minnesota (Siderits 1976). Past densities have often surpassed 40 deer/km^2 in winter, but the yard has undergone serious over-browsing and maturation in recent years. The total population at this location in 1976 was estimated at 840 deer (Siderits 1976).

Generally speaking, white cedar habitats do not hold the same importance in Minnesota for deer that they do in Wisconsin and Michigan. Within the Minesite, for example, cedar-dominated forest types occupy only 0.4 percent of the area. However, the limited distribution of true white cedar swamps is unique for the species and/or density of lichens, song-birds and vegetation they foster and warrant protection on these merits alone.

Food Requirements

Overbrowsing was not a problem at 53 deer wintering stands in the Ely-Isabella area in 1970-71 (Wetzel 1972). Although quantity was not limited, quality may be. Mech and Karns (1977) have suggested that fawn: doe ratios from northern counties with little or no wolf predation have decreased an average of 1.8 percent per year from 1955-73. In Cook and Lake Counties, which have wolf predation, the decrease has averaged 3.3 percent per year. Mech and Karns interpreted this 1.8 percent decline as representing a general reduction in quality of browse associated with the maturing forest. The 3.3 percent decrease combined succession and wolf predation, and may represent the current annual rate of loss in deer reproduction for much of the Study Area.

The most applicable deer summer food study was conducted west of the Study Area in northeastern Itasca County (Kohn and Mooty 1971). Plant species growing in the upland aspen-birch community were preferred. Browse (leaves and current year's twigs) was the most important summer food (68 percent), followed by forbs (32 percent) and grass (Gramineae, 1 percent). The most heavily-used browse species were hazel (Corylus spp., 30 percent), trembling aspen (8 percent), willows (Salix spp., 8 percent) and paper birch (5 percent). McCaffery (1970) found aspen leaves preferred in northern Wisconsin, and Westell (1954) showed intensive seasonal use of big-toothed aspen (P. grandidental) clearcuts in Michigan for one to three years after cutting. In addition to aspen clearcuts, we have noted large quantities of the above browse species present on shrub-dominated uplands and young conifer plantations. These two types also provide food for a longer time interval than aspen clearcuts because stems do not grow out of reach as rapidly.

Kohn and Mooty (1971) found that one-half of the forb use was from four species: large-leafed aster (Aster macrophyllus, 5 percent); purple pea (Lathyrus venosus, 4 percent); jewelweed (Impatiens pallida, 4 percent); and bracken fern (Pteridium aquilinum, 3 percent). Both large-leafed aster and bracken fern reach significantly higher coverage in aspen-birch cover types (see terrestrial vegetation report). Jewelweed is less common on the area, and the majority of plants are a different species (I. capensis) and found primarily in moist deciduous stands of ash, aspen and alder. Kohn and Mooty suggest that the low use of grass (1 percent) is probably an underestimation of its importance in the summer diet and related to the difficulty of detection during their studies.

Food habits in late fall and winter have been examined in a number of studies. Important deer food during this period in the Lake States and adjacent Canada are listed in order: white cedar (Verme 1965, Upper Peninsula of Michigan); willow, honeysuckle (Diervilla lonicera spp.), balsam fir and green alder (Alnus crispa) (Orke 1966, Itasca County, Minnesota); beaked hazel (Corylus cornuta), mountain maple, (Acer spicatum), white cedar and red-osier dogwood (Cornus stolonifera), (Wetzel 1972, northeastern Minnesota); dogwood (Cornus spp.), paper birch, white cedar and red maple (Acer rubrum), (Huot 1974, Quebec, Canada); White cedar, red-osier dogwood, mountain maple, alternate-leafed dogwood (Cornus alternifolia), red maple, juneberry (Amelanchier spp.), black ash (Fraxinus nigra) and mountain ash (Sorbus americana), (Erickson et al., 1961 Minnesota). With the current low deer density in the Study Area, the quantity of browse (especially in winter) is probably not a principal limiting factor for deer. This situation could be seriously altered if large areas affected by air and/or water pollution from mining developments in the future.

Sources of Mortality

"Except for man, the most important predators upon deer in Minnesota are wolves, coyotes and dogs" (Mech 1971). This list can be shortened to man and wolves for a great majority of the Study Area.

The wolf population in portions of the SNF has had a detrimental effect on the deer population. Mech and Karns (1977) have concluded that "if wolves had not inhabited the Interior of the Superior National Forest (a region of some 3070 km^2), the deer herd would not have disappeared there, the decline would not have been so dramatic in the surrounding area, and any tendency for the deer population to recover would not take so long." We must point out that extirpation of deer from the largely roadless interior area has a limited effect on sport hunting since most of the area is inaccessible to hunters. However, the decline on the "surrounding area" (Mech and Karns 1977) includes at least the northeastern one-quarter of the Study Area.

The competition for deer by wolves and man within the SNF is apparently limited to a rather small area. Mech (1971) has estimated that less than 25 percent of the deer herd in this region is accessible to sport hunting because of the limited road system. This situation will be only slightly changed, if at all, in the near future. The addition of mining roads will not benefit hunters (and thus increase deer mortality) because these routes are closed to the general public.

Wolves will probably remain the major predator of deer in the Study Area, followed by man.

Impact

The major impact to the deer population within the Study Area will be directly related to the amount of land used by mining operations. Severe changes in present land use in the Kawishiwi River-White Iron-Farm Lake region (Watershed I), the Hoyt Lakes-FR130 area and the aspen-birch forest adjacent to and north of Highway 16 in the southeastern part of the Study Area (Watershed IV) will have the most detrimental impact on winter, and perhaps summer, habitat. The highest deer densities were reported for these areas during our recent winter census (Appendix A). In addition, many of these same sites have had a history of winter use by deer (Figure 2).

Development in the southeastern portion of the Study Area may destroy important summer habitat as well. The east central portion of the Study Area has extremely low winter, and perhaps summer, densities. (Appendix A). This is also true of the northeastern area represented by Watershed III. Development in these latter two areas will have very limited impact on the total number of deer using this region.

Recent findings involving deer behavior and habitat use on the western portion of the SNF have significant implications that must be considered when assessing changing land use relative to white-tailed deer. A number of recent papers (Hoskinson and Mech 1976, Mech and Karns 1977, Mech 1977) have shown that a large proportion of the low density deer population in the Ely-Harris Lake area (and presumably on a majority of the SNF) is residing on 2 km wide zones between established wolf territories. Favorable deer habitat within wolf territories are of limited value presently due to intensive predation. These buffer zones "...may have critical significance to the entire wolf-deer relationships..." for future repopulation of large tracts of land currently devoid of deer (Mech 1977). These currently occupied deer habitats should receive particular attention when they coincide with areas requested for development.

Other detrimental activities affecting deer would be extensive barriers caused by tailings ponds, pipelines, open-pit mines, factory facilities, etc. which either directly destroy or form a physical barrier across migration routes separating summer and winter habitat. Verme (1973) has shown that deer in the Upper Peninsula of Michigan do not shift from one wintering area to another, but return to the same area each year. These deer also returned to the same general summer location each spring. As a result, if a wintering area is destroyed or access to it prevented, the end result is the loss of an "ancestral summering" grounds as well. This void can be created even in areas "...of seemingly excellent carrying capacity..." and may persist for years (Verme 1973). Similar dispersal patterns have been demonstrated for deer living on or near the Study Area (Hoskenson and Mech 1976; Nelson 1977). Several of these areas concentrated deer from as far away as 40 km. Protection of these habitats and corridors may be even more critical when deer populations are severely reduced as they currently are on our Study Area.

The most serious threat to big game hunting in the area would be extensive development within the southeastern region encompassing most of Watershed IV and a portion of Watershed II. Specifically the area involved is the aspen dominated Toimi Drumlin Field and adjacent habitat. This area includes the southern one-half of townships T58N, R13 and R14W and all of townships T57N, R13 and R14W.

A large proportion of the accessible, high density (for this area) deer range is located in this area (Appendix A). Hunter densities in this southern area in 1976 were in the range of five times greater than for the central two-thirds of the area (Appendix B).

Development within the Toimi Drumlin Field and adjacent environs would destroy an area that presently has a high density of wildlife relative to the remainder of the region. If portions of this area were intensively managed by logging and/or controlled fires, the future potential would be even greater.

References Cited

Byelich, J.D., J.L. Cook, and R.I. Blouch. 1972. Management for deer. In Aspen Symposium Proceedings, p. 120-125, Illus. USDA For. Serv. Tech., Rep. NC-1, 154 p., Illus. North Cent. For. Exp. Stn., St. Paul, Minn.

Erickson, A.B., V.E. Gunvalson, M.H. Stenlund, D.W. Burcalow and L.H. Blankenship. 1961 The white-tailed deer of Minnesota. Minn. Dep. Conserv. Tech. Bull. 5, 64 pp.

Floyd T.J. 1978 See App. A.

Hoskinson, R.L. and L.D. Mech. 1976. White-tailed deer migration and its role in wolf predation. J. Wildl. Manage. 40 (3): 429-421.

Huempfner, R.A. 1978 See App. B.

Huot, J. 1974 Winter habitat of white-tailed deer at Thirty-one Mile Lake, Quibec, Canada. Can. Field-Nat. 88(3): 293-301.

Kohn, B.E. and J.J. Mooty. 1971. Summer hagitat of white-tailed deer in northcentral Minnesota. J. Wildl. Manage. 35 (3) :476-487.

Longley, W.H. and L.W. Knudson. 1974. Minnesota game population statistics, harvests, and hunting regulations. Original authors R.N. Johnson, M.R. Kohout and M.N. Nelson. Minn. Dept. of Nat. Res, Sec. of Wildlife, St. Paul, Minn. 45 pp.

McCaffery, K.R. 1970. Relation of forest cover types to deer populations. Wis. Dept. of Nat. Resour. Pittman-Robertson Job Completion Rep. 201-2, W-141-R-6,5 pp.

McCaffery, K.R. and W.A. Creed. 1969. Significance of forest openings to deer in northern Wisconsin. Wis. Dept. of Nat. Resour. Tech. Bull. 44, 104 pp.

Mech, L.D. 1971. Wolves, coyotes and dogs. 19-22. In The white-tailed deer in Minnesota, Symp. Proc., edited by M.M. Nelson. Minn. Dept. of Nat. Resour., St. Paul, Minn., 88pp.

Mech, L.D. 1977. Population trends and winter deer consumption in a Minnesota wolf pack. 55-83. In Proceedings of the 1975 predator symposium. R.L. Phillips and C. Jonkel, Eds. Montana For. and Conserv. Exp. Stn., Univ. of Montana, Missoula, Montana. 268 pp.

Mech, L.D. and P.D. Karns. 1977. Role of the wolf in a deer decline in the Superior National Forest. USDA For. Ser. Res. paper NC-148. 23 pp.

Mooty, J.J. 1971. The changing habitat scene. 27-33. In The white-tailed deer in Minnesota. Symp. Proc., Edited by M.M. Nelson, Minn. Dept. Nat. Resour., St. Paul, Minn. 88 pp.

Mooty, J.J. 1972. Winter habitat of white-tailed deer in north-central Minnesota. 34th Midwest and Wildlife Conference. Des Moines, Iowa. 5pp.

Nelson, M.E. 1977. Migration and social organization of white-tailed deer in northeastern Minnesota. Unpubl. M.S. Thesis. University of Minn., St. Paul. 119 pp.

Olson, H.F. 1938. Deer tagging and population studies in Minnesota. Trans. N. Am. Wildl. Conf. 3:280-286.

Orke, D.L. 1966. Patterns and intensity of white-tailed deer browsing on the woody plants of Itasca Park. A major report submitted to the School of Forestry, Univ. of Minn. 61 pp.

Ozaga, J.J. 1968. Variations in microclimate in a conifer swamp deer yard in northern Michigan. J. Wildl. Manage. 32(3):574-585.

Rogers, L. 1976. Per. comm. of pending paper on results of deer drive-census in Superior National Forest on north-eastern portion of Regional Copper-Nickel Study Area.

Rutske, L. 1975. 1975 firearm deer season. Minn. Dept. Nat. Resour. Inner Dept. Report. 24 pp.

Siderits, K. 1976. Jonvik deer yard. Unpublished summary paper. USFS. 65 pp.

Steinlund, M.H., M.A. Morse, D.A. Burcalow, J.L. Zorichak and B.A. Nelson. 1952. White-tailed deer bag checks. Gegoka Management Unit, Superior National Forest. J. Wildl. Manage. 16(1):58-63.

U.S. Forest Service--Eastern Region Publ. 1976. A program for fish and wildlife habitat on the National Forests in Minnesota. U.S. Forest Service, Eastern Region Publ.

Verme, L.J. 1965. Swamp conifer deer yards in northern Michigan. J. For. 63(7):523-529.

Verme, L.J. 1973. Movements of white-tailed deer in Upper Michigan. J. Wildl. Manage. 37(4):545-552.

Westell, C.E., Jr. 1954. Available browse following aspen logging in Lower Michigan. J. Wildl. Manage. 18(2):266-271.

Wetzel, J.F. 1972. Winter food habits and habitat preferences of deer in northeastern Minnesota. M.S. thesis. Univ. of Minn. 108 pp.

Fig. 1. Location of deer kill recording areas in northeast Minnesota that are discussed in text.

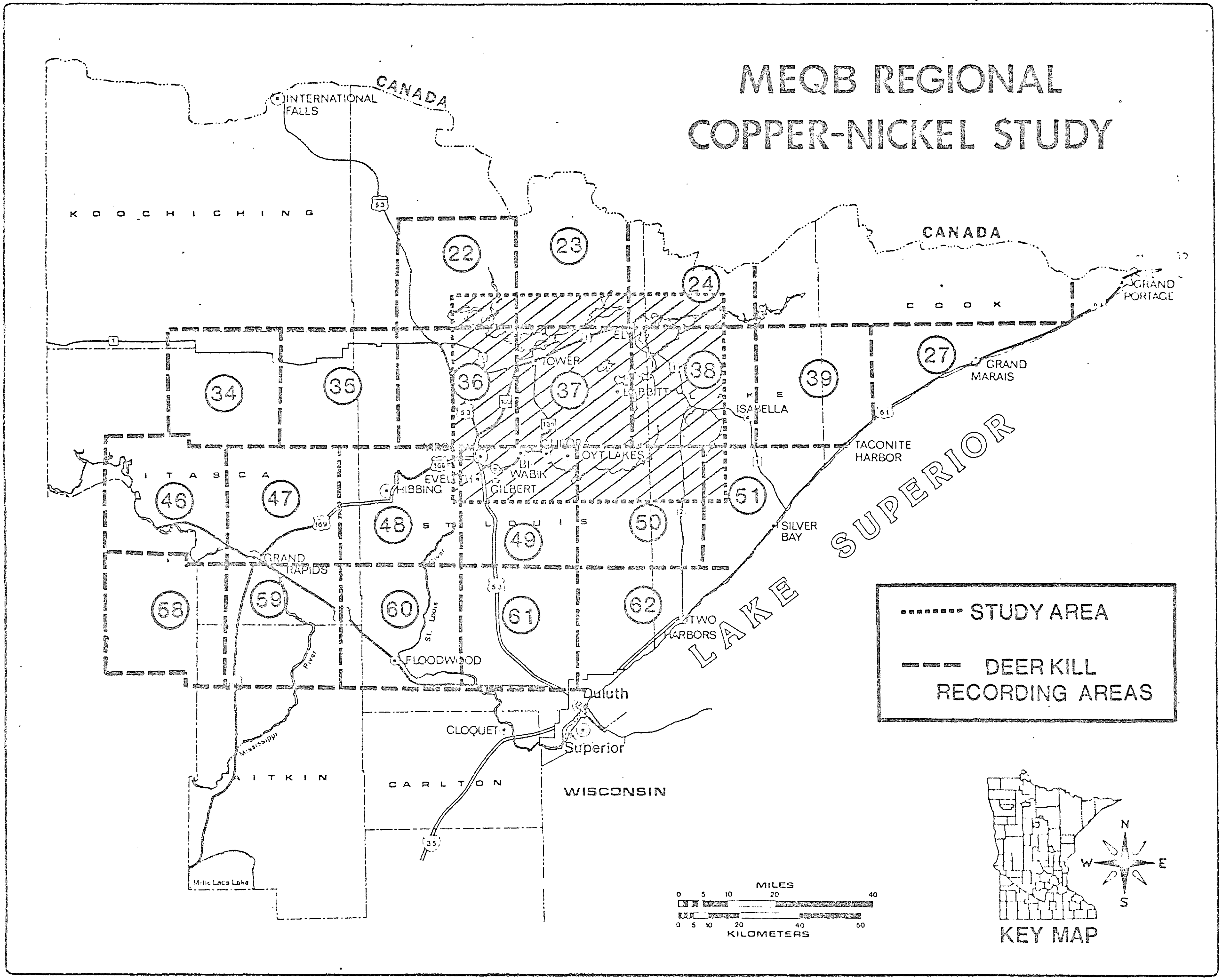

Figure 2. Currently active white-tailed deer wintering areas in the eastern one-half of our Study Area.

Sites 1 through 8, inclusive, were obtained from D.L. Mech, USFWS, from map provided in January, 1977, to Copper-Nickel Study.

Sites 9 through 16, inclusive, were obtained from J. Breyen, MDNR, from map provided in August, 1976, to Copper-Nickel Study.

Site No.	Tech. Desc.
1	T63N, R11W, Sec 33
2	T63N, R11W, Sec 17, 18, 19, 20
3	T69N, R10W, Sec 9
4	T62N, R10W, Sec 17, 18, 19, 20
5	T62N, R11W, Sec 22, 23
6	T62N, R11W, Sec 27, 28, 33, 34
7	T62N, R11W, Sec 32, 33
	T61N, R11W, Sec 5
8	T61N, R11W, Sec 8, 17
9	T59N, R12W, Sec 29, 30, 31, 32, 33
	T58N, R12W, Sec 4, 5, 6, 7 8, 9, 16, 17, 18
10	T57,N, R13W, Sec 25, 35, 36
11	T57N, R14W, Sec 28, 32, 33
12	T57N, R14W, Sec 7,8
13	T58N, R15W, Sec 25, 26, 35, 36
14	T58N, R14W, Sec 19, 20, 29, 30
15	T58N, R14W, Sec 21
16	T57N, R12W, Sec 15

Site 17 is Vermilion, Fall, Moose and Knife Lake Yard (from map in Mech and Karns 1977).

Site 18 are plots with high deer densities during the 1977-78 winter (T. Floyd, App. A).

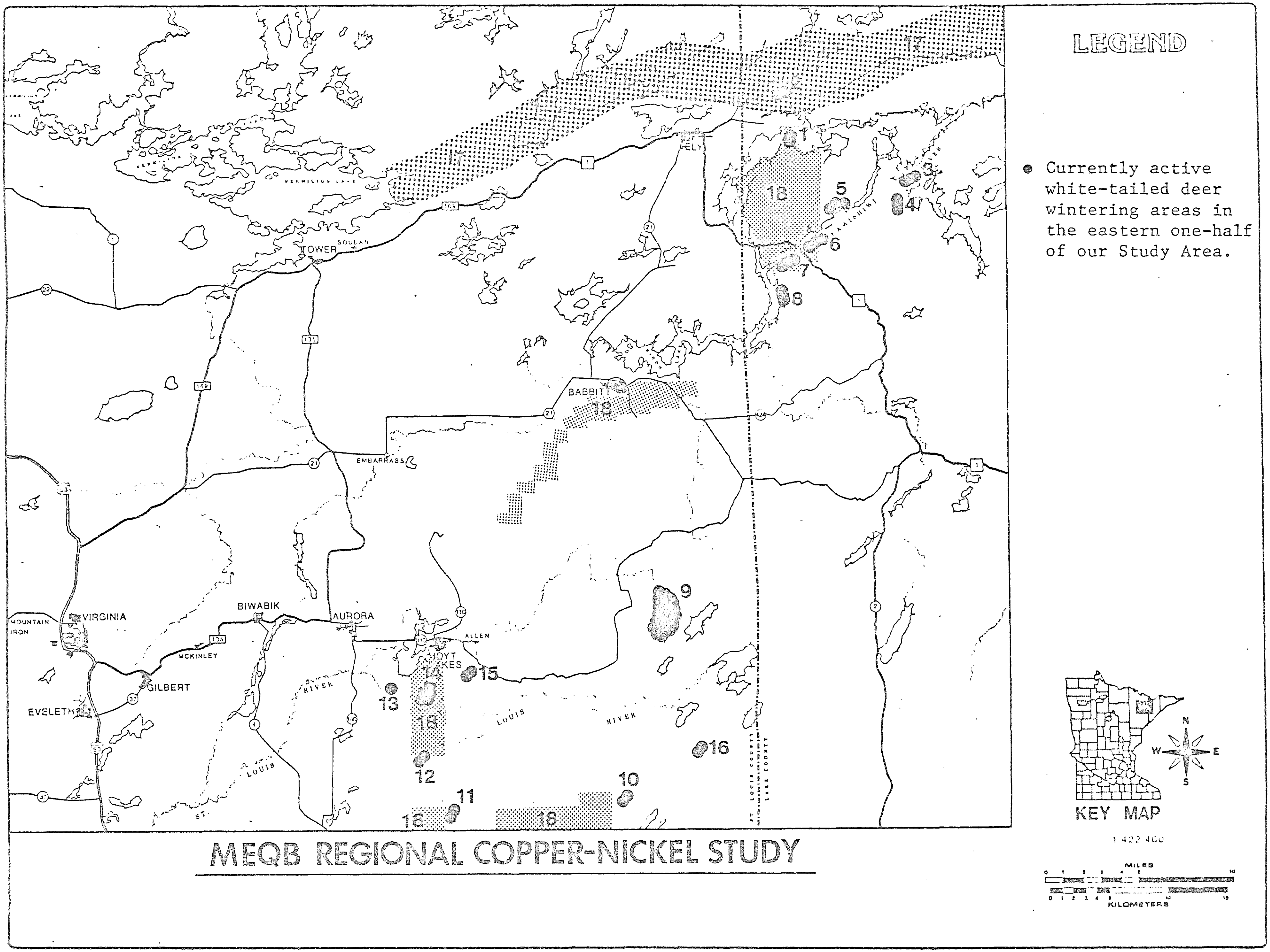
LEGEND
Currently active white-tailed deer wintering areas in the eastern one-half of our Study Area.
MEQB REGIONAL COPPER-NICKEL STUDY
KEY MAP
MILES
KILOMETERS
ELY
TOWER
SOUDAN
BABBITT
EMBARRASS
VIRGINIA
MOUNTAIN IRON
BIWABIK
AURORA
ALLEN
HOYT LAKES
MCKINLEY
GILBERT
EVELETH
ST. LOUIS RIVER
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Table 1. Regional deer harvest by kill-blocks for 1972-1975 (incl.) comparing north, middle, and south data tiers.[a,b]

North		Middle		South	
Block No.	Kill/mi^2 [c]	Block No.	Kill/mi^2	Block No.	Kill/mi^2
34	2.21	46	1.20	58	1.75
	1.99		1.20		.90
	2.23		1.63		1.21
	2.64		1.40		1.19
35	2.11	47	1.96	59	1.19
	1.78		1.62		.82
	1.38		1.78		.67
	1.51		1.52		.64
36	1.23	48	1.06	60	1.48
	1.43		1.02		.87
	.87		.62		.58
	.67		.52		.74
37	1.02	49	1.46	61	1.36
	.92		1.32		.89
	.73		.77		.85
	.66		.81		.80
38	.37	50	.59	62	.69
	.31		.44		.74
	.17		.31		.55
	.23		.44		.46
39	.13	51	.75		
	.10		.61		
	.09		.32		
	.07		.29		
27	1.05				
	.91				
	.37				
	.40				
Total =	27.58		23.46		18.38
N = 28		24		20	
$\bar{x}$ =	0.99/mi^2		0.98/mi^2		0.92/mi^2
SD =	0.76/mi^2		0.51/mi^2		0.34/mi^2
$\bar{x}$ =	0.38/km^2		0.38/km^2		0.35/km^2

one-way analysis of variance of means, $F_{2,69} = 0.08$ N.S. ($P < 0.05$, $F = 3.13$) 2,69 d.f.

a See Figure 1 for location of each kill block.

b Data in table compiled from MDNR statistics.

c Data in each kill block listed for 1972-1975, top to bottom. Statistics worked on original MDNR data calculated in deer/mi^2, with deer/km^2 given at bottom of table.

Table 2. Regional deer habitat harvest by kill-blocks for 1972-1975 (incl). comparing data tiers from west to east.[a,b]

WEST		WEST		MIDDLE		MIDDLE		EAST		EAST	
Block No.	Kill/mi^2 [c]	Block No.	Kill/mi^2	Block No.	Kill/mi^2	Block No.	Kill/mi^2	Block No.	Kill/mi^2	Block No.	Kill/mi^2
	2.21		2.11		1.23		1.02		.37		.13
34	1.99	35	1.78	36	1.43	37	.92	38	.31	27	.10
	2.23		1.38		.87		.73		.17		.09
	2.64		1.51		.67		.66		.23		.07
	1.20		1.96		1.06		1.46		.59		.75
46	1.20	47	1.62	48	1.02	49	1.32	50	.44	39	.61
	1.63		1.78		.62		.77		.31		.32
	1.40		1.52		.52		.81		.44		.29
	1.75		1.19		1.48		1.36		.69		1.05
58	.90	59	.82	60	.87	61	.86	62	.74	51	.91
	1.21		.67		.58		.85		.55		.37
	1.19		.64		.74		.80		.46		.40
TOTAL=	19.55		16.98		11.09		11.56		5.30		5.09
N =	12		12		12		12		12		12
$\bar{X}$ =	1.63mi^2		1.42mi^2		0.92mi^2		0.96mi^2		0.44mi^2		0.42mi^2
SD =	0.54mi^2		.49mi^2		.33mi^2		.27mi^2		.18mi^2		.33mi^2
$\bar{X}$ =	.63/km^2		.55/km^2		.35/km^2		.37/km^2		.17/km^2		.16/km^2

One-way analysis of variance of means, F=20.45** P<0.01
(5,66d.f., F=3.31 at P<0.01)

See Fig. 1 for location of each kill block.
Data in table compiled from MDNR statistics.
Data in each kill block listed for 1972-1975, top to bottom.
Statistics worked an original MDNR. Data calculated in deer/mi^2, with deer/km^2 given at bottom of totals

Table 3. RCNSA deer harvest by kill-blocks for 1972-1975 (incl.) comparing north, middle and south data tiers.[a,b]

North		Middle		South	
Block No.	Kill/mi^2 [c]	Block No.	Kill/mi^2 [c]	Block No.	Kill/mi^2 [c]
22	.93	36	1.23	49	1.46
	.95		1.43		1.32
	.56		.87		.77
	.69		.67		.81
23	.43	37	1.02	50	.59
	.44		.92		.44
	.26		.73		.31
	.28		.66		.44
24	.67	38	.37	51	.75
	.43		.31		.61
	.17		.17		.32
	.11		.23		.29
Total =	5.98		8.61		8.11
N =	12		12		12
$\overline{x}$ =	.49/mi^2		.72/mi^2		.68/mi^2
SD =	.28/mi^2		.40/mi^2		.38/mi^2
$\overline{x}$ =	.19/km^2		.28/km^2		.26/km^2

one-way analysis of variance of means, $F = 1.34$, N.S. ($P < 0.05$, $F = 3.28$) 2,33 d.f.

a See Figure 1 for location of each kill block.

b Data in table compiled from MCNR statistics.

c Data in each kill block listed for 1972-1975, top to bottom. Statistics worked on original MDNR data calculated in deer/mi^2, with deer/km^2 given at bottom of table.

Table 4. RCNSA deer harvest by kill-blocks for 1972-1975 (incl.) comparing data tiers from west to east.

West		Middle		East	
Block No.	Kill/mi^2 c	Block No.	Kill/mi^2	Block No.	Kill/mi^2
	.93		.43		.67
22	.95	23	.54	24	.43
	.56		.26		.17
	.69		.28		.11
	1.23		1.02		.37
36	1.43	37	.92	38	.31
	.87		.73		.17
	.67		.66		.23
	1.46		.59		.75
49	1.32	50	.44	51	.61
	1.77		.31		.32
	.81		.41		.29
Total =	12.69		6.62		4.43
N =	12		12		12
$\overline{x}$ =	1.06/mi^2		.55/mi^2		.37/mi^2
SD =	.38/mi^2		.24/mi^2		.21/mi^2
$\overline{x}$ =	.41/km^2		.21/km^2		.14/km^2

one-way analysis of variance of means, F = 18.67 ** $P < 0.01$
(2,33 d.f., F = 5.29 at $P < 0.01$)

a See Figure 1 for location of each kill block.

b Data in table compiled from MCNR statistics.

c Data in each kill block listed for 1972-1975, top to bottom. Statistics worked on original MDNR data calculated in deer/mi^2, with deer/km^2 given at bottom of table.

Table 5. Estimated deer harvest on our Study Area and proportion of total harvest in Minnesota for 1972 to 1977 (incl.) from MDNR statistics.

Fall Hunting Season	1972	1973	1974	1975	1976[a]	1977	Avg ($\bar{x}$)
State Harvest	73448	67106	64997	62469	(27834)	45918	62788
No. of Deer Harvested on Minesite[c]	400	344	223	254	--	286	301
% of State Harvest[b]	0.5	0.5	0.3	0.4	--	0.6	0.5
No. of Deer Harvested on RCNSA [c]	1952	1858	1131	1183	--	1494	1523
% of State Harvest[b]	2.7	2.8	1.7	1.9	--	3.2	2.4

a The summer and fall fire ban this season may have been an important factor in the low statewide kill. Values were not calculated for this year, and the total kill figure was not used for calculating the mean.

b Calculated from total harvest on each Study Area ÷ total state harvest.

c Harvest data from MDNR (Rutske 1975 and data provided by R. Carlson). Kill estimated by multiplying the percent of each kill block located within each respective Study Area by the total registered deer kill for a given year for that block. The summation of all values from pertinent blocks is the kill estimate. Assumption made that harvest was uniform across each block.

WINTER DENSITIES AND DISTRIBUTION

OF

DEER AND MOOSE IN NORTHEASTERN MINNESOTA

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Abstract: An aerial census for deer (Odocoileus virginianus) and moose (Alces alces) was completed in the winter of 1977-78 in northeastern Minnesota. A stratified random sampling technique with optimal allocation of sample plots was used. Uncorrected census results were 0.8 deer and 0.1 moose per square kilometer. The accuracy of the census was improved for deer by estimating numbers of animals missed within census plots. Moose results were adjusted using values from the literature. Corrected results are 2.3 deer and 0.3 moose per square kilometer. Deer and moose distributions were determined from aerial transects flown prior to the census. Distribution patterns and population densities may not be valid for times of the year other than the census period because of seasonal habitat changes.

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This census is part of an environmental impact statement on copper-nickel mining being prepared by the Minnesota Environmental Quality Council. The 1542 square kilometer area is located in north-eastern Minnesota between the City of Ely and the City of Hoyt Lakes. It includes portions of Townships 57, 58, 59, 60, 61 and 62 North in Ranges 10, 11, 12, 13 and 14 West (Figure 1). Figures 2 and 3 illustrate by sections what areas are included.

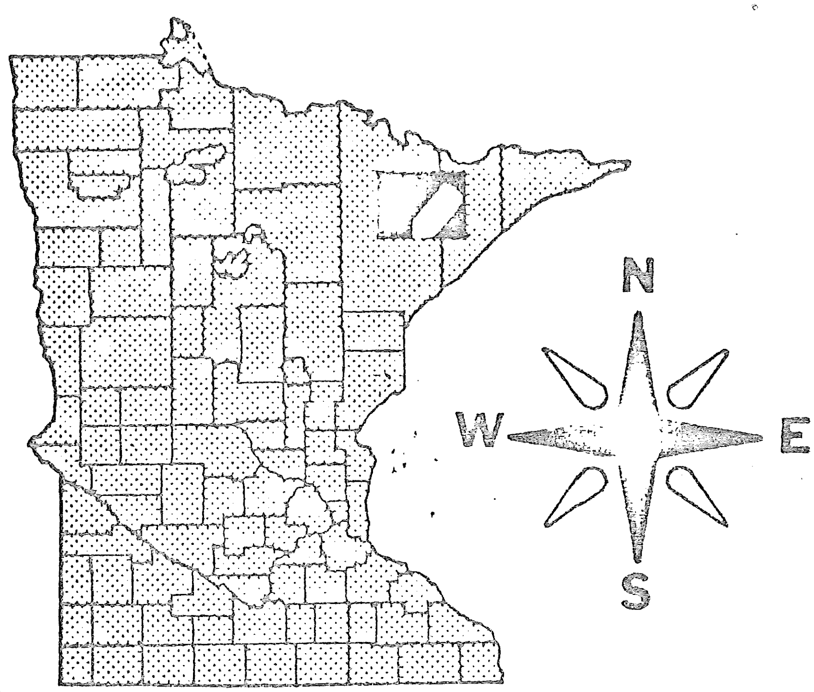


Figure 1. The study area

I wish to thank Dick Hempfner, Mark Kortkamp and Steve Knick for their assistance.

METHODS

The 1977-78 deer-moose aerial census was designed and analyzed according to criteria established by Cochran (1967) for stratified random samples with optimal allocation. Several studies used this technique to advantage in estimating big game populations (Bell et al. 1973, Eberhardt 1957, LeResche and Rausch 1974, Ryell 1960, Peek 1971, Siniff and Skoog 1964). Big game populations often occur in clumped distributions so stratified random sampling is particularly applicable to them. The basic objective in stratified random samples is to define strata which are relatively homogeneous. A stratum is a geographical area with a homogeneous density of animals. Thus precise estimates of stratum means can be obtained with smaller sample sizes and variances than with other sampling methods.

Defining strata requires prior knowledge of distributions and densities of the population.

After strata have been defined, sample sizes must be allocated for each stratum. Cochran (1967) defines two types of sample allocation: proportional and optimal. Optimal allocation is desirable when large differences exist between stratum means and is made proportional to both the stratum area and its variance. This requires knowledge of strata variances prior to the census. Often variances are not known and other estimates must be substituted. Population estimates can serve this purpose with the assumption that differences in strata densities reflect, in roughly the same proportions, the difference between strata variances.

Strata were defined from deer and moose distribution observed from the air along transects 1.6 kilometers (one mile) apart. Transect flights proceeded in a north-south direction. Trails and sightings of moose and deer were plotted on topographic maps by an observer watching from one side of the plane.

Transect data also provided the data for optimally allocating sample plots within strata. Previous studies (Bell et al. 1973, Peek 1971, Siniff and Skoog 1964) had established that estimates of strata densities could be successfully substituted for strata variances. The census design used here assumed that numbers of animals and trails, recorded from transects, within strata would be equally effective in reflecting strata variances. Table 1 illustrates the necessary computations for optimally allocating plots among strata.

Sample plots were approximate square miles (2.6 square kilometers) with boundaries based on identifiable geographic landmarks where possible. Unlike plots based on a grid system, boundaries easily identified from the air reduced the possibility of mistakenly counting animals which may or may not have been in the plot.

Census flights were begun on the 28th of December and completed on the 16th of March. Eighty plots were intensively searched at altitudes of from 60 to 150 meters (200 to 500 feet) above ground with a Piper PA-18A-150 Super Cub. Plots were searched in a series of overlapping circles so that each piece of ground was observed at least once. Both pilot and passenger functioned as observers. When deer or moose were sighted, the pilot was requested to circle until observers were satisfied that as many animals as possible were counted..

RESULTS AND DISCUSSION

Deer-Moose Distribution

Deer distribution was classified as high, medium, and low density range (Figure 2). Moose distribution was classified as high and low density (Figure 3). Data needed to stratify the areas in figures 2 and 3 were gotten from recording trails and animals sighted during transect flights. Comparison of figures 2 and 3 reveals little overlap between high density deer and moose range during winter.

High density deer range comprised 16% of the total area and contained 48% of all trails and animals observed. Medium density range occupied 21% of the area and included 24% of the trails and animals observed. The rest of the area (63%) was low density range which included 28% of all trail and animal observations. In census plots, 140, 29 and 36 deer were observed in high, medium and low density strata respectively (Table 3).

High density deer range was located along the southern shores of White Iron and Farm Lakes surrounding the Kawishiwi river area (Figure 2). It also included an area extending approximately eight miles southwest of Birch Lake and the City of Babbitt. A third area of high density range existed in the southern end of the study area south and southeast of Hoyt Lakes and north of the Whiteface Reservoir. Medium density deer range primarily occupied zones surrounding high density area in the northern half of the study area, while in the southern one-third it occupied most of the area. Nearly all of the area east of a line extending lengthwise northeast-southwest through the center of the study area was low density.

High density moose range was mostly confined to the northeast one-third of the study area. A small portion was located about eight miles east of Hoyt Lakes (Figure 3). It comprised 14% of the total area and contained 68% of the total moose trail and animal observations recorded during transect flights and 33% (Table 3) of all moose observed in census plots.

Deer-Moose Density

Deer and moose densities were determined similarly, the methodology of which is illustrated in Table 2. Table 3 presents results for both deer and moose. Appendix 1 presents initial plot data from which values in Table 2 and 3 were calculated. Plot densities ranged from zero to 14 deer and zero to five moose per plot. Eighty plots were sampled for deer and moose. For deer 20, 14, and 46 plots were optimally allocated for sampling in high, medium, and low density strata respectively (Table 1). For moose 21 of high and 59 plots of low density strata were allocated. Each plot averaged 20 minutes for completion. The average area per plot was 2.6 square kilometers (one square mile).

Of 205 deer observed, 140 (68%) were in high, 29 (14%) were in medium, and 36 (18%) were located in low density plots (Table 3). These values projected for each stratum result in uncorrected figures of 654, 267 and 299 deer in high, medium and low density strata respectively for an overall uncorrected estimate of 1,221 deer in 1542.4 square kilometers (595.5 square miles).

It is acknowledged that a number of factors affect the observability of animals in aerial censues (Norton-Griffiths 1976, Caughley et al. 1976, LeResche and Rausche 1974, Pennywick and Western 1972). Probably in this area the factor most affecting census accuracy is forest cover type. Deer in coniferous cover are easily missed. Floyd et al. (submitted and included as Appendix II) describe a technique for correcting deer census results in an area included in this census. We assumed the correction factor includes the overall effects of all types of biases encountered during the census. The method was followed in this census and a correction factor was applied to results listed in Table 3 for deer. With the observers used, approximately 34% of all deer in each plot were actually observed, resulting in a correction factor of 2.92 (the reciprocal of 34%),(Table 4).

The corrected population estimate for the study area is 3567.7 deer (Table 3). The corrected mean is 2.3 deer per square kilometer (6.0 deer per square mile).

A total of 30 moose were observed in 80 sample plots, 10 (33%) in high density and 20 (67%) in low density range. The uncorrected projected total is 217 moose in 1542 square kilometers (Table 3), 40 moose in high density and 177 in low density stratum.

It should be assumed that moose are subject to observability biases similar to deer, although not necessarily of the same magnitudes. A moose correction factor was not determined for this study using techniques described by Floyd et al. (submitted). Instead, in analyzing data presented by LeResche and Rausche (1974), I assumed that about 50% of all moose in plots were not observed. Thus uncorrected results in Table 3 were multiplied by two.

The corrected moose population estimate in 1542 square kilometers is 434 moose (Table 3). This results in a mean of 0.3 moose per square kilometer (0.7 per square mile).

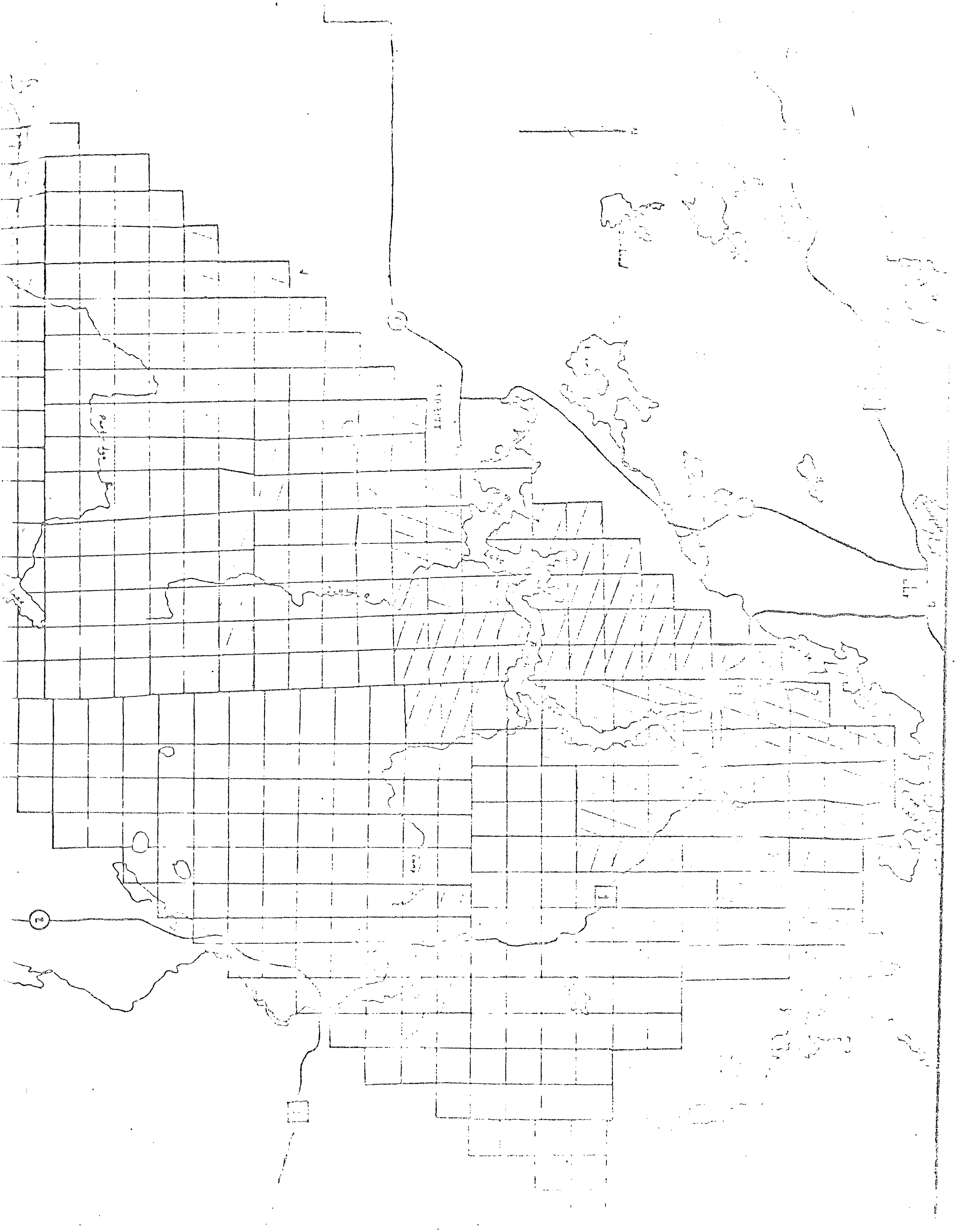
Various studies, including research done in this area (Hoskinson and Mech. 1976, Nelson 1977), have shown that deer exhibit seasonal migration patterns and that summer and winter ranges may differ. Thus it should be assumed that results presented here reflect population densities and distribution of deer in their winter range and may not hold true for other times of the year. This census was not begun until after a sample of radio-monitored deer had settled on their winter range (Nelson, personal communication).

In northeastern Minnesota there is a lack of data on seasonal habits of moose. To my knowledge it is not known whether winter and summer ranges differ. I am assuming that, like deer, moose were present on their winter range when the census was made. Thus as is the case with deer, census results may not be valid during other times of the year.

FIGURES

TABLES

APPENDICES



1977-78 WINTER DEER DISTRIBUTION *Figure 2*

- HIGH DENSITY
- MEDIUM DENSITY
- LOW DENSITY

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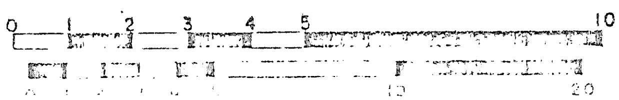

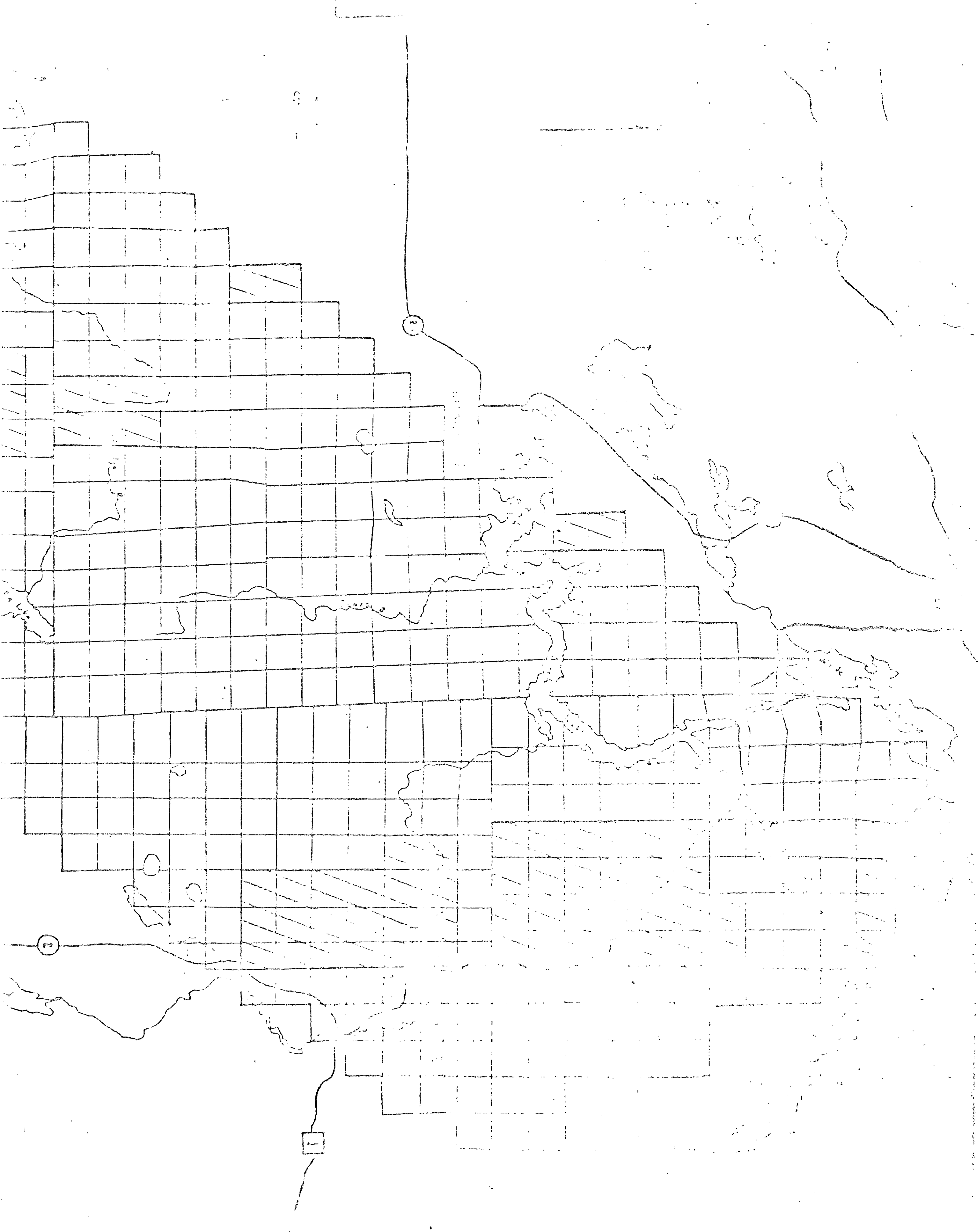

1977-78 WINTER MOOSE DISTRIBUTION Figure 3

-HIGH DENSITY

-LOW DENSITY

1:126,720

Table 1. Example of computations required for optimally allocating sample size within strata. Taken from deer data.

Stratum Density	N_h	W_h	s_h	$W_h s_h$	$W_h s_h$ as a proportion	Optimal allocation of sample units 1/
High	94.1	0.158	697	110.1	0.25	20
Medium	127.6	0.214	356	76.2	0.17	14
Low	373.8	0.628	404	253.7	0.58	46
Totals	595.0	1.000		440.0	1.00	80

Definitions:

N_h = Total number of possible sample units 2/ per stratum.

W_h = Proportion of possible sample units per stratum .

s_h = Number of trail and animal sightings within strata from transect data. Used in place of standard deviation.

$W_h s_h$ = Product of W_h and s_h .

1/ Optimal allocation values represent the number of sample units chosen for the census (80) multiplied by $W_h s_h$ as a proportion.

2/ A sample unit was one square mile (2.59 square kilometers).

Table 2. Example of calculations required to derive a population estimate and variance. Taken from deer data.

Stratum Density	n_h	N_h	w_h	W_h	x_h	$\bar{x}_h$	s_h^2	x_h / w_h	$(W_h^2 s_h^2 / \Sigma n_h)(1-w_h)$
High	52.2	243.7	0.214	0.158	140	2.7	14.2	653.9	0.014
Medium	35.9	330.5	0.109	0.214	29	0.8	15.6	267.3	0.045
Low	116.5	968.2	0.120	0.628	36	0.3	2.7	299.3	0.020
Totals	204.6	1542.4		1.000	205			1220.5	0.079

Total population estimate $X_{est} = \Sigma (x_h / w_h) = 1220.5$ deer

Population mean $\bar{X}_{est} = X_{est} / N = 0.8$ deer/kilometer^2 (2.1 deer/mile^2)

Variance of the population estimate $S^2_{X_{est}} = \Sigma (W_h^2 s_h^2 / \Sigma n_h)(1-w_h)$ 1/ $= 0.079$

Definitions:

n_h = Amount of area (kilometers^2) sampled in each stratum.

N_h = Amount of total area included in each stratum.

N_h = Total area included in study area (ΣN_h).

w_h = Proportion of each stratum sampled (n_h / N_h).

W_h = Proportion of area included in each stratum (N_h / N).

x_h = Number deer observed per stratum.

$\bar{x}_h$ = Sample mean number of deer per stratum (x_h / n_h).

s_h^2 = Strata variance = $\Sigma (x_h - \bar{x}_h)^2 / n_h - 1$.

1/ The quantity 1-w is a population correction factor which may be ignored if less than 0.1.

Table 3. Results of the 1977-78 deer-moose aerial census.

Density Strata	DEER: Area Counted Km^2	DEER: Area Counted % of Stratum	DEER: Deer Seen No.	DEER: Deer Seen Per Km^2	DEER: Projected Total	MOOSE: Area Counted Km^2	MOOSE: Area Counted % of Stratum	MOOSE: Moose Seen No.	MOOSE: Moose Seen Per Km^2	MOOSE: Projected Total
High	52.19	21.41	140	2.68	653.9	54.55	25.06	10	0.18	39.9
Medium	35.87	10.85	29	0.81	267.3	- 1/	-	-	-	-
Low	116.50	12.03	36	0.31	299.3	149.39	11.28	20	0.13	177.3
Totals	204.56		205		1220.5	203.94		30		217.2

Deer	Moose
Correction factor 2/ x 2.92	Correction factor 3/ x 2
Corrected total 3567.7	Corrected total 434.4
Deer/Km^2 4/ 2.3	Moose/Km^2 4/ 0.28
Deer/mile^2 6.0	Moose/mile^2 0.73

1/ The distribution and density of moose did not warrant a medium density stratum.

2/ From Table 4.

3/ A value chosen from LeResche and Rausch 1974.

4/ Study area was 1542.4 kilometers^2 (595.5 miles^2).

Table 4. Results of deer observability tests.

Test Date	Weather 1/	Known No. of Collared Deer	No. Collared Deer Observed 2/	Percent Observed	Correction Factor 3/
February 21, 1978	Fair	11	1	9.1	
February 28, 1978	Fair	5	2	40.0	
March 10, 1978	Good	11	4	36.4	
March 24, 1978	Poor	11	6	54.5	
Totals		38	13	34.2	2.92

1/ Weather was poor when any of the following conditions prevailed: winds at 10 mph or above, temperature below -28°C, a low cloud cover or snow falling. When temperature was above -10°C, winds were light or calm, cloud cover was light, and there was no precipitation, conditions were considered good.

2/ Number of radio-tagged deer observed by both pilot and passenger.

3/ Reciprocal of percent observed.

APPENDIX I. Plot location and statistics.

Plot Location	Minutes for Completion	Area Km^2	MOOSE Stratum Density	MOOSE Number Observed	DEER Stratum Density	DEER Number Observed
T.62-R.11-Sec.3	21	2.1	Low	0	High	2
" " Sec.9	28	2.7	Low	2	High	0
" " Sec.17	26	2.2	Low	0	High	4
" " Sec.22	25	2.5	Low	0	High	7
T.62-R.12-Sec.25	17	2.3	Low	0	Medium	0
T.62-R.11-Sec.31	24	3.2	Low	0	High	6
" " Sec.35	30	2.7	Low	1	High	4
T.61-R.11-Sec. 5	20	2.4	Low	0	High	6
" " Sec. 1	18	2.7	High	5	Low	0
" " Sec. 7	21	2.9	Low	3	High	2
" " Sec. 9	24	2.7	Low	0	High	4
T.61-R.10-Sec. 7	16	2.5	High	0	Low	0
" " Sec.10	14	2.4	High	0	Low	0
" " Sec.17	25	2.8	High	0	Low	0
" " Sec.15	20	2.6	High	0	Low	0
" " Sec.13	22.	3.2	High	0	Low	0
T.61-R. 9-Sec.17	17	2.9	High	3	Low	0
T.61-R.11-Sec.23	15	2.0	High	0	Low	0
T.61-R.12-Sec.25	24	2.8	Low	1	Medium	0
T.61-R.11-Sec.27	22	2.8	High	2	Low	0
" " Sec.25	15	2.6	High	0	Low	0
" " Sec.31	14	2.8	Low	3	Medium	0
T.61-R.10-Sec.31	23	2.6	High	0	Low	2
T.60-R.12-Sec. 2	21	2.5	Low	0	Medium	13
T.60-R.13-Sec.11	12	2.5	Low	0	High	9
T.60-R.12-Sec. 7	18	2.6	Low	0	High	14
T.60-R.11-Sec.10	20	2.6	High	0	Low	4
" " Sec.11	21	2.7	High	0	Low	0
T.60-R.10-Sec. 9	16	2.9	Low	0	Low	0
T.60-R.13-Sec.13	25	2.8	Low	0	High	9
60-R.11-Sec.15	18	2.7	High	0	Low	0

Plot Location	Minutes for Completion	Area Km^2	MOOSE Stratum Density	MOOSE Number Observed	DEER Stratum Density	DEER Number Observed
_.60-R.10-Sec.18	22	2.5	High	0	Low	0
T.60-R.13-Sec.21	31	2.6	Low	0	High	10
" " Sec.22	20	2.3	Low	0	High	9
T.60-R.12-Sec.21	19	2.5	Low	0	Low	0
" " Sec.24	15	2.6	Low	3	Low	0
T.60-R.13-Sec.29	27	2.9	Low	0	High	7
T.60-R.11-Sec.26	23	2.4	High	0	Low	6
" " Sec.35	20	2.6	High	0	Low	0
T.60-R.10-Sec.31	18	2.6	High	0	Low	3
T.59-R.12-Sec.4	21	2.2	Low	0	Medium	0
T.59-R.10-Sec. 6	23	2.4	High	0	Low	1
T.59-R.13-Sec. 8	20	2.3	Low	0	Low	0
" " Sec.11	17	2.3	Low	0	Low	0
T.59-R.12-Sec.12	21	2.2	Low	0	Low	0
" " Sec.18	30	3.4	Low	2	Low	4
" " Sec.13	19	2.7	Low	0	Low	0
T.59-R.13-Sec.22	19	2.4	High	0	Low	0
T.59-R.11-Sec.23	14	2.3	Low	0	Low	0
T.59-R.13-Sec.27	11	2.6	High	0	Low	0
T.59-R.12-Sec.28	16	2.3	Low	0	Low	0
T.59-R.14-Sec.35	20	2.6	Low	0	Low	1
T.58-R.12-Sec. 4	14	2.3	Low	0	Low	2
T.59-R.11-Sec.31	17	2.4	Low	0	Low	0
T.58-R.13-Sec. 5	20	2.3	Low	0	Low	7
T.58-R.12-Sec. 4	14	1.8	Low	0	Low	0
T.58-R.11-Sec. 5	17	2.0	Low	0	Low	0
T.58-R.14-Sec.11	20	2.3	Low	0	Medium	2
T.58-R.12-Sec.12	20	2.7	Low	0	Low	0
T.58-R.14-Sec.15	20	2.7	Low	0	Medium	2
" " Sec.13	25	2.9	Low	0	Medium	0
" " Sec.20	26	2.8	Low	0	High	14
" " Sec.23	20	1.6	Low	0	Low	2
" " Sec.24	18	2.2	Low	0	Medium	1

Plot Location	Minutes for Completion.	Area Km^2	MOOSE Stratum Density	MOOSE Number Observed	DEER Stratum Density	DEER Number Observed
T.58-R.12-Sec.22	17	1.9	Low	0	Low	0
T.58-R.14-Sec.30	22	2.6	Low	0	High	8
" " Sec.31	23	2.7	Low	0	High	10
" " Sec.32	25	2.3	Low	0	High	10
" " Sec.33	21	2.5	Low	0	Medium	0
" " Sec.34	26	2.5	Low	0	Medium	9
T.58-R.13-Sec.36	15	2.5	Low	3	Low	2
T.57-R.13-Sec. 5	26	2.6	Low	0	Medium	0
T.57-R.12-Sec. 6	18	2.8	Low	0	Low	0
T.57-R.14-Sec. 9	21	2.6	Low	0	Low	0
T.57-R.13-Sec. 7	25	2.9	Low	0	Medium	2
T.57-R.12-Sec. 7	18	2.8	Low	0	Low	0
T.57-R.14-Sec.23	15	2.8	Low	2	Low	0
" " Sec.24	17	2.7	Low	0	Medium	0
T.57-R.12-Sec.19	22	2.8	Low	0	Low	2
T.57-R.14-Sec.36	24	3.0	Low	0	High	5
Totals	1624	204.4	80	30	80	205
Means	20	2.6	-	-	-	-

APPENDIX II

Floyd, T.J., L.D. Mech, and M.E. Nelson. 1978.
An improved method of censusing
deer in deciduous-coniferous forests.
Submitted - J. Widl. Manage.

AN IMPROVED METHOD OF CENSUSING DEER IN DECIDUOUS-CONIFEROUS FORESTS

Aerial censusing has been used to determine densities of many large mammals, including deer (Odocoileus virginianus) in agricultural areas or deciduous forests (Saugstad 1942, Morse 1946, Petrides 1953, Sanderson 1953, Berner pers. Comm.). However, observability of deer from the air remains a problem in northern coniferous forests. LeResche and Rausch (1974) determined that even with the much larger and more observable moose (Alces alces) during ideal snow conditions, experienced observers only counted 68 percent of a known number of animals; inexperienced observers counted 43 percent. Caughley (1974) and Caughley et al. (1976) suggested that the best solution to the problem of observability in aerial censuses is to measure the magnitude of the biases that exist, and correct estimates accordingly. This paper describes an attempt to measure observability bias in an aerial census of deer in deciduous-coniferous habitat and to produce an accurate estimate of numbers.

STUDY AREA

The study was conducted in a 393 to 399 km^2 portion of the Superior National Forest (SNF) in Lake County, Minnesota lying northeast to northwest of Isabella. The area included parts of Townships 59, 60, and 61 North in Ranges 8, 9, and 10 West of the Fourth Principle Meridian.

The vegetation of the study area is mostly maturing coniferous-deciduous forest. Few unmixed stands remain except in lowlands, which occupy about one-third of the area and are dominated by white and black spruce (Picea glauca and mariana). Balsam fir (Abies balsamea), red pine (Pinus resinosa) jack pine (Pinus banksiana), aspen (Populus tremuloides), and birch (Betula papyrifera) predominate in the uplands. About 25 percent of the upland consists of red pine and jack pine plantations. Much of the area has been cutover since 1935 (Peek et al. 1976), and is still being logged on a small scale.

Deer had declined in the region from 1968 through 1974, and an area of more than 3,000 km^2 just north of the study area has been devoid of wintering deer since 1972 (Mech and Karns 1977). Some deer immigrate into the study area to winter, usually by December (Nelson 1977), but there is no evidence that deer resident in the study area emigrate in winter. Thus our winter estimates probably exceed the actual number of deer inhabiting the study area for most of the year.

METHODS

Our census technique involved two basic steps: (1) aerially counting deer in census plots, and (2) testing the observability of deer in test plots similar to the census plots. We conducted three censuses, from 7 December 1975 through 4 January 1976, from 25 January through 11 February 1977, and from 13 February through 3 March 1978. Maximum snow depths during the three censuses were 61, 46, and 73 cm, while minimum temperatures were -37C, -40C, and -35C. The counts were based on stratified random sampling with optimal allocation of sample plots, a type of sampling particularly applicable to populations with clumped distributions (Cochran 1967). Census stratification and plot allocation were based on aerial strip surveys of deer and tracks in transects .8 km apart, involving 7 hours of flying. Plots within high, medium, and low density strata were chosen at random. Several workers have used this design in estimating populations of big game animals and describe the technique in greater detail (Peek et al. 1976; Siniff and Skoog 1964).

Our censuses were made under clear to bright-cloudy light conditions at altitudes from 60 to 150 meters above ground from a Piper PA-18A-150 Super Cub aircraft. The Super Cub proved highly advantageous because of its maneuverability and ability to fly at low speeds and altitudes.

Both pilot and passenger (senior author) searched the plots intensively in a series of over-lapping circles such that each piece of ground was observed at least once. Whenever a deer was sighted, the pilot was requested to circle until the observer was satisfied that as many animals as possible were observed. Census plots were approximately 2.6 km^2 each with boundaries based on identifiable landmarks such as ridges or streams, and averaged 17 minutes each for completion. We censused 40 to 45 plots each year.

We used radio-tagged deer (Hoskinson and Mech 1976; Nelson and Mech in prep.) to test our observability bias in the census. Thirty radio-tagged deer with color-coded collars were available, ten in winter 1975-76, four in 1976-77, and 16 in 1977-78 (Nelson 1977). The collars did not seem conspicuous enough to increase the observability of the deer. Test plots of 1.3 to 2.6 km^2 containing radioed deer were located on maps by an impartial observer and a pilot other than the census pilot (Table 2). Test plots were then searched within the next few hours by the senior author without redio telemetry, using the same pilot, plane, and search techniques as in the counts. In several instances the same deer were used during different days but only if their locations changed between trials. The test plots were located in the same region as the census area, although not actually within the census area. Weather and cover variation among plots and tests was similar to that during counts. Thus we assumed that the proportion of collared deer missed in the test plots approximated the proportion of deer missed in the census plots. Correcting census data with the figures thus derived gave an estimate of the actual deer density.

RESULTS AND DISCUSSION

Deer were observed under forest conditions varying from open canopy to an estimated 80 percent closed canopy. In winters 1975-76, 1976-77, and 1977-78, 51, 55, and 69 deer were seen during the censuses. However, the low density stratum constituted an increasing proportion of the cen us area each year, from 62 percent in 1975-76 and 63 percent in 1976-77 to 79 percent in 1977-78. Furthermore, the number of deer seen in the low density stratum dropped from .16/km^2 in 1975-76 through .15/km^2 in 1976-77 to 0 in 1977-78 (Table 1). Therefore, when these densities are projected to the entire study area the mean number of deer seen actually decreased from .40 deer per km^2 in 1975-76 to .33 in 1976-77 and .20 in 1977-78.

The observability tests indicated that 56 percent of the deer were seen during the first winter, and 50 percent during the second and third (Table 2). Correcting the census results by multiplying them times the reciprocals of the observability figures for each year yields total estimates of .70, .66, and .40 deer per km^2 (Table 1).

The observability of collared deer remained remarkably constant between test days and between winters despite variable weather (Table 2). The results of the observability tests indicate that, with the intensive search method of counting deer under the conditions in our study, approximately half of the deer are seen.

To apply our technique for correcting aerial censuses of deer over large areas, we suggest that observability tests be made several times during the census, because ground and weather conditions can change throughout the census, and that deer observability be tested in different cover types, with separate correction factors applied for each type.

Although observability tests add substantial expense to a deer census, they increase the accuracy of the results considerably. Furthermore monitoring the movements of the radioed deer provides significant insight into seasonal migration patterns and distribution, phenomena that other deer census methods have failed to consider. Such insight puts census data into both seasonal and areal perspective.

It is not yet clear whether our census technique is sensitive enough to make precise year-to-year comparisons. However, it certainly is accurate enough to provide an excellent indication of gross deer density and to document the fact that in the present study area, deer numbers are exceptionally low.

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LITERATURE CITED

CAUGHLEY, G. 1974. Bias in aerial survey. J. Wildl. Manage. 38(4):921-933.

__________, R. SINCLAIR and D. SCOTT-KEMMIS. 1976. Experiments in aerial survey. J. Wildl. Manage. 40(2):290-300.

COCHRAN, W. G. 1967. Sampling techniques, second edition. John Wildey and Sons Inc., New York. 413 pp.

HOSKINSON, R. L. and L. D. MECH. 1976. White-tailed deer migration and its role in wolf predation. J. Wildl. Manage. 40(3):429-441.

LE RESCHE, R. E. and R. A. RAUSCH. 1974. Accuracy and precision of aerial moose censusing. J. Wildl. Manage. 38(2):175-182.

MECH. L. D. and P. D. KARNS. 1977. Role of the wolf in a deer decline in the Superior National Forest. USDA For. Serv. Res. Pap. NC-148, 23 pp.

MORSE, M. 1946. Censusing big game from the air. Minn. Conserv. Volunteer 9(52):29-33.

NELSON, M. E. 1977. Migration and social organization of white-tailed deer in northeastern Minnesota. Unpubl. MS Thesis. U. of Minn. St. Paul. 119 pp.

PEEK, J. M., D. J. URICH, and R. J. MACKIE. 1976. Moose habitat selection and relationships to forest management in northeastern Minnesota. Wildl. Monogr. 48. 65 pp.

PETRIDES, G. A. 1953. Aerial deer counts. J. Wildl. Manage. 17(1):97-98.

SANDERSON, G. C. 1953. Aerial deer survey. Iowa Conserv. 12(1):98.

SAUGSTAD, S. 1942. Aerial census of big game in North Dakota. Trans. N. Am. Wildl. Conf. 7:343-356.

SINIFF, D. B. and R. O. SKOOG. 1964. Aerial censusing of caribou using stratified random sampling. J. Wildl. Manage. 28(2):391-401.

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Table 1. RESULTS OF THREE AERIAL CENSUSES

Density Strata	1975-76 Area counted km^2	% of stratum	Deer seen No.	Per km^2	Projected Total	1976-77 Area counted km^2	% of stratum	Deer seen No.	Per km^2	Projected Total	1977-78[1/] Area counted km^2	% of stratum	Deer seen No.	Per km^2	Projected Total
High	50.8	41	40	.79	97.6	56.4	71	37	.66	52.1	72.0	88	69	.96	78.4
Medium	4.5	15	3	.67	20.0	18.2	26	11	.60	42.3	-	-	-	-	-
Low	49.5	21	8	.16	38.1	46.8	19	7	.15	36.8	33.0	11	0	0	0
	104.8			Total	155.7	121.4			Total	131.2	105.0			Total	78.4
				corrected factor[2/]	x 1.77				correction factor[2/]	x 2.00				correction factor[2/]	x 2.00
				corrected total	276				corrected total	262				corrected total	157
				deer/km^2	.70[3/]				deer/km^2	.66[3/]				deer/km^2	.40[3/]

/ Because of increase d winter severity, deer were more concentrated, so there was no medium density stratum.

/ From Table 2.

/ Study area was 393 km^2 in 1975-76, 399 km^2 in 1976-77, and 395 in 1977-78.

E 2. RESULTS OF DEER OBSERVABILITY TESTS

	Weather[1]	Known Number of Collared Deer	Number Collared[2] Deer Observed	Percent Observed	Correction Factor[3]
ary 8, 1976	Fair	6	3	50.0	
ary 9, 1976	Good	10	6	60.0	
1 1976		16	9	56.3	1.79
uary 3, 1977	Fair to poor	4	2	50.0	
uary 9, 1977	Good	4	2	50.0	
1 1977		8	4	50.0	2.00
uary 28, 1978	Fair	7	4	57.0	
h 12, 1978	Good	3	1	33.0	
h 15, 1978	Fair	6	3	50.0	
al 1978		16	8	50.0	2.00

/ Weather was considered poor when any of the following conditions prevailed; winds high, temperature below -28° C, cloud cover low, or snow falling. When temperature was above -10° C, winds were light or calm, cloud cover was light, and there was no precipitation, conditions were considered good.

/ Number of radio-tagged deer observed using both pilot and passenger.

/ Reciprocal of percent observed.

LITERATURE CITED

Bell, R.H., J.R. Grimsdell, L.P. VanLavieren, and J.A. Sayer. 1973. Census of the Kafue Lechive by aerial stratified sampling. E. Afr. Wildl. J. 11(1):55-74.

Caughley, G., R. Sinclair, and D. Scott-Kemmis. 1976. Experiments in aerial survey. J. Wildl. Manage. 40(2): 290-300.

Cochran, W.G. 1967. Sampling techniques, second edition. John Wiley and Sons Inc., New York. 413 pp.

Eberhardt, L. 1957. Some uses of stratified sampling in wildlife investigations. Mich. Dept. Cons., Game Div. Rept. 2158. 5 pp.

Floyd, T.J., L.D. Mech, and M.E. Nelson. 1978. An improved method of censusing deer in deciduous-coniferous forests. Submitted - J. Wildl. Manage.

Hoskinson, R.L. and L.D. Mech. 1976. White-tailed deer migration and its role in wolf predation. J. Wildl. Manage. 40(3): 429-441.

LeResche, R.E. and R.A. Rausche. 1974. Accuracy and precision of aerial moose censusing. J. Wildl. Manage. 38(2):175-183.

Nelson, M.E. 1977. Migration and social organization of white-tailed deer in northeastern Minnesota. Unpubl. M.S. Thesis. U. of Minn., St. Paul. 119 pp.

Norton-Griffiths, M. 1976. Further aspects of bias in aerial census of large mammals. J. Wildl. Manage. 40(2):368-371

Peek, J.M. 1971. Moose habitat selection and relationships to forest management in northeastern Minnesota. Ph.D. Thesis, U. of Minn. 250 pp.

Pennywick, C.J. and D. Western. 1972. An investigation of some sources of bias in aerial transect sampling of large mammal populations. E. Afr. Wildl. J. 10(3):175-191.

Ryell, L.A. 1971. Evaluation of pellet group survey for estimating deer populations in Michigan. Ph.D. Thesis, Mich. State Univ. 255 pp.

Siniff, D.B. and R.O. Skoog. 1964. Aerial censusing of caribou using stratified random sampling. J. Wildl. Manage. 28(2): 391-401.

DEER HUNTER SURVEY

Introduction

Each November 250 to 300 thousand hunters take to the forest and farmlands of Minnesota in pursuit of the white-tailed deer. Within the Study Area, deer hunting is one of the most important forms of terrestrial recreation based on the number of persons involved and total time spent in the field.

We investigated the possibility of using existing data collected by the Minnesota Department of Natural Resources (MDNR) to determine hunter densities on various portions of the Study Area. Some of the traditional methods currently used on a state-wide basis include the following (Karns 1971); (1) hunter report cards which are voluntarily required of all license holders; (2) telephone census of randomly picked hunters to determine, among other things, the hunting success ratio; (3) other methods such as hunter check stations, pellet counts, summer track census and reproductive condition of road-killed does are techniques used to determine survivability, size, age structure and condition of the deer herd.

None of these methods provided us with the type of information for the Study Area that would allow estimation of relative hunter densities. Consequently, we conducted a hunter survey during the first three days of the 1976 rifle deer season on the eastern portion of the Study Area designed to obtain these basic hunter statistics.

Methods

The deer hunter survey had five principle goals: (1) to determine the number of vehicles (which was then expanded to the number of hunters) per kilometer of primary forest roads throughout the eastern portion of the Study Area; (2) since hunters try to maximize their success, we assumed that hunter densities were also linked to the relative size of local deer population; (3) to provide a data base for evaluating the potential loss of certain parcels of land to mining operations and the effect of this loss on deer hunting; and (4) to determine the proportion of "local" to "non-local" hunters using the area to obtain an estimate of the distance hunters were willing to travel to hunt deer in this region.

Nineteen routes were established from the far north eastern portion of the Study Area to the south central (Fig. 1). Each route was established along accessible (improved gravel) U.S. Forest Service (USFS) or county roads. In all, 164 km of roads were censused in a period of 6-7 hours for three consecutive days, with a total trip of 272 km required to return to base.

Hunters were censused on opening weekend (November 13 and 14) and the first Monday (November 15) of the state's rifle season. These early season figures for the number of vehicles observed and hunter density estimates were thus the maximum expected for the area during the 1976 season. The 19 routes were censused from north-south on the 13th and 15th, and from the south-north on the 14th to reduce any time bias that may be present.

The main census technique employed was to record license plate numbers from all vehicles observed. For each observation, the following information was recorded: road number, township-range-section, license plate number, time seen, and whether the vehicle was stopped or moving (Table 1). License numbers were checked with the State Motor Vehicle Dept. to determine the registration address of each vehicle. Parked vehicles were assumed to belong to deer hunters since use of forests in the Study Area by non-hunters in November was very limited. Only parked vehicles were used to calculate the number of cars/kilometer of route censused since moving vehicles could be counted twice. The total number of different cars and trucks observed on the area during the three days was determined from both parked and moving vehicles.

The actual density of hunters per km and per hectare was determined by: (1) calculating the number of hunters per vehicle. This was done by counting hunters in moving vehicles and asking persons seen hunting near roads the size of their hunting party (person/vehicle); (2) calculating the number of hunters per hectare. Mech (1971) has estimated that the average distance hunters are willing to deer hunt from an access road in the Superior National Forest (SNF) is one-quarter mile. The area hunted was calculated by multiplying the length of each route (to the nearest 0.1km) x 80.4 hectares (the area of a rectangular 1000 m. long x 805m wide (¼ mile on both sides of the road)).

Hunters encountered near their vehicle were also asked: (1) whether they had hunted the area before; and (2) to rank the area as good, fair or poor, based on the number of deer seen.

A total of six person-days (2 persons for 3 days) were required to complete this hunter survey.

Results

White tailed deer are associated with successional forest, primarily represented on the Study Area by the aspen or aspen-birch community type.

An area of approximately 260 km^2 located adjacent to and south of the St. Louis River to County Road 16 contains the largest, nearly continuous aspen type on our Study Area. This area is represented on Fig. 1 by the land adjacent to Route 11 to 19. The majority of this area is included in the Toimi Drumlin Field, a gentle undulating landscape of aspen dominated uplands and alder fringed, narrow spruce lowlands.

Roads that provide hunter access to the above area that we censused during this survey are FR 420, 120, 569, 128, 130 and County Road 16. The density of vehicles and hunters along these roads was generally far greater than the mean for all census routes (Tables 2, 3). The only other route that was used extensively was FR 181 (known as the Spruce Road, Route 1, Fig. 1). Habitat adjacent to this road is some of the best deer habitat available in the northeastern portion of the Study Area. The proximity of this area to Ely may also help explain the high hunter density.

In general, the northern routes(1-5, incl.) traversed cover types with much larger proportions of 20-30 year old conifer plantations and mature conifer stands than present on the area as a whole. The central routes (6-11, incl.) censused an area that has been heavily cut-over, much of which is in upland shrub, sparse canopied forest or young (< 20 years) conifer forest. Neither of these areas were heavily used by deer hunters in November, 1976 (Table 2,3), and winter aerial census in 1977-78 showed low deer densities. (Floyd 1978)

Fifty-four people were interviewed and asked if they had previously hunted on the area. Eleven (20 percent) were using the area for the first time, while most (n = 43, 80 percent) had hunted on the Study Area for one or more years.

When asked to rank the area as good, fair or poor for deer hunting, 62 responses were divided as follows: (1) good (n= 17, 27 percent); (2) fair (n = 22, 36 percent); (3) poor (n = 23, 37 percent). The majority of the "good" responses (12 of the 17) were from hunters interviewed on the southern portion of the area (routes 12 to 19, Fig. 1).

A total of 270 different vehicles were observed on our Study Area at least once during the first three days of the 1976 deer season. The three day average was two hunters per vehicle, or 3.2 hunters/km^2 (Table 2). Hunter density ranged from 0.44 to 0.65/100 ha, averaging 0.44/100 ha (Table 3).

The 270 vehicles were registered in 58 different municipalities. Average distance traveled to hunt on the Study Area was 98.0 km. A total of 191 of these (70.7 percent) were registered in cities located within this mean radius, with 79 (29.2 percent) located outside of this area. The distribution of these towns and cities is shown in Fig. 2. Almost identical numbers of hunters using the area were from Aurora (n = 26), Babbit (n = 28) and Ely (n = 27) (Table 4). Hoyt Lakes had nearly as many hunters (n = 72) as all three of these towns combined. A substantial number of hunters also traveled from Duluth (n = 22) and the Twin Cities (n = 24) to hunt on the Study Area.

Conclusion

A deer hunter survey conducted during the first three days of the 1976 season provided information on the distribution and intensity of deer hunting in the eastern portion of the Study Area. The heaviest concentration of hunters was in the southern portion of this area, a region dominated by aspen and aspen-birch ecosystems. Hunter densities in this area were approximately 5 times greater than found along most northern and central census routes. The Toimi Drumlin Field and adjacent areas currently have the highest deer hunter densities in the eastern portion of the Study Area, averaging about 0.74 hunters/100 HA.

Literature Cited

Floyd, J.J. 1978, see Appendix A.

Karnes, P.D. 1971. Censuses and Harvests. In The white-tailed deer in Minnesota Symp. Proc., Edited by M. M. Nelson. Minn. Dept. Nat. Resour., St. Paul, Minn. P. 16-18.

Mech, L. D. 1971. Wolves, coyotes and does. In The white-tailed deer in Minnesota Symp. Proc., Edited by M. M. Nelson. Minn. Dept. Nat. Resour., St. Paul, Minn. P. 19-22.

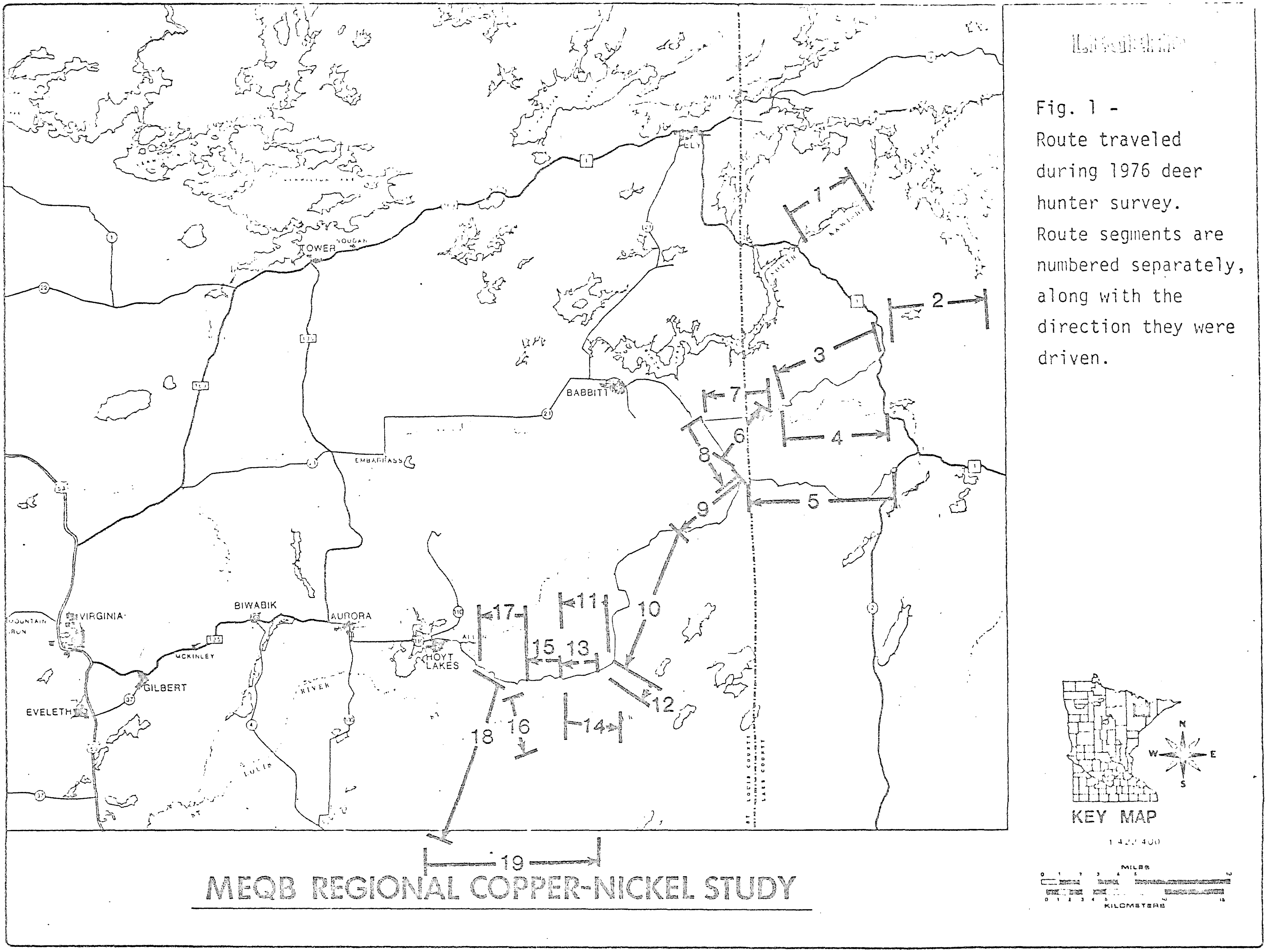
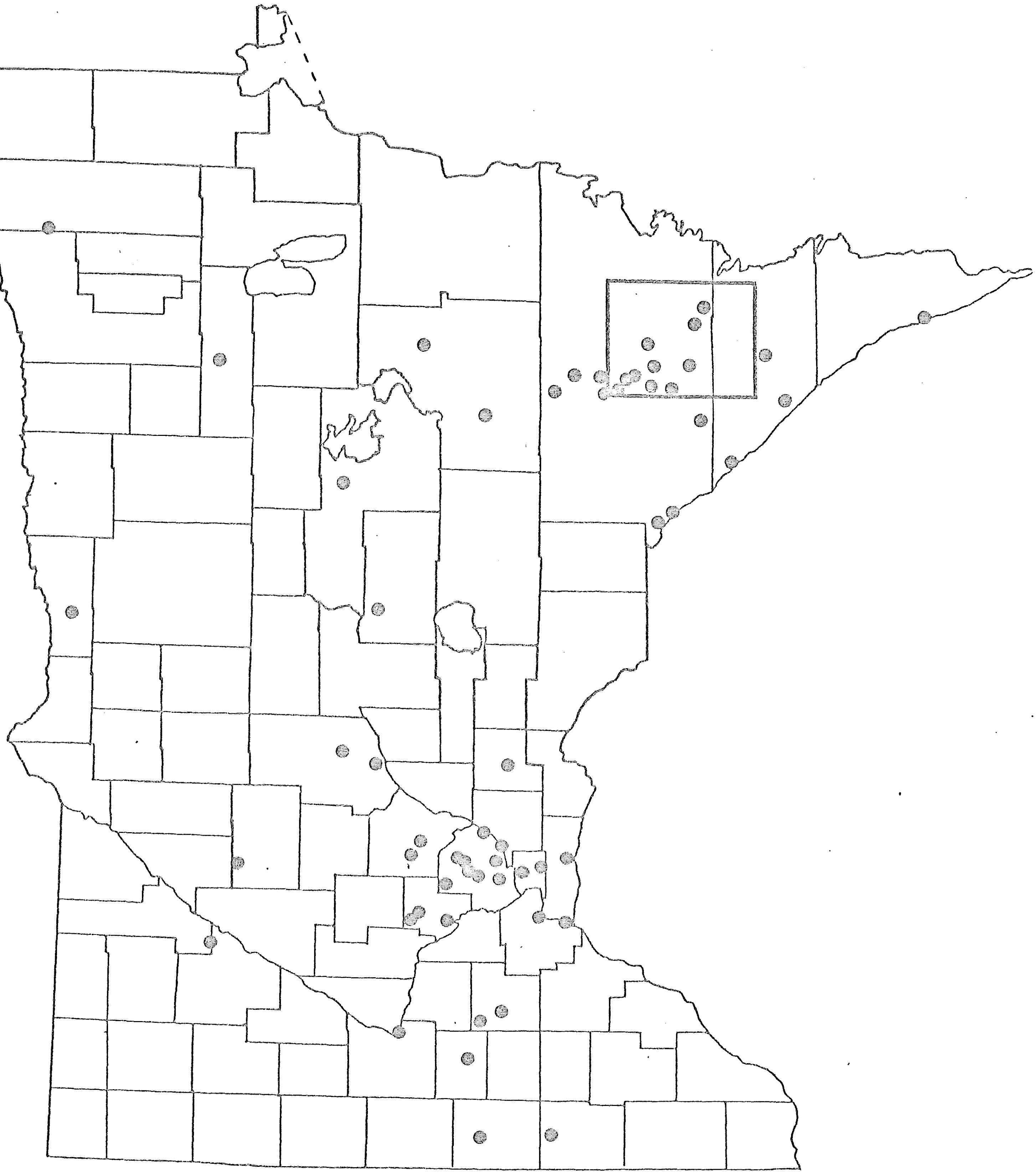


Fig. 1 - Route traveled during 1976 deer hunter survey. Route segments are numbered separately, along with the direction they were driven.

Fig. 2. Distribution of points of origination of 270 vehicles seen on the Study Area during the first three days of Deer Hunting in 1976.



... used during this hunter census.

TERRESTRIAL BIOLOGY
REGIONAL COPPER-NICKEL STUDY

BIG-GAME HUNTER CENSUS

SEASON__________ DATE__________ ODOMETER READINGS: START______

FINISH______

TOTAL MILES______

Hunter Eval. of Area	Poor																		
	Fair																		
	Good																		
Use of Area	Used Before																		
	First Time																		
No. of Hunters In or Near Vehicle																			
Success	Moose																		
	Bear																		
	Deer																		
Vehicle	Moving																		
	Stopped																		
Odometer Readings (000.00)		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Time (Military)																			
Vehicle License No.																			
Sq. Mile No.																			
Road No.																			

Table 2.

The number of deer hunter vehicles and deer hunters per kilometer by route number and date for the 1976 season[a].

Road No.[b]	Route No.[c]	Route Length(km)	Nov. 13 (cars/km)	Nov. 14 (cars/km)	Nov. 15 (cars/km)	Average for 3 days (cars/km	(Hunters/) km[d]
FR181	1	8.2	4.4*	1.2	1.6*	2.4*	4.8 *
FR173	2	9.9	0.8	0.0	0.2	0.3	0.6
FR424	3,7	16.6	1.4	0.6	0.3	0.8	1.6
FR178	4	12.5	1.5	0.2	0.6	0.8	1.6
FR112	5,8	22.2	0.9	0.8	0.7	0.8	1.6
FR1431	6	6.2	1.2	0.4	0.4	0.7	1.4
FR114,116	9	8.3	0.9	0.9	0.3	0.7	1.4
FR113	10,12	16.8	1.1	0.6	0.1	0.6	1.2
FR420	11	5.6	1.8	1.4	0.9*	1.4	2.8
FR120	13,15,17	11.8	1.5	2.0*	1.3*	1.6*	3.2 *
FR569	14	6.1	3.4*	3.4*	0.8	2.5*	5.0 *
FR128	16	7.2	6.4*	5.3*	2.1*	4.6*	9.2 *
FR130	18	16.5	2.2*	3.7*	1.7*	2.5*	5.0 *
County Road 16	19	16.0	3.4*	4.5*	1.1*	3.0*	6.0 *
Totals & Averages	19 routes	163.9 km	2.2 cars/km	1.8 cars/km	0.9 cars/km	1.6 cars/km	3.2 Hunters/ km

a only parked vehicles used in these calculations.

b FR is the Forest Road number designated by the USFS.

c see Figure 1 for location of route on study area.

* Routes at or above the mean.

d mean no. of cars multiplied by mean no. of hunters per car for 3 days (see e, Table 3).

Table 3.

The number of deer hunters per 100 hectare by route number and date for the 1976 season.

Road No.	Route No.	Area of Route in Hectares[a]	Nov. 13 (hunters/100 HA)[b]	Nov. 14 (hunters/100 HA)[c]	Nov. 15 (hunters/100HA)[d]	Average for 3 days (hunters/100HA)[e]
FR181	1	659.3	1.40*	0.38	0.41*	0.73*
FR173	2	796.0	0.21	0.00	0.04	0.08
FR424	3,7	1334.6	0.22	0.09	0.04	0.12
FR178	4	1005.0	0.31	0.04	0.10	0.15
FR112	5,8	1784.9	0.10	0.09	0.07	0.09
FR1431	6	498.5	0.51	0.17	0.14	0.27
FR114,116	9	667.3	0.28	0.28	0.08	0.21
FR113	10,12	1350.7	0.17	0.09	0.01	0.09
FR420	11	450.2	0.84*	0.65*	0.34*	0.61*
FR120	13,15,17	948.7	0.33	0.44	0.23*	0.33
FR569	14	490.4	1.46*	1.46*	0.28*	1.07*
FR128	16	578.9	2.32*	1.92*	0.62*	1.62*
FR130	18	1326.6	0.35	0.58*	0.22*	0.38
County Road 16	19	1286.4	0.55	0.73*	0.15	0.48*
Totals & Averages	19 routes	13177.5 hectares	0.65 hunters/100H	0.49 hunters/100H	0.19 hunters/100H	0.44 hunters/100H

a area calculated by route length(km) x 80.4 hectares (the area of a rectangle 1000m long x 804m wide (one quarter mile hunted on either side of the road)). in area between routes was not

b 2.1 hunters/vehicle from Nov. 13 sample.

c 2.1 hunters/vehicle from Nov. 14 sample.

d 1.7 hunters/vehicle from Nov. 15 sample.

e 2.0 hunters/vehicle from Nov. 13, 14, and 15 sample, averaged.

* Routes at or above the average.

Table 4. Distribution of Deer Hunters Using the Study Area by City of Origin and Distance Traveled[a] (Nov. 13, 14, and 15, 1976)

City	Kilometers	x	No. of Different Vehicles Recorded	=	Total Kilometers
Albert Lea	461*		2		922
Anoka	298*		2		596
Aurora	29		26		754
Austin	461*		1		461
Avon	307*		1		307
Babbitt	13		28		364
Bagley	283*		1		283
Belview	435*		1		435
Biwabik	38		2		76
Bovey	128*		1		128
Brainerd	230*		2		460
Brimson	38		2		76
Buffalo	320*		1		320
Cambridge	256*		1		256
Carver	352*		1		352
Duluth	102*		22		2244
Ely	38		27		1026
Embarrass	26		2		52
Eveleth	51		7		357
Faribault	397*		1		397
Finland	51		2		102
Fox Home	376*		1		376
Fridley	298*		1		298
Gilbert	43		8		344
Grand Marais	118*		1		118
Hackensack	218*		1		218
Hastings	333*		1		333
Hibbing	77		1		77
Hoyt Lakes	26		72		1872

a. Distances are figured from the junction of the Laurentian Divide and Erie Mining railroad tracks (straight line in Km, rounded to nearest Km.

Table 4 cont'd.

City	Kilometers	x	No. of Different Vehicles Recorded	=	Total Kilometers
Isabella	38		3		114
Loretto	320*		1		320
Mankato	422*		2		844
McKinley	42		1		42
Minneapolis	320*		9		2880
Minnetonka	328*		1		328
Montrose	333*		1		333
Morristown	402*		1		402
Mound	320*		1		320
Mountain Iron	64		2		128
New Brighton	320*		1		320
Norwood	358*		1		358
Proctor	110*		1		110
Raymond	397*		1		397
Rosemount	320*		1		320
Soudan	32		1		32
Spring Lake Park	314*		1		314
St. Cloud	294*		1		294
St. Louis Park	320*		1		320
St. Paul	320*		5		1600
Stillwater	312*		2		624
Two Harbors	64		1		64
Virginia	51		3		153
Warren	384*		1		384
Waseca	422*		1		422
Wayzata	320*		1		320
White Bear Lake	320*		2		640
Winton	38		3		114
Young America	358*		1		358
			270		26,459

*Cities located greater than the $\overline{X}$ = 98.0km from the center of our Study Area

$\overline{X}$ = 98.0 km (26459/270)