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Seasonal Movements, Habitat Use Patterns, and Population Dynamics of White-tailed Deer (*Odocoileus virginianus*) in an Agricultural Region of Northern Lower Michigan

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Kristie L. Sitar

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Scott R. Winterstein
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SEASONAL MOVEMENTS, HABITAT USE PATTERNS, AND POPULATION DYNAMICS OF WHITE-TAILED DEER (*Odocoileus virginianus*) IN AN AGRICULTURAL REGION OF NORTHERN LOWER MICHIGAN

By

Kristie L. Sitar

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ABSTRACT

SEASONAL MOVEMENTS, HABITAT USE PATTERNS, AND POPULATION DYNAMICS OF WHITE-TAILED DEER (*Odocoileus virginianus*) IN AN AGRICULTURAL REGION OF NORTHERN LOWER MICHIGAN

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In recent years, damage to agricultural crops by white-tailed deer (*Odocoileus virginianus*) has been a growing concern of farmers and wildlife biologists in Michigan's northeastern lower peninsula. Biologists issue crop damage control permits and vary harvest quotas to manage localized, high density populations. The distance, direction and initiation dates of spring and fall migration of deer greatly influence the degree of crop damage. Seasonal habitat use patterns and home range sizes of deer also potentially impact damage levels by dictating how much time deer forage in and around crop fields.

I trapped deer during the winters of 1994 and 1995 and marked deer with radio collars or ear-tags. Radio collared deer were tracked during all seasons and at various times of the day to determine the magnitude and direction of migrations, home range sizes and habitat use patterns. Home range size was compared among years, seasons, migratory groups, migratory destinations, and sexes using ANOVA models and deer were evaluated for traditional use of home ranges between years. Habitat use was

evaluated for individual deer and analyses were made by period of the day, year, season, migratory groups, migratory destination, and sex. Overwinter deer densities were estimated for the study area using pellet group counts performed each spring. Deer counts from monthly road surveys were used to compare yearly trends and estimate fawn to doe productivity ratios, fall-recruitment ratios, and fall buck to doe ratios. Annual and period survival of adults and yearlings were estimated from collared and tagged deer. Additional productivity ratios were estimated from observations of collared does and incidental sightings of does and fawns during summer. Fall recruitment ratios were estimated from the fawn to doe ratios of the captured deer. The sexes and ages of the trapped deer were also used to estimate buck to doe ratios and age structure.

In the two years, 73 deer were radio collared and 4,172 deer locations were obtained. Approximately half of the collared deer in each year were migratory. Spring migrations of collared deer began from mid-to late March and fall migrations began in October or November and were mostly completed by the end of firearm season. Deer migrated an average of 10 km with males tending to travel farther than females although differences were not significant. Home range sizes were not different by year, season, sex, migratory category or migratory destination, although pairwise comparisons of seasonal ranges indicated smaller winter than summer ranges in a heavy snow winter and larger winter than summer ranges in a light snow winter. Summer ranges were used with greater fidelity than winter ranges, probably due to the relative mildness of winters. Habitat use differed between years, migratory groups during 1994, migratory destinations, and between sexes. No overall seasonal differences were detected.

However summer habitat use differed by sex, migratory group and migratory destination. Wooded habitats were often the most frequently used habitats by all deer groups. All groups showed significant habitat selection or avoidance patterns, with agricultural selection indicated by varying degrees in all deer groups except for deer migrating to non-agricultural summering areas. Overwinter deer densities ranged from 8.94 - 34.86 deer km^2 across the study area. Most deer were counted in March and April monthly surveys, corresponding with snow melt in each year, and counts increased from May through early fall and decreased in late fall. Annual and period survival rates for adults and yearlings were not significantly different although adult survival was higher than yearling survival both annually and during all periods. Productivity estimates ranged from 0.49 - 1.36 fawns per doe and fall-recruitment ratios ranged from 0.67 - 2.28 fawns per doe. Sex ratios determined from observed counts approximated 1 buck for every 4 - 5 does. The age structure of the captured deer was skewed toward younger age classes with males more highly skewed than females.

The timing of deer arrival on winter ranges is crucial to determining the vulnerability of deer to block permits. Adjustments to crop damage control permits or Deer Management Unit boundaries might increase the probability of harvesting deer responsible for damage. High value crops should not be planted adjacent to wooded habitats. However, if necessary, habitat management practices could be employed to increase the quality and quantity of forest openings in non-adjacent wooded habitats.

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INTRODUCTION

White-tailed deer (*Odocoileus virginianus*) have been a valuable natural resource in Michigan since pre-settlement times. Historically, deer were utilized principally for subsistence purposes. The introduction of market hunting and widespread logging of forested lands decreased deer numbers in the late 1800's (McCabe and McCabe 1984, Langenau 1994). Regulated hunting and habitat regeneration allowed deer populations to expand until the early 1950's when heavy browsing and succession depleted deer habitat, again causing deer numbers to decline. Following this period, a growing timber industry and habitat improvement programs enabled deer numbers to peak in 1989 at approximately two million individuals (Langenau 1994, Ozoga et al. 1994). The 1993 population estimate was approximately 1.5 million individuals (Winterstein et al. 1995).

Today, deer are still valued by both consumptive and non-consumptive users. Bow, rifle, and muzzleloader hunters spend millions of days afield and generate in excess of $300 million per year for Michigan's economy (Dudderar et al. 1989, Reis 1990). Non-consumptive uses consist primarily of recreational observation of deer or other related activities (Langenau 1979). The current management goal of the Michigan Department of Natural Resources (MDNR) is for a statewide deer herd of 1.3 million pre-harvest individuals (Langenau 1994).

High deer densities often lead to high rates of deer-vehicle accidents (Blouch 1984, Bashore et al. 1985) and complaints of crop damage (Langenau 1994, Vecellio et al. 1994). As deer densities increase, populations expand into new habitats. Deer often forage in agricultural croplands within their home ranges (Larson et al. 1978, Dusek et al. 1989, Vecellio et al. 1994). Inevitably, these agricultural lands become an integral and traditional part of deer ranges (Flyger and Thoerig 1962, Dusek et al. 1989). The establishment of deer in habitats adjacent to agricultural areas leads to crop damage both from foraging (Larson et al. 1978) and through the trampling of crops (Putnam 1986, Vecellio et al. 1994).

Agricultural deer damage is a growing problem in the United States. Deer have been reported to damage grains (winter wheat, buckwheat, millet, and rye), cash crops (soybeans, sunflowers, beans, tobacco, and corn), truck crops (tomatoes, watermelon, sweet potatoes, sugar beets, peas, and squash), and numerous other crops including fruit orchards, Christmas trees, and alfalfa (Hammerstrom and Blake 1939, Swift 1948, Moore and Folk 1977, Dusek et al. 1989). Deer damage complaints were first recorded in Michigan in the late 1930s (Langenau 1994). Complaints reappeared again in 1971 (Hansen 1978) and have persisted to current times.

Beginning in 1976, special kill permits were issued to landowners across the state to help control damage (Dudderar et al. 1989). Two types of permits are commonly issued; summer shooting permits and block permits. Summer shooting or “kill” permits are intended for use on antlerless deer during the summer when crop damage is occurring, and block permits are intended for the harvest of antlerless deer during the hunting season. Despite the permit system, crop damage complaints reached an all time high in Michigan's northeastern lower peninsula in 1988 and 1989 (T. Carlson, MDNR, pers. commun.), corresponding to the period when deer numbers peaked in Michigan.

Crop depredation leads to varying degrees of economic loss incurred by farmers (Conover 1994). The timing of damage in relation to crop growth stage or characteristics affects the recovery potential of the crop and extent of economic loss (Flyger and Thoerig 1962, Putnam 1986). The crop damage issue is further complicated by the variation farmers exhibit toward tolerance of damage, even at severe damage levels (Brown et al. 1978, Decker and Brown 1982, Conover 1994). Furthermore, management of the issue requires not only controlling deer numbers and damage levels but maintaining sufficient deer numbers to provide quality hunting opportunities.

It is often assumed that deer-caused crop damage increases with deer density (Hansen 1978, Alverson et al. 1988, Vecellio et al. 1994). While the relationship between damage and deer density is likely to be important, additional factors including habitat interspersion, habitat type and quality surrounding croplands, field size and shape, crop type, deer movement patterns, seasonal habitat use patterns, and home range size of deer should be examined to determine their influence on the severity of crop damage. These elements must be incorporated into the evaluation of agricultural damage to provide a better understanding of the nature of the crop damage problem. In addition, consideration of these factors will aid in determining an effective means of controlling or reducing depredation. Deer damage to crops has been examined and quantified in numerous studies (Palmer et al. 1982, Garrison and Lewis 1987, Austin and Urness

1993, Vecellio et al. 1994), but minimal effort has been made to examine the underlying factors that contribute to agricultural damage.

The first attempts to examine some of these underlying factors and their contributions to damage incorporated habitat area, animal density, and the area and value of damage into a mathematical model (Gorynska 1981). The author reported positive relationships despite large variability in the input data. Vecellio et al. (1994) found that damage to corn and wheat was related to deer density and possibly to distance from woodlands. While these studies are important first steps toward understanding the factors influencing damage, they do not address the relationship of deer behavioral patterns to crop damage levels.

Migration

Movement and habitat use patterns of white-tailed deer have been studied since the 1930's (Bartlett 1932). Movement and habitat use vary regionally and are characterized or influenced by behavioral traits, climatic conditions, deer densities (Sanderson 1966), landscape level attributes, land use practices, and hunting (Kufeld et al. 1988, Root et al. 1988).

In the northern parts of their range, where weather extremes are pronounced, white-tailed deer are usually migratory, spending the winters congregated in yarding areas that act to effectively buffer adverse climatic conditions (Ozoga 1968, Marchington and Hirth 1984, Nixon et al. 1988). The timing of migration is influenced by winter severity (Verme 1968), often with a sharp decline in temperature or heavy snowfall acting as the stimulus for deer migrations to winter yards (Ozoga 1968, Hoskinson and Mech 1976). Deer yards are often comprised of dense coniferous swamps primarily dominated by northern white cedar (*Thuja occidentalis*), fir (*Albies* spp.) or spruce (*Picea* spp.) (Habeck 1960, Ozoga 1968, Verme 1973, Moen 1976, Marchington and Hirth 1984). Yards provide thermal cover and browse (Hammerstrom and Blake 1939, Verme 1973, Moen 1976) for wintering deer as well as serving to reduce the risk of predation by decreasing the predator-prey ratio and facilitating escape through increased runway densities (Hoskinson and Mech 1976, Messier and Barrette 1985, Beier and McCullough 1990, Ozoga et al. 1994).

In the winter, deer conserve energy by reducing metabolism and activity levels in response to reduced food intake experienced from fall to winter (Silver et al. 1969, Moen 1976, 1978, Mautz 1978, Marchington and Hirth 1984). Reduced winter activity is thought to influence range size. For instance, several studies report winter ranges of migratory deer, in deep snow areas, to be considerably smaller than summer ranges (Moen 1978, Tierson et al. 1985, Mooty et al. 1987). Others have reported larger winter ranges than summer ranges due to reduced snow levels and shorter distances between seasonal forages and protective cover in summer (Dusek et al. 1988, 1989, Beier and McCullough 1990).

At the onset of spring, when the snow pack and weather conditions permit free movement, deer leave protective yards in search of high quality spring foods (Sparrowe and Springer 1970, Verme 1973, Hoskinson and Mech 1976, Tierson et al. 1985). Forest openings are thought to benefit deer by providing the first spring foods; high quality grasses and forbs (McCaffery and Creed 1969, Gladfelter 1984, Lenarz 1987). Likewise, forested edges supply an array of high quality foods. Deer are considered an edge species due to the opportunistic, preferential foraging behavior they exhibit along habitat edges (Williamson and Hirth 1985).

Deer migrations tend to be traditional (Verme 1973, Drolet 1976, Marchington and Hirth 1984, Nelson and Mech 1984) and are passed along within a family group from does to fawns. Several studies have suggested that migration distance is a function of food availability; deer density; habitat type, interspersion, or quality; or a combination of all of these (Dahlberg and Guettinger 1956, Verme 1968, Rongstad and Tester 1969). Verme (1973) reported that deer in the western upper peninsula of Michigan were able to meet their summer food requirements closer to winter yards due to greater habitat interspersion. Eastern upper peninsula deer migrated an average of three kilometers farther between seasonal ranges than did western deer. This difference was attributed to diminished habitat interspersion resulting from large tracts of monotypic forest type in the eastern portion of the upper peninsula. In addition, several studies report younger male deer migrating greater distances between seasonal ranges (Carlsen and Farmes 1957, Marchington and Hirth 1984, Dusek et al. 1989).

Deer tend to be resident, or non-migratory, in regions where seasonal weather extremes are minimal (Dahlberg and Guettinger 1956, Sparrowe and Springer 1970, Larson et al. 1978, Dusek et al. 1989, Brown 1992). Several studies have reported a portion of a deer herd to be migratory and a portion which remains sedentary (Hoskinson and Mech 1976, Nixon et al. 1991, Brown 1992, Kufeld and Bowden 1995).

Springer and Sparrowe (1970) and Larson et al. (1978) found that most deer in South Dakota and Wisconsin respectively, were non-migratory and did not develop completely distinct winter and summer ranges. Instead, seasonal ranges of individual deer often overlapped with seasonal shifts in primary use areas (Dahlberg and Guettinger 1956, Larson et al. 1978, Dusek et al. 1989, Brown 1992).

Home range and habitat use

Home range is defined as the area traveled on a seasonal or annual basis by an individual in its normal activities of foraging, caring for young, and mating (Burt 1943). Home ranges are large enough in size to provide specific yearly or seasonal requirements and are comprised of many different vegetation types (Sanderson 1966, Marchington and Hirth 1984). Several studies have suggested that home ranges are traditional through the observation that two-year-old deer often establish home ranges that are adjacent or identical to their mother's (Hammerstrom and Blake 1939, Marchington and Hirth 1984, Nelson and Mech 1984, Tierson et al. 1985). In addition, strong fidelity to winter (Beier and McCullough 1990) and summer ranges (Tierson et al. 1985, Brown 1992) was indicated by seasonal ranges having approximately equal centers of activity in successive years.

Home range size is greatly influenced by habitat quality, interspersion, and food and cover availability (Sanderson 1966). In regions where habitat interspersion is high, deer home range sizes are smaller (Beier and McCullough 1990). However, regardless of the degree of interspersion, deer often display non-uniform use of the area and habitats within their home range (Heezen and Tester 1967, Rongstad and Tester 1969, Kufeld and Bowden 1995).

It is assumed that deer select habitats that optimize survival and fitness (McCullough et al. 1989, Hobbs and Hanley 1990). As a result, different habitat types are utilized in different seasons (Bender and Haufler 1987). In addition, habitat use by deer varies by sex (Dusek et al. 1989, McCullough et al. 1989, Beier and McCullough 1990), age (Dusek et al. 1989), and time of day (Kohn and Mooty 1971, Drolet 1976, Murphy et al. 1985, Dusek et al. 1989, Kufeld and Bowden 1995).

Loss of forested habitat in the midwest region of the U. S. has resulted in increased foraging on agricultural fields by deer (Gladfelter 1984). Agricultural openings in forested landscapes provide both edge and high quality food. Agricultural crops are commonly thought to comprise a large part of a deer's year-round diet in Missouri (Korschgen 1962) and parts of Montana (Dusek et al. 1989).

As with other habitats, use of agricultural lands by deer has been reported to vary seasonally. One study (Austin and Urness 1993) reported the heaviest use of croplands in early spring while others (Gladfelter 1984, Putnam 1986) have indicated heavy use of grain residues throughout the fall and winter. Moreover, deer have been reported to select crop types in different seasons in relation to various food and cover attributes that each crop provides (Dusek et al. 1989). For instance, Murphy et al. (1985) found that hay fields were used heavily during the fawning period and following mowing. Other studies (Kohn and Mooty 1971, Putnam 1986, Dusek et al. 1988, 1989, Kufeld and

Bowden 1995) reported an increased use of agricultural fields from late spring-early summer to fall.

Disproportional use of habitats in excess of availability defines selection or preference and use below expectation (in relation to availability) denotes avoidance (Kohn and Mooty 1971, Putnam 1986, Mooty et al. 1987, Dusek et al. 1989, Beier and McCullough 1990). Some studies indicate that deer use agricultural lands in proportion to their availability (Murphy et al. 1985, Putnam 1986). However, Dusek et al. (1989) recorded cropland selection by deer despite preferred cover being greater than 1 km away.

In some regions, differences in habitat use by male and female deer have been observed (Dusek et al. 1989, McCullough et al. 1989, Beier and McCullough 1990). Females are thought to forage in higher quality habitats due to the high energetic costs associated with ovulation and lactation (Bowyer 1984, Beier 1987, Dusek et al. 1989, Beier and McCullough 1990). In addition, fawn survival has been shown to be related to the quality of diets of adult does in the winter and spring (Murphy and Coates 1976, Langenau and Lerg 1976).

While research on deer ecology in agricultural landscapes has been conducted (Hammerstrom and Blake 1939, Kohn and Mooty 1971, Larson et al. 1978, Murphy et al. 1985, Nixon et al. 1988, Dusek et al. 1989, Nixon et al. 1991, Kufeld and Bowden 1995), the degree of potential impact that deer have on crop damage is still poorly understood. Michigan State University began a comprehensive three part deer damage research project in 1992 to examine the ecological, sociological and economic factors influencing crop depredation in a region of Michigan with substantial reports of agricultural crop damage. The first project (Braun 1996) quantified damage levels to three agricultural crops and examined landscape and habitat characteristics and land use practices as possible factors impacting damage levels. The second project is the subject of this thesis. The last project addressed the economic costs associated with crop damage and examined the attitudes and perceptions of farmers and hunters regarding crop damage.

The main purpose of this research was to examine seasonal movement and habitat use patterns and home range characteristics of deer in a region of Michigan with historical complaints of agricultural damage. The timing, distance and direction of deer movements, the extent and timing of agricultural and non-agricultural habitat use and the home range sizes of deer in agricultural landscapes were described in relation to their potential influences on crop damage.

Population characteristics such as survival, productivity, age structure and sex ratio dictate how a population changes over time (Caughley 1977). Estimation and prediction of population size is an essential tool for managers in the manipulation of wildlife populations. The control of crop damage requires an understanding of all aspects that characterize deer biology and effect crop depredation. Population characteristics of the deer herd were studied and the potential effects on current or future crop damage are discussed. Lastly, recommendations regarding the future management of crop damage as it relates to deer biology and behavior will be made based on considerations of the above analyses.

OBJECTIVES

The specific objectives of this study were to:

1. Determine seasonal movement and habitat use patterns of white-tailed deer in an agricultural landscape and evaluate potential influences on crop damage.

2. Quantify deer densities within the study area by mark-recapture techniques and population indices.

3. Estimate survival rates, productivity, recruitment, sex ratio and age distribution of the deer population in the northeastern lower peninsula of Michigan.

4. Make management recommendations to reduce deer damage to agricultural crops based on deer biology and population dynamics.

STUDY AREA

The study was conducted during 1994 and 1995 in the northeastern lower peninsula of Michigan. Presque Isle, Montmorency, and Alpena counties (Figure 1) were selected due to the high deer densities of approximately 4 to 19 deer per square kilometer (T. Carlson, MDNR, pers. commun.) associated with these counties. In addition, these three counties received medium to high numbers of kill permits in response to damage complaints submitted to the MDNR (Dudderar et al. 1989).

The climate of the northern lower peninsula of Michigan is more variable than other regions of the state. Northern Michigan experiences decreased precipitation during the growing season, cooler temperatures and greater winter snowfalls than southern Michigan as a result of its proximity to the Great Lakes. The lacustrine climate moderates temperatures and produces relatively long growing seasons due to slow spring warming and slow fall cooling. The average growing season is 122 days long with a range of 80 to 150 days. The average maximum summer temperature is moderate, 24.8 ^{0}C, and usually occurs in July, while the average daily winter minimum, - 10.8 ^{0}C, normally occurs in February (Knapp 1988).

Average annual snowfall for the region is approximately 175 cm and average

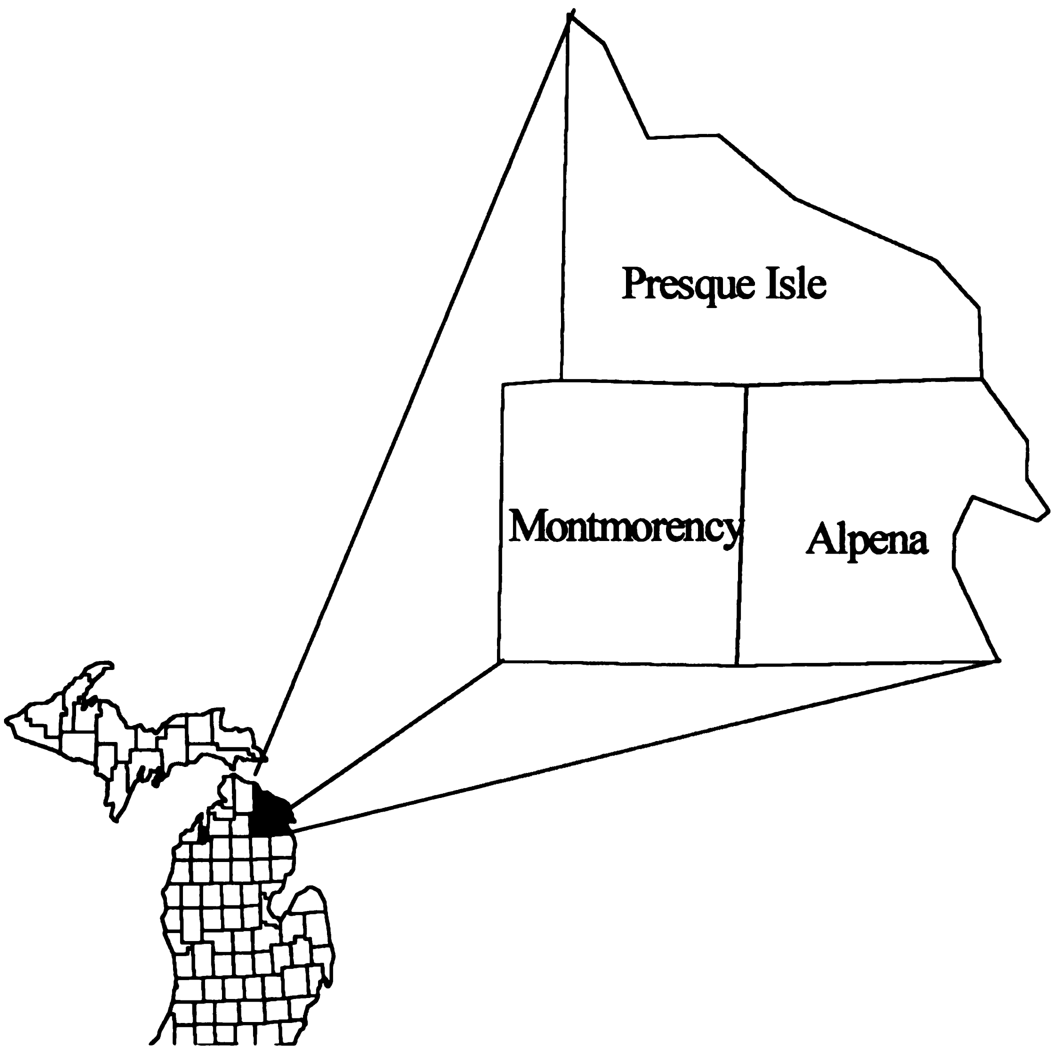


Figure 1. Study area comprised of Presque Isle, Montmorency, and Alpena counties in the northeastern lower peninsula of Michigan.

rainfall is 72.5 cm per year (Eichenlaub et al. 1990). Presque Isle and Montmorency counties receive slightly more rainfall than Alpena county with a mean annual precipitation level of 77 cm. The average yearly temperature for the region is approximately 6.2 ^{0}C, and the average daily temperature during the growing season (May through September) was reported to be 15.9 ^{0}C (Albert et al. 1986).

Elevation in the study area is relatively consistent with a range of only 177 m to 427 m above sea level. The soil types are mostly composed of sand, loam, or glacial deposit and are poorly to moderately well drained (Knapp 1988).

The majority of the land (65%) is forested, and approximately 20% of the region is maintained in agricultural production (Knapp 1988). Conifer species such as northern white cedar (*Thuja occidentalis*), balsam fir (*Abies balsamea*),white spruce (*Picea glauca*), and jack pine (*Picea banksiana*) and deciduous species including quaking aspen (*Populus tremuloides*), maples (*Acer* spp.), basswood (*Tilia americana*), and oaks (*Quercus* spp.) are common throughout (Albert et al. 1986).

The study area has several large regions that are comprised of more than 75% agricultural lands. Forested lands almost completely surround these agricultural areas creating agricultural “islands” in a forested landscape (T. Carlson, MDNR, pers. commun.).

A variety of crop types are cultivated in the three counties. Low to medium production of beans, corn, and hay in all three counties have been recorded in the study area. High potato and low fruit tree production are reported for Presque Isle county (Dudderar et al. 1989).

METHODS

Capture and handling

Deer were trapped in all three counties during the winter months of 1994 and 1995. The trapping period began in mid-to late January and ended in early April during both years. Single-gate, collapsible Clover traps (Clover 1954, 1956, McCullough 1974) were selected for trapping because of their mobility, ability to be used in remote areas (Rongstad and McCabe 1984), and minimal personnel requirements for operation. Additional minor modifications, including the incorporation of a rabbit bar (Roper et al. 1971) along the back of selected traps, were made to increase trapping efficiency. Shelled corn was the most frequently used bait, but cullings of farm crops, hay and apples were occasionally used to increase capture rates. Trap sites were baited for two to four days before setting the traps.

Summer trapping of deer was attempted at three locations within Montmorency and Alpena counties from July 25 to August 16, 1994. Methods followed winter trapping with the exception of using salt as the primary bait.

Traps were placed in wooded areas immediately adjacent to agricultural fields with reported crop damage whenever possible. In addition, two hunting clubs that bordered agricultural lands, were centrally located within the study area, and had large, well established, supplemental deer feeding programs, were chosen as trap sites.

Traps were placed along deer travel routes in cedar swamps, to provide thermal cover and protection from wind (Hammerstrom and Blake 1939, Verme 1973). Trap disturbance and subsequent deer stress were minimized by placing traps away from coyote (*Canis latrans*) travel routes or snowmobile trails. New trap sites were selected when the incidence of successful trapping diminished to less than one deer captured in a two to three week period.

Deer were manually restrained upon capture to collect sex and age information. Handling procedures followed the methods of McCullough (1974). Deer were aged based on the characteristic wear and replacement patterns of the molariform teeth on the lower jaw (Severinghaus 1949, Ryel et al. 1961). Tooth eruption and replacement patterns were used to classify deer as fawns, yearlings, or adults. In addition, adult deer were classified as two, three, four, five, six, or older than six years, based on the wear patterns of the lower pre-molars and molars. Inspection of adult deer jaws upon mortality allowed for corrections of age. Following mortality, the central lower incisor was removed in deer determined to be older than three years of age for cementum analysis (Gilbert 1966, Ransom 1966, DeYoung 1989). Cementum analysis was performed by Matson's Laboratory (Milltown, Montana) for deer in 1994 and Rose Lake Wildlife Research Station (East Lansing, Michigan) for deer mortalities in 1995.

Supplemental age information was gathered following these aging methods for all road-killed deer encountered within the study area. Additional data were collected from a subsample of harvested deer within the study area in 1994 and 1995. A centrally located check station was established (for the first five days of firearm season) where hunters could voluntarily bring their kill to be aged. These data were used as supplemental age data due to the biases associated with their collection (Coe et al. 1980).

All captured deer were marked using one or two colored, serially numbered ear-tags (National Band and Tag Co. Newport, Ky.). Distinct combinations of color and tag placement (left or right ear) allowed for identification of individual deer trapped in 1994. Different colored tags were used to mark different sex and age classes of deer captured in 1995. Date, time, location, and habitat type were recorded from sightings of ear-tagged deer.

Newborn fawns that were encountered early in the fawning period each year were captured by quick, noisy approaches that elicited the “drop” or “freeze” response (Downing and McGinnes 1969, Nelson and Woolf 1987, Ozoga et al. 1994). Fawns were ear-tagged according to the above protocol, sexed and released. Researchers minimized handling time and immediately left the area to lessen the chances of abandonment.

Radio collars (Lotek Inc. Ontario, Canada) were issued to a subsample of the trapped deer in each year to determine movement, habitat use and home range. Collars were equipped with 7-hour motion-sensitive mortality sensors, had a minimum battery life of three years, and weighed less than 0.453 kilograms. Fawn radio collars were identical to adult collars except for the attachment of a bio-degrading foam lining on the inside to prevent the collar from slipping before the fawn reached adult size. All collars were marked with an appropriate address and phone number to facilitate return of the collars.

Radio collars were distributed among all age and sex classes of captured deer and collars were stratified across all three counties. Deer selected to be radio collared appeared physically healthy and were not experiencing obvious severe nutritional deprivation. Radio collars were fitted so that the thickness of one hand (at the palm) could rest between the deer's neck and the collar. Collars recovered from deer mortalities or slippage in 1994 were re-issued during the 1995 trapping season. All trapping, handling, and marking procedures were reviewed and approved by the All-University Committee on Animal Use and Care (AUF # 01/94-024-01).

Radio telemetry

Radio collared deer were located using a hand-held receiver (Lotek Inc. Ontario, Canada) and a two (Telonics Inc. Mesa, Ariz.) or three (Advanced Telemetry Systems Isanti, Minn.) element Yagi antenna. Collared deer were located at least twice a week from the time of capture until collar failure or death. The location period began in February, 1994 and continued through mid-December, 1996. Locations were stratified across three 8-hour sampling periods (0800-1559, 1600-2359, 0000-0759 hours) because deer activity and habitat use patterns vary throughout the day (Montgomery 1963, Larson et al. 1978, Beier and McCullough 1990).

Location data were gathered by recording two or more azimuths for each deer from known map locations. Whenever possible, azimuths considered to be erroneous due to signal bounce were corrected in the field. An azimuth standard deviation was determined for all personnel performing radio telemetry. Locations were plotted using LOCATE II (Pacer, Truro, Nova Scotia). Confidence ellipses were estimated for locations with two or more azimuths (Nams 1990) using the maximum likelihood estimator procedures of LOCATE II and the mean azimuth standard deviation. Locations with 95% confidence ellipses greater than 200 hectares (ha), were determined to be unreliable or incorrect and were eliminated from data analysis (White and Garrott 1990).

Migration, home range, and habitat use

The initiation date, direction, destination, and distance of seasonal migrations were analyzed for radio collared deer. In addition, reliable movement information on three ear-tagged deer was known and included in analyses of collared deer migration. Deer were considered migratory if their winter and summer ranges did not overlap and were greater than 1 km apart. Migration distance for each deer was measured as the distance between centers of activity of seasonal ranges. Destination of seasonal migrations was categorized as agricultural land or non-agricultural, forested land. The start of migration for an individual was the day it left its current seasonal range and began movement toward its reciprocal seasonal range. If a deer was not located on the day it began migrating, the day half way between its last known location on its current range, and its first location on its reciprocal range was assigned. Transitional migratory locations were not included in either seasonal home range. The time period when most deer migrations occurred was considered the peak period. Seasonal migration dates were compared between years using the Kolmogorov-Smirnov test (Sokal and Rohlf 1995). Migration distances of deer were compared by sex and destination category using the Wilcoxin-Mann-Whitney test (Siegel and Castellan 1988). Significance for these and all other statistical tests was set at 0.05.

Home ranges of collared deer were determined using the harmonic mean method of Dixon and Chapman (1980) with 20 grids specified. The 95% contour was used to eliminate outliers in calculating size and harmonic mean center of activity for each deer using Telem88 software (Department of Wildlife Ecology, University of Wisconsin). The minimum number of locations (5) required to estimate home range size by Telem88 was not thought to adequately represent deer home ranges, therefore home ranges were only calculated for deer having 10 or more radio-locations. Traditional use, or fidelity to seasonal ranges, was analyzed for deer that were radio-tracked for longer than one year. Range use was considered traditional if an individual's seasonal ranges overlapped in successive years. Home range size was compared between years, seasons, migratory groups, migratory destinations, and sexes using analysis of variance models (SAS Institute 1985). Normality was tested using the (studentized range) w/s test (Kanji 1993) and Bartlett's test for homogeneity of variances (Sokal and Rohlf 1995) was used to test for equal variances. Home range size is not dependent upon year (correlation coefficient = 0.031, $P > 0.50$) therefore, yearly samples were considered independent.

Pairwise comparisons of seasonal ranges of individual migratory deer were made using the Wilcoxin signed-ranks test (Sokal and Rohlf 1995).

Habitat use was derived from deer locations. Deer locations were converted to point coverages using the geographic information system PC ARC/INFO (ESRI Redlands, Calif.). Base land coverages of PC ARC/INFO were digitized by MDNR personnel from 1978 aerial photographs and designated as Michigan Inventory Resource System (MIRIS) categories. Deer locations were assigned a MIRIS code upon intersection of point coverages with base coverages within PC ARC/INFO. The MIRIS code designation was also used to record cover type from visual observations of tagged or radio-collared deer.

Due to the age of PC ARC/INFO base land coverages, habitat type of all deer locations was ground truthed in the summer of 1995. Aerial and ground surveys were conducted to identify changes in habitat occurring since 1978. Boundary coordinates of altered habitats were delineated and used to ground truth future locations.

Determination of habitat use can be biased by large telemetry confidence ellipses (White and Garrott 1986, Nams 1989). Therefore, potential bias was estimated by comparing mean telemetry error, determined from deer locations, with mean habitat patch size, computed from sampling all habitat patches within three randomly selected townships where radio collared deer were located.

Habitat selection was determined using deer home ranges and PC ARC/INFO. Deer home ranges were positioned on habitat base maps using centers of activity and 95% contours, determined from Telem88. The areas of various habitat types composing an individual's seasonal range were calculated using PC ARC/INFO. The null hypothesis of random use of habitats was tested for each deer using a Chi square goodness of fit test comparing an individual's proportional use of habitats (as determined from locations) with the proportional availability of those habitats within its home range. Random habitat use was also tested within an extended home range (an area 1.5 times as large as the individual's home range) to compensate for potential underestimation of deer home range sizes. Comparisons were made on individual deer since deer had different habitats available to them. General trends in habitat use patterns were determined by analyzing selection (use greater than expected) or avoidance (use less than expected) of habitat types among deer groups. Overall statistical significance of habitat use patterns for each deer group was tested by combining probabilities from independent tests of significance (Sokal and Rohlf 1995).

Habitats were grouped and classified into eight categories; cropland, northern and central hardwoods, lowland hardwoods, aspen and white birch, lowland conifers (primarily northern white cedar, black spruce and tamarack), pine, non-forested openings, and other. The 'other' category is comprised of habitat types that commonly made up 1% - 5% of deer locations (scrub shrub wetland, pasture land, and old meadow). Habitat use was compared among the three daily time periods, and between seasons, years, sexes, migrating and non-migrating deer groups, and deer migrating to agricultural or non-agricultural areas. Significance was tested using the Chi square test for two independent samples (Siegel and Castellan 1988) which assumes independent observations, no expected values equal to zero, and less than 20% of categories with expected values less than five. The experimentwise error rate for each type of comparison was set using the Bonferroni method (Sokal and Rohlf 1995) where the critical value was determined by α divided by the number of comparisons per category.

Population parameters

Abundance

Population size was estimated from mark-recapture data using the CAPTURE program (Department of Fishery and Wildlife Biology, Colorado State University). CAPTURE determined model selection and trapping occasions were defined as three day intervals. The main assumption of this closed population model was that population size remained constant throughout the duration of the study. This assumption was relaxed so that the population was unchanging and no unknown losses occurred during yearly trapping periods (Otis et al. 1978, White et al. 1982). Furthermore, it assumes that no animal marks were lost or unnoticed during the experiment, all animals have constant and equal probability of capture on each capture occasion (Otis et al. 1978), and mortality is equal for marked and unmarked individuals.

Population indices were used to estimate relative differences in population abundance between years (Lancia et al. 1994). Pellet groups counts were used to compare abundance between years and standardized roadside observations were used to compare trends within years.

Overwinter estimates of population size were determined from pellet counts (Bennett et al. 1940, Eberhardt and Van Etten 1956, Neff 1968, Ryel 1971) conducted after snow melt in the spring of each year. In 1994, eighty random points (plots), stratified by habitat type (hardwoods, pine, cedar, open, and aspen), were established in the study area. Plots established in 1994 were used in 1995. At each point, a 1m x 25m transect was sampled for pellet groups in each of the cardinal directions. A count of the number of pellet groups deposited since autumn leaf fall along the four transects at each point was summed. An average number of pellet groups was obtained for each of the five strata.

An estimate of population size (N) is determined for each strata by the following formula (Mooty 1980):

$$\hat{N} = \frac{\overline{X}pg \, * \, (plot\ size)^{-1} \, * \, size\ of\ the\ study\ area}{deposition\ period \, * \, defecation\ rate \, * \, number\ of\ plots}$$

where

$\overline{X}pg$ = average number of pellet groups per plot.

The deposition period represents the average number of days between leaf drop in the previous fall, and sampling date for plots. Defecation rate varies with diet, sex and age (Neff 1968, Ryel 1971, Rogers 1987), but winter, free-ranging deer defecate approximately 13 to 14 groups per day (Neff 1968). A rate of 13.47 groups per day is used by the MDNR for deer in Michigan (H. Hill, MDNR, pers. commun.) and is the value used here. An overall density per county was obtained by weighting deer densities by the percent of each strata per county.

Assumptions for a pellet group based census include: 1) defecation rate is constant and known, 2) pellet groups exist long enough to be counted and are detected and counted accurately, and 3) a deposition period can be delineated and groups can be aged relative to the deposition period (Ryel 1971, Mooty 1980). Differences in pellet-group densities between years were tested using the Wilcoxin-Mann-Whitney test.

Roadside observations of deer were recorded along a 180 km standardized route established in the study area (Appendix Figure 1). The route was designed in a figure eight pattern that encompassed both agricultural and non-agricultural areas throughout the study area. The route was driven beginning two hours before dusk on two consecutive nights from February to December in 1994, and approximately one hour before dusk on three consecutive nights from January to October in 1995. Road surveys were conducted twice a month during summer months (June, July, and August). The direction the route was driven (north to south, or south to north) was alternated on a monthly basis. Routes were not driven on evenings when poor weather such as rain, blizzards, thunderstorms, or high winds were likely due to possible effects on deer behavior (Zagata and Haugen 1974, Gladfelter 1980). Total number of deer seen was recorded and deer were classified into sex and age categories (adult and sub-adult) during months when they were discernible (Downing et al. 1977). Deer of unknown sex or age were also recorded and included in total counts.

Roadside observations were originally intended to be an index of abundance, however, the driving procedure was altered in the second year to facilitate obtaining more accurate age and sex ratios. Therefore, monthly counts were used to indicate trends in population fluctuation within years.

Survival

Radio telemetry allows for direct estimation of survival patterns by providing information on the timing of mortality. The Mayfield survival estimator (Mayfield 1961, 1975) was used to estimate survival patterns of radio collared deer. A staggered entry approach whereby exposure days accumulate as new individuals are added (similar to the Kaplan-Meier product limit estimator staggered entry design discussed by Pollock et al. 1989) was used. The estimator requires that newly added animals have the same survival probability up to entering the study as previously added animals. In addition, it assumes that animals were sampled randomly, survival events are independent and constant across animals and periods, capturing and radio collaring have no impact on future survival of the animal, and censoring of animals (individuals with unknown fates) is independent of deaths.

When a radio signal became lost, ground searches were made in increasingly larger concentric circles around the last known location in attempts to locate it. Following this, a fixed wing aircraft was employed to search for the lost signal on several occasions before the individual was classified as censored.

Annual and period survival rates, with 95% confidence intervals, were determined for collared deer in three categories; adults, yearlings, (deer born in that calendar year) and both age classes combined, due to differential survival of yearlings and adults reported by Nelson and Mech (1986) and Fuller (1990). Three periods were established in which survival of deer was considered to be constant (Fuller 1990); the winter or post-harvest interval (from January 1 through April 15) encompasses the period of high overwinter mortality due to starvation (Fuller 1990) and predation (Nelson and Mech 1986), the summer or pre-harvest interval (April 16 through September 30), and harvest period (October 1 through December 31) which includes all hunting seasons in Michigan. Additional survival information was gathered from the observed mortality of six ear-tagged deer. Survival rates were compared between years, age classes, and periods. Chi square 2 X 2 contingency tables and the Bonferroni method (described above in the habitat use section) were used to determine significant differences.

Causes of mortality for radio collared deer that died during the course of the study were determined whenever possible. Carcasses were located and closely inspected upon detection of mortality. Sources of mortalities were classified into seven categories; natural mortality (including predation, disease and drowning), legal and illegal harvest, road kill, starvation, crop permit harvest, and unknown causes.

Predation was considered the cause of mortality when there were signs of a chase (blood and hair trail) and tooth punctures on the neck and throat (Ozoga and Harger 1966, Messier and Barrette 1985). Coyote and domestic dog (*Canis familiaris*) predation were combined since they were not reliably distinguishable despite differences in hunting behaviors (Lowry and McArthur 1978). Condition of the femur marrow, in conjunction with amount of fat on the mesentery and other connective tissues, were used as indicators of malnutrition (Verme and Ullrey 1984, B. Odum, MDNR, pers. commun.). Mortality of collared deer found in the winter or spring that showed signs of predation and malnutrition were classified as unknown to avoid erroneous inflation of either category.

Productivity

Adult radio-collared does were repeatedly observed throughout the fawning period (late May - end of June) in each year to estimate productivity. Does that produced fawns were observed again in late August to estimate fall-recruitment fawn to doe ratios (Dusek et al. 1989). Based on the results of a previous study (Hamlin et al. 1982), it was assumed that productivity of does was not affected by trapping and handling.

Estimates of productivity were also calculated from deer counts recorded along monthly road surveys (see the above section on abundance). Deer were classified into age categories (adult and sub-adult) during months when fawns and does were easily discernible to determine fawn to doe ratios (Downing et al. 1977). Counts during late summer and early fall surveys were used to estimate productivity and late fall surveys were used to estimate fall-recruitment fawn to doe ratios. In addition, doe counts were decreased by 10% (to allow for possible inflation of counts from small-antlered bucks) and "adjusted" ratios were estimated.

Incidental observations of does with fawns recorded during the summer months of each year were used to supplement productivity estimates. Fawn to doe ratios of the captured deer were used to supplement fall recruitment ratios determined from road surveys. The Wilcoxin-Mann-Whitney test was used to test for significant differences in ratios between years.

Sex ratio and age structure

Sex ratios were estimated from the observed counts of male and female deer recorded on monthly road surveys during months when both sexes were considered equally observable (Downing et al. 1977). Adjusted ratios (see above) were also calculated from deer counts. The Wilcoxin-Mann-Whitney test was used to test for significant differences in ratios between years. The ratios of the captured deer were used to supplement sex ratio data.

Age structure was determined from the age composition of the trapped deer. Captured deer were classified into five age categories for age structure calculations; fawns (less than one year old), yearlings (one year old), 2 - 3 year-olds, 4 - 5 years-olds, and older than six years. Age classes were combined to reduce the impact of incorrect age determination on age structure estimates. Age or sex biases inherent in single animal capture traps (Garrott and White 1982) may introduce bias into sampled populations, therefore, analyses using these data were considered cautiously. Age composition data gathered from harvested deer at a deer check station (centrally located within the study area) and road killed deer encountered in the study area during the study were compared to the age composition of trapped deer. No statistical comparisons of age structure data were made because of the biases inherent in their collection.

RESULTS

Over the two years of the study, twenty-three winter traps sites were established (Figure 2). Deer were ear-tagged or radio collared at 14 out of 16 traps in 1994 and 11 out of 17 traps in 1995 (Appendix Table 1). Captures totaled 190 deer during the two years; 117 different individuals, and 73 recaptures. Ten deer were not marked due to mortalities, or potential injuries. Thus, 107 of the trapped deer were marked with radio collars or ear-tags. Radio collars were distributed to 73 deer and 34 additional deer were ear-tagged during the two years of the study (Table 1). In addition, eight newborn fawns (four males, four females) were ear-tagged during the two years.

Winter trapping success increased from approximately 33% in 1994 to approximately 47% in 1995 (Appendix Table 2). Trapping mortality was minor during both 1994 (3.7%, N = 4) and 1995 (1.2%, N = 1). Summer trapping resulted in no captures in 1994 and was not attempted in 1995.

During the study period, 4,172 locations were collected for radio collared deer. Most locations (72.9%) were gathered during the first time period (0800 - 1600 hours) of the day (Appendix Table 3) and deer were located approximately twice as often during summer months (Appendix Table 4). The average number of locations obtained

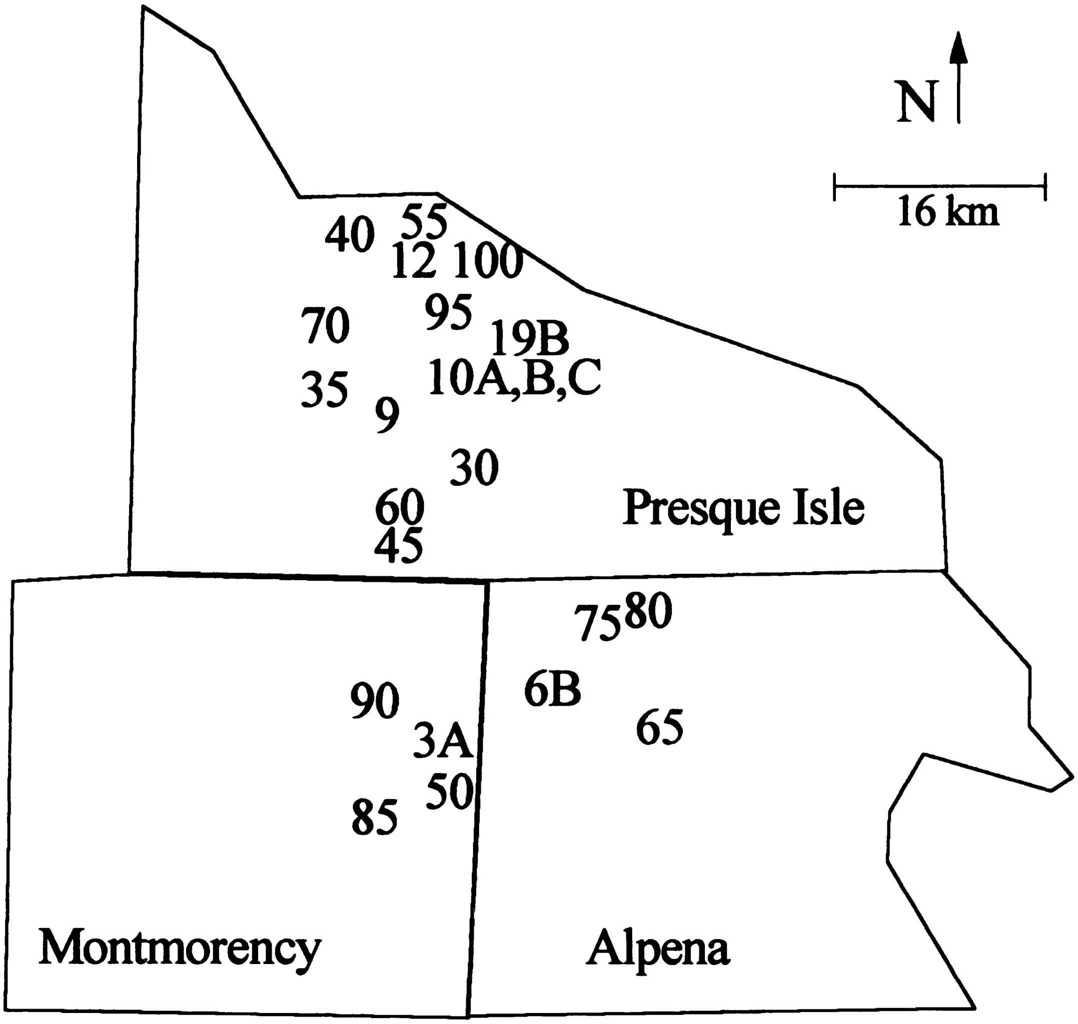


Figure 2. Distribution of traps across study area with numbers indicating individual trap location. Trap designations refer to numbers listed inAppendix Table 1.

Table 1. Age and sex of deer marked in Presque Isle (PI), Montmorency (M), and Alpena (A) counties in 1994 and 1995. Table entries represent number of collared deer and numbers in parenthesis represent number of ear-tagged deer.

		Female			Male			
Year	County	Adult	Yearling	Fawn	Adult	Yearling	Fawn	Total
1994								
	PI	15	1	11 (6)	0	1	11 (4)	39 (10)
	M	0	1	2	0	0	1	4
	A	0	1	0	0	0	0	1
1995								
	PI	2 (5)	0	4 (6)	0	2	5 (4)	13 (15)
	M	4 (1)	0	1 (2)	0	0	3	8 (3)
	A	2	0 (1)	1 (3)	0	0	5 (2)	8 (6)
Total		23 (6)	3 (1)	19 (17)	0	3	25 (10)	73 (34)

for deer surviving longer than 30 days was 75 with a standard error (SE) of 0.81 (N = 54). The mean 95% confidence ellipse area of triangulated deer locations was 37.2 ha (SE = 0.02 ha). The mean azimuth standard deviation for triangulation was 9.4 °.

Migration

Most of the collared deer (67.5%) in 1994, and approximately half (48.8%) of the collared deer in 1995 made spring migrations (Table 2). In addition, three ear-tagged deer were sighted or harvested from 2 to 7 km from where they were trapped in 1995 and were considered migratory. Spring migrations for collared deer began approximately two weeks later in 1994 than in 1995 (Figure 3). The Kolmogorov-Smirnov test determined that the distribution of spring migration dates differed between the two years ($P < 0.01$). The median date for the last day on winter ranges was April 8 ($N = 27$) in 1994 and March 27 ($N = 22$) in 1995. Most migratory collared deer (>80%) left winter ranges before May 1st in both years. Generally, spring migrations were either in a northwestern or southwestern direction during both years (Figure 4, Figure 5).

The average migration distance of collared or tagged deer in 1994 was not significantly different (Wilcoxin-Mann-Whitney z value (z_{WMW}) = - 0.424, $P = 0.337$) from the 1995 distance (Figure 6). Males tended to travel greater distances between winter and summer ranges than females, however, distances were not significantly different in either year (Table 3).

More than half of spring migrating collared deer migrated to non-agricultural,

Table 2. Migratory status of collared deer by sex and age category for spring 1994 and 1995. Numbers in parenthesis indicate deer collared in 1994.

		Male			Female			
Year	Classification	Adult	Yearling	Fawn	Adult	Yearling	Fawn	Total
1994	Migratory	0	1	10	9	1	6	27
	Non-migratory	0	0	1	5	2	5	13
1995	Migratory	0	(2)	4	2 (7)	(2)	3	20
	Non-migratory	(1)	2	5	4 (5)	(2)	2	21
	Total	1	5	20	32	7	16	81

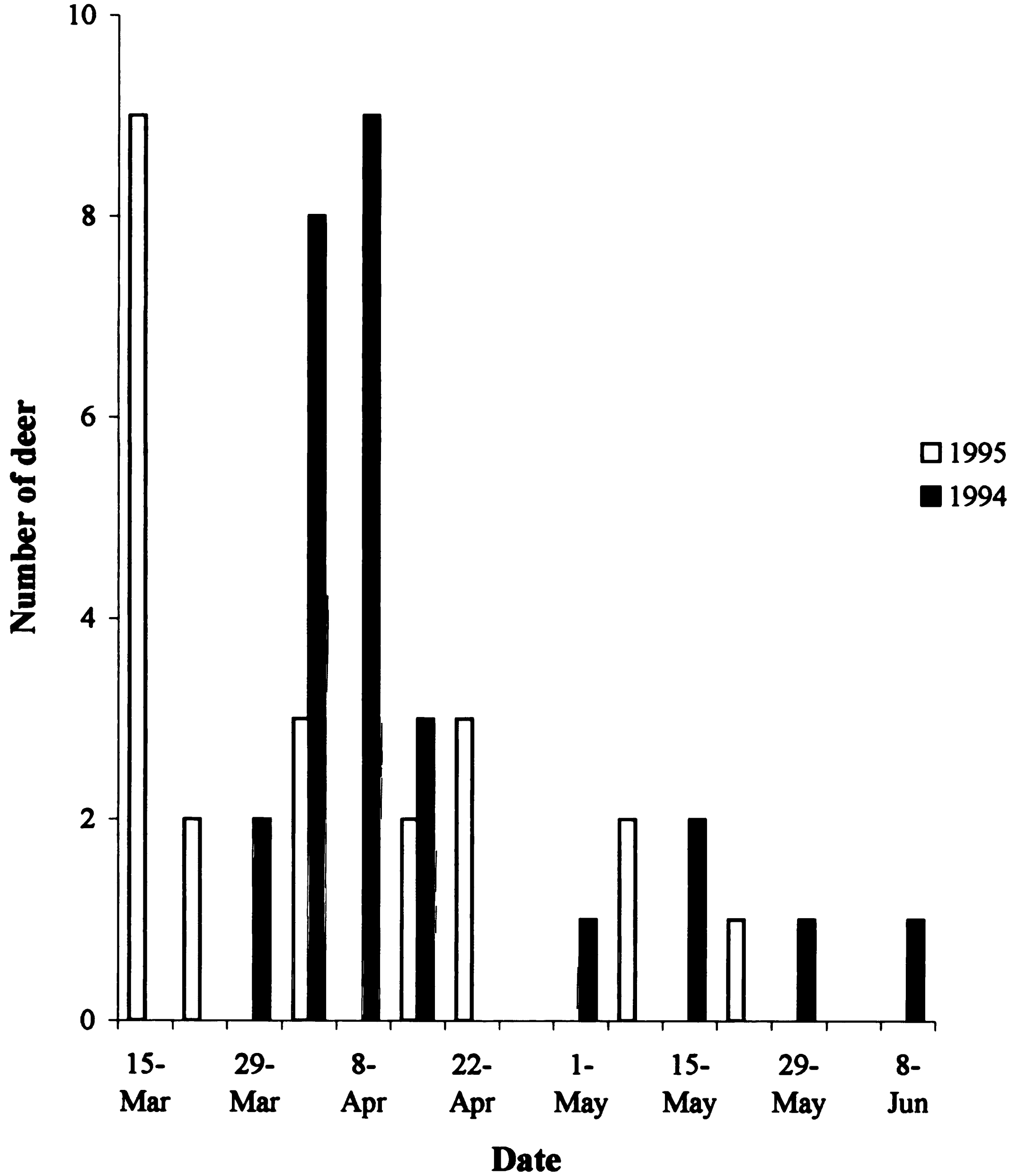


Figure 3. Initiation of spring migration for collared deer in 1994 and 1995.

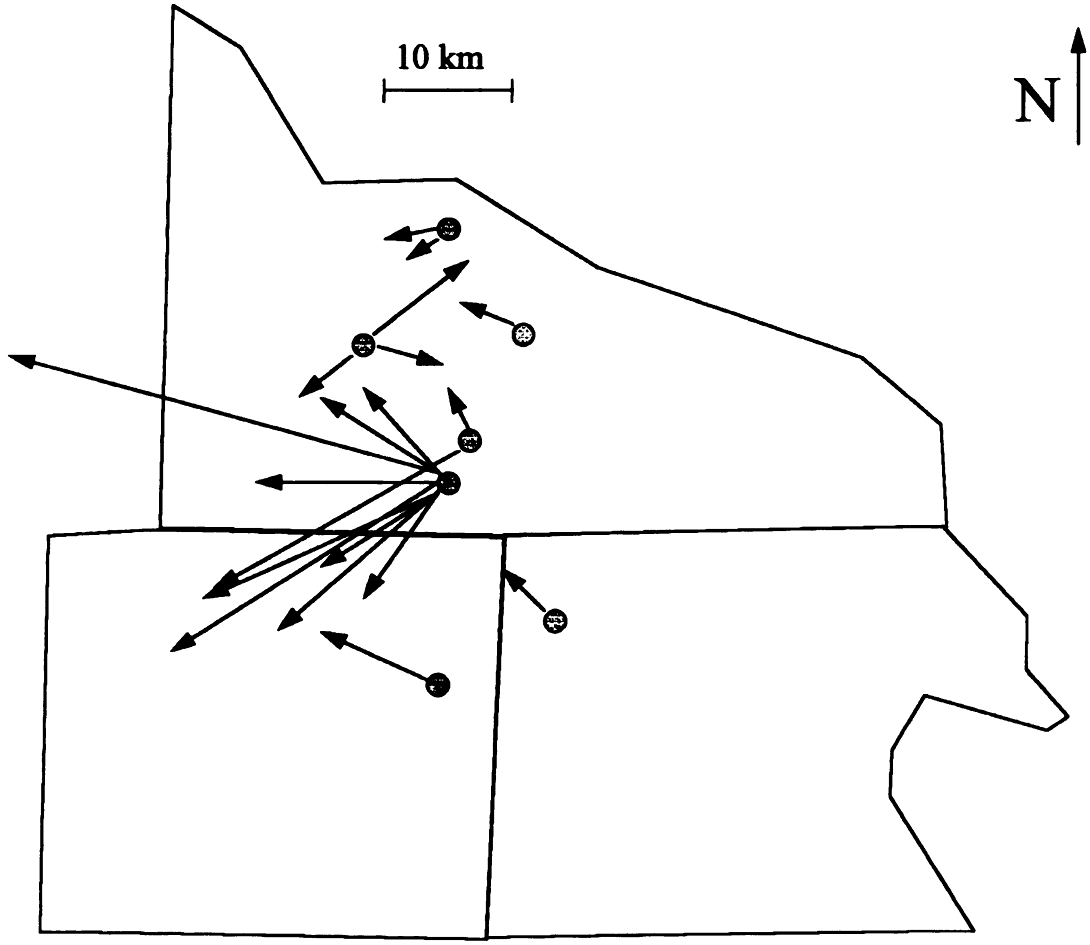


Figure 4. Distance and direction of spring migrations of collared deer in 1994. Circles represent trapping location and arrows represent movements for one or more deer.

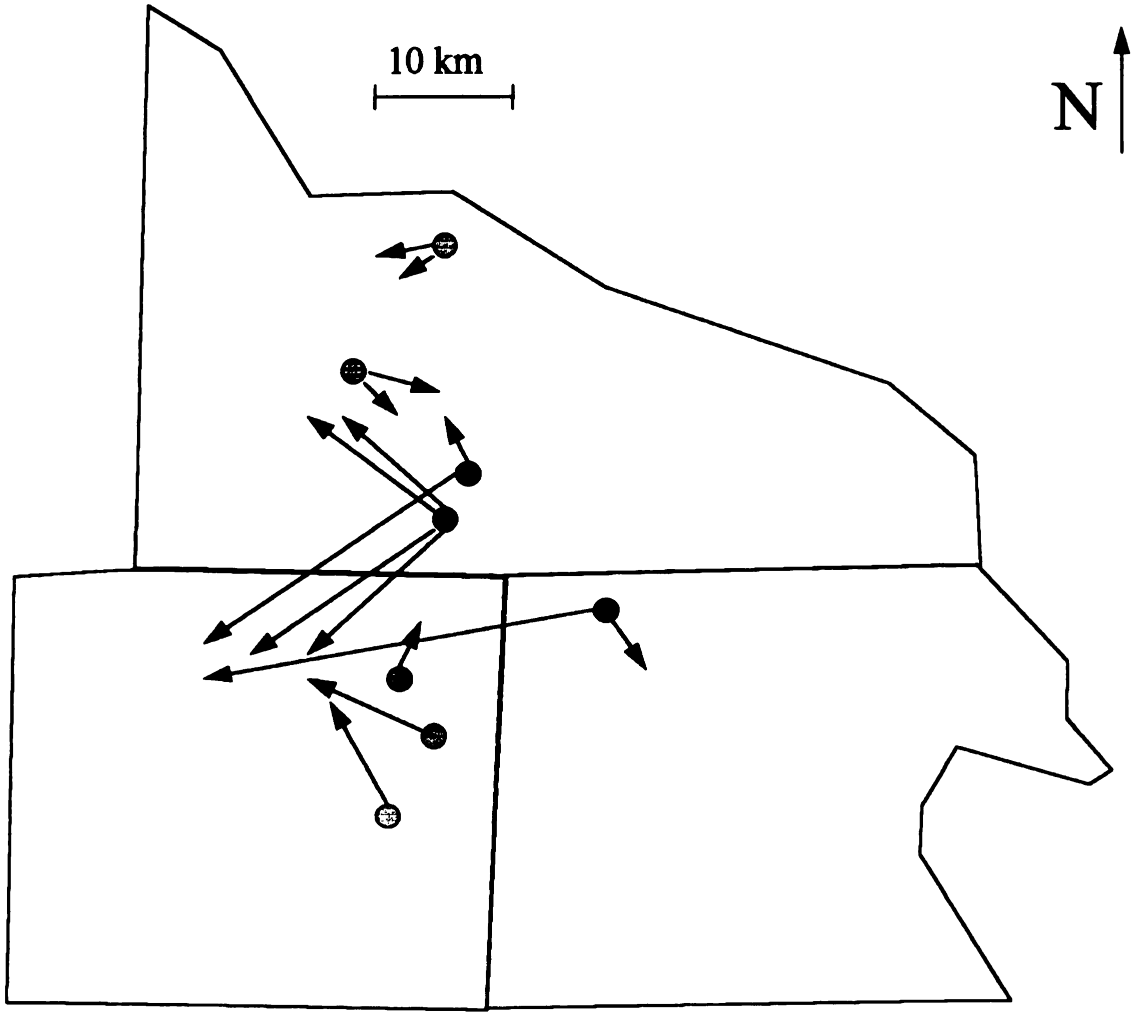


Figure 5. Distance and direction of spring migrations of collared deer in 1995. Circles represent trapping location and arrows represent movements for one or more deer.

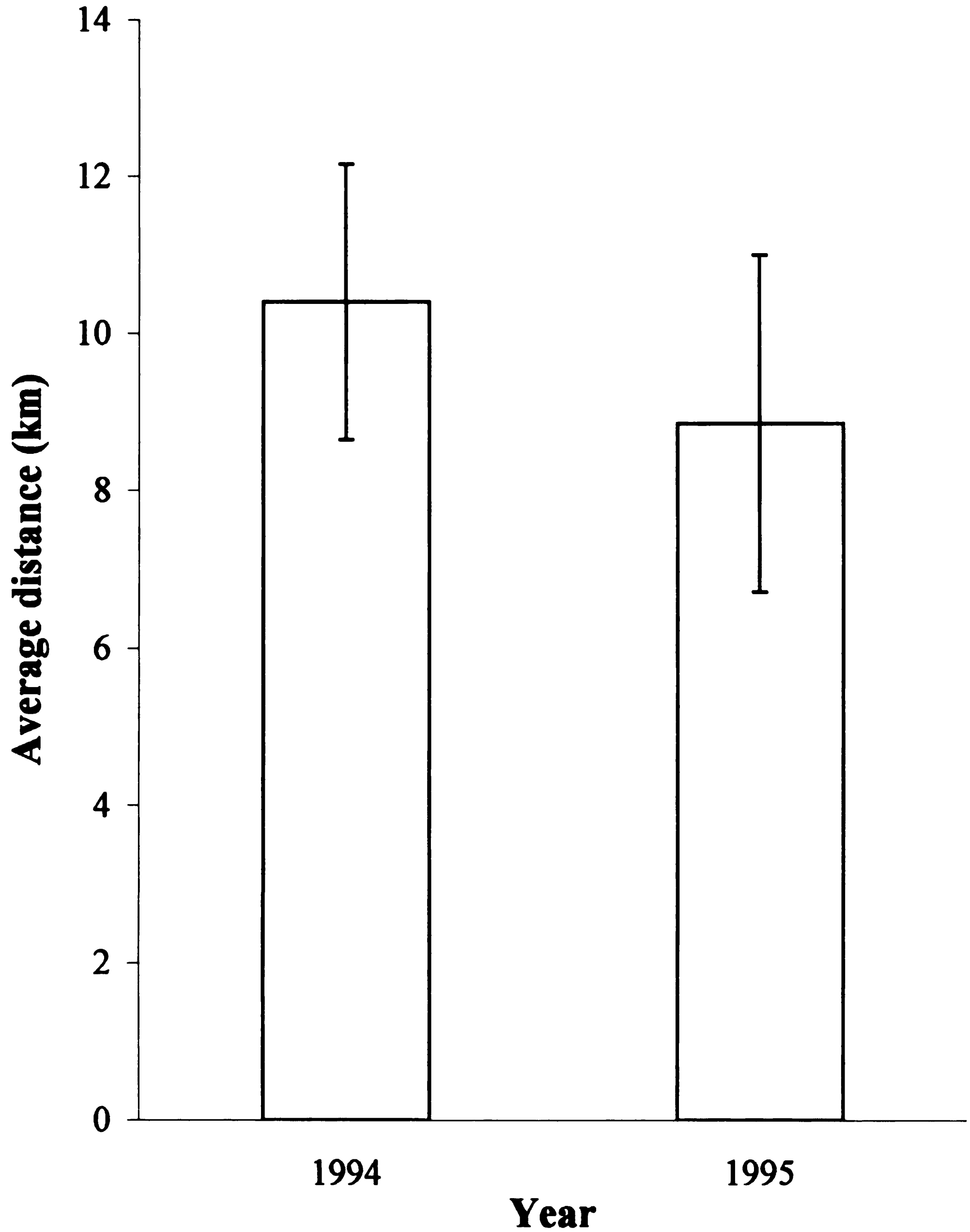


Figure 6. Average spring migration distance of collared and tagged deer in 1994 and 1995. Error bars represent one standard error.

Table 3. Average migration distances (km) of collared and tagged deer by sex in 1994 and 1995.

	Males			Females			P value[a]
	$\bar{x}$	SE	n	$\bar{x}$	SE	n	
1994	13.67	3.25	11	8.05	1.78	16	P = 0.090
1995[b]	11.67	4.65	6	7.91	2.11	6	P = 0.999

[a] Wilcoxin-Mann-Whitney
[b] includes deer collared in 1995 only

forested lands in 1994 and 1995. The remainder of the migratory deer established summer ranges in neighboring agricultural areas (Figure 7). Deer that migrated to non-agricultural forested land in the spring traveled greater average distances than deer migrating to agricultural areas in both years (Figure 8), however differences were only significant in 1994 ($z_{WMW} = 3.74$, $P < 0.0001$).

The median last day on summer ranges was November 29 (N = 11) in 1994 and November 19 (N = 12) in 1995 (Figure 9). In addition, a deer ear-tagged in 1995 was known to return to its winter range by November 22. The Kolmogorov-Smirnov test determined that the distributions of 1994 and 1995 fall migration dates were not significantly different ($P > 0.05$). The sample size of fall migrating deer was small in both years because many collared deer died during the summer and early fall. The majority of collared deer that migrated back to winter ranges in the fall were females (Table 4) because most collared males were harvested during the bow or firearm hunting seasons, prior to fall migration.

Home range

Non-migratory deer established yearly home ranges in agricultural areas. The average home range size of non-migratory deer was larger than for migratory deer in both 1994 and 1995. Likewise, females had average home range sizes greater than male home ranges during 1994 (Table 5). However, analysis of variance model results of home range size indicated no significant interactions or differences between years, migratory status of deer, or sex (Table 6).

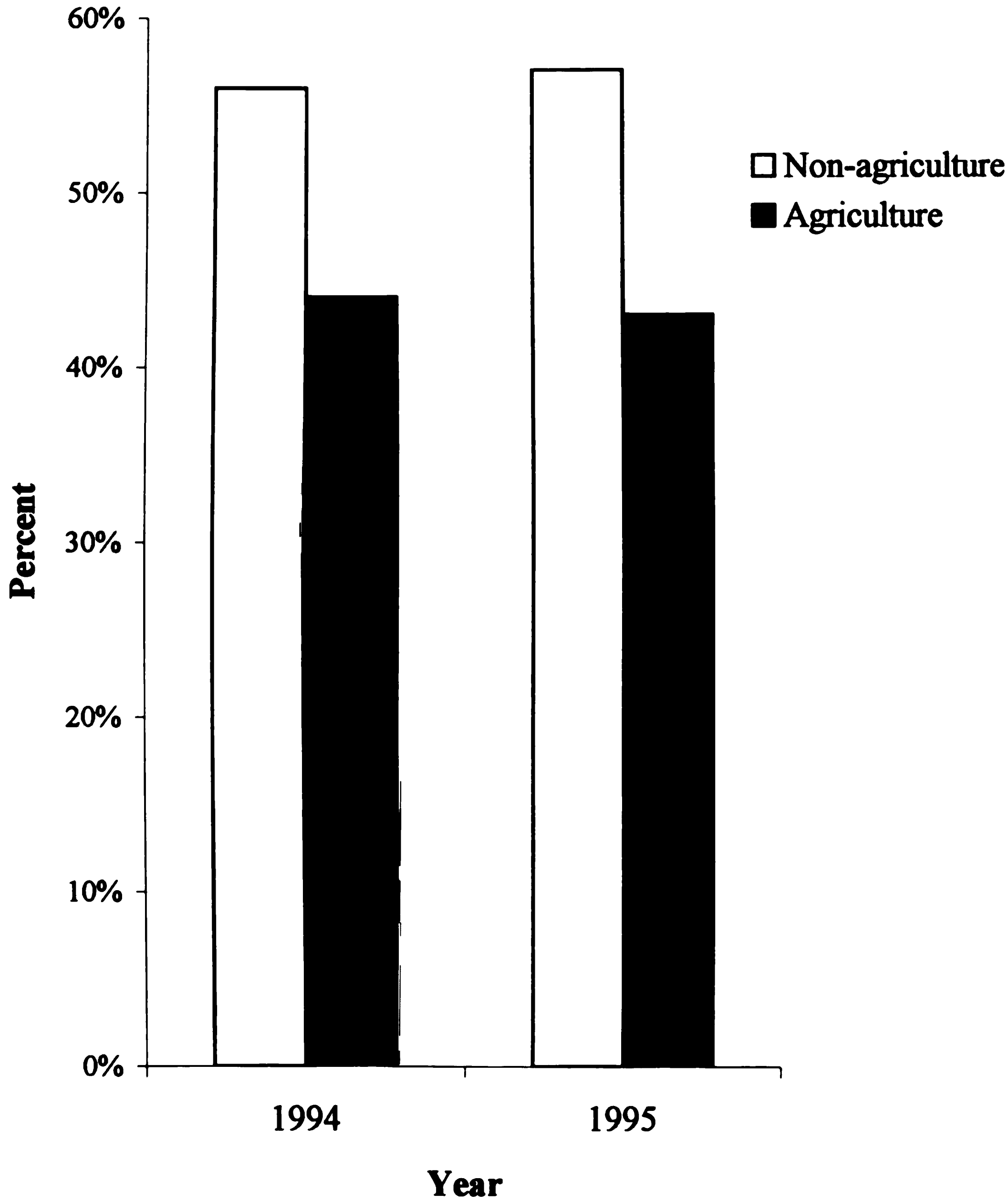


Figure 7. Destination of spring migrating collared and tagged deer in 1994 and 1995.

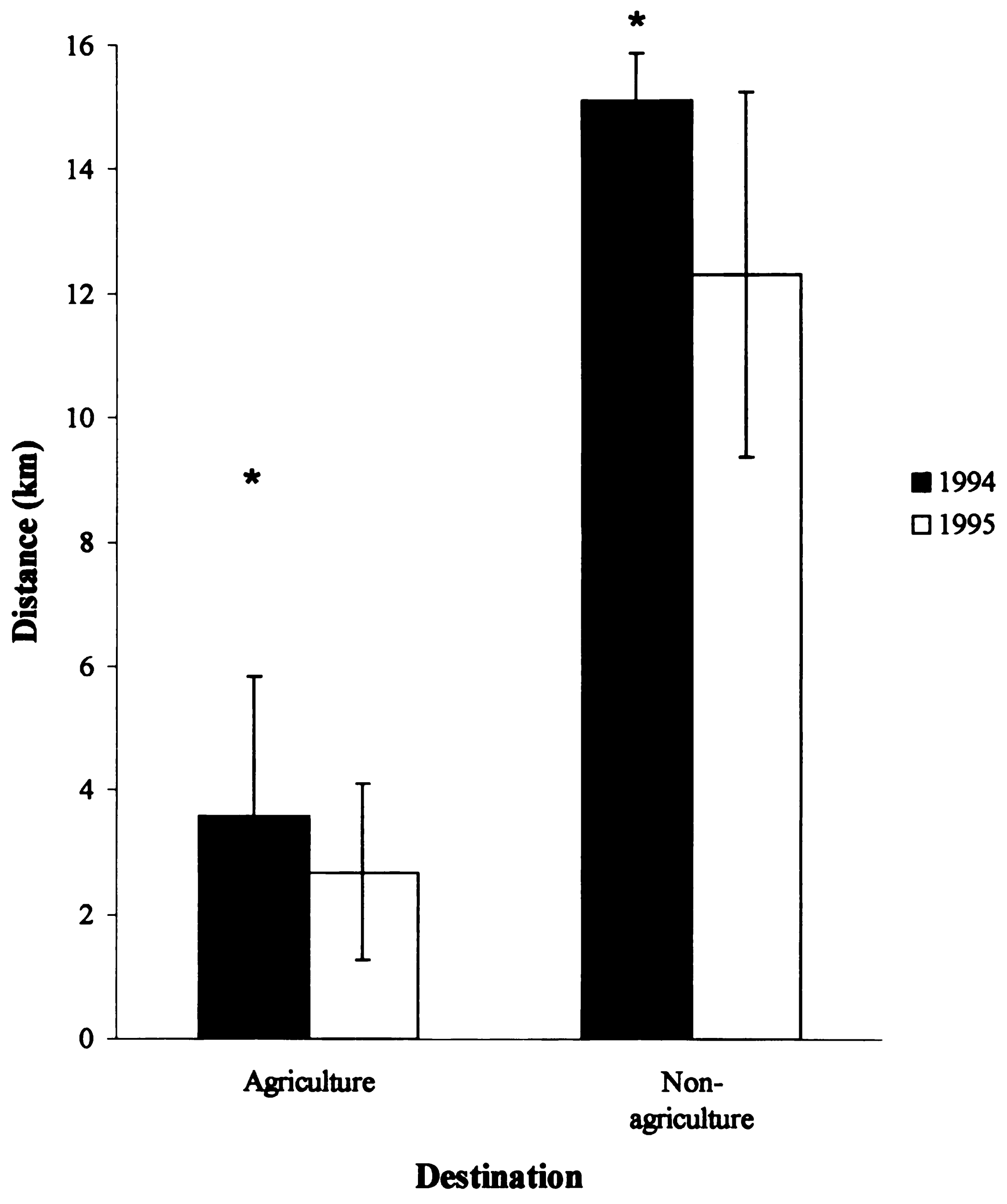


Figure 8. Average distances of spring deer migration (error bars represent one standard error) to agricultural and non-agricultural land in 1994 and 1995. Asterisks indicate significant differences in destination migration distance within years.

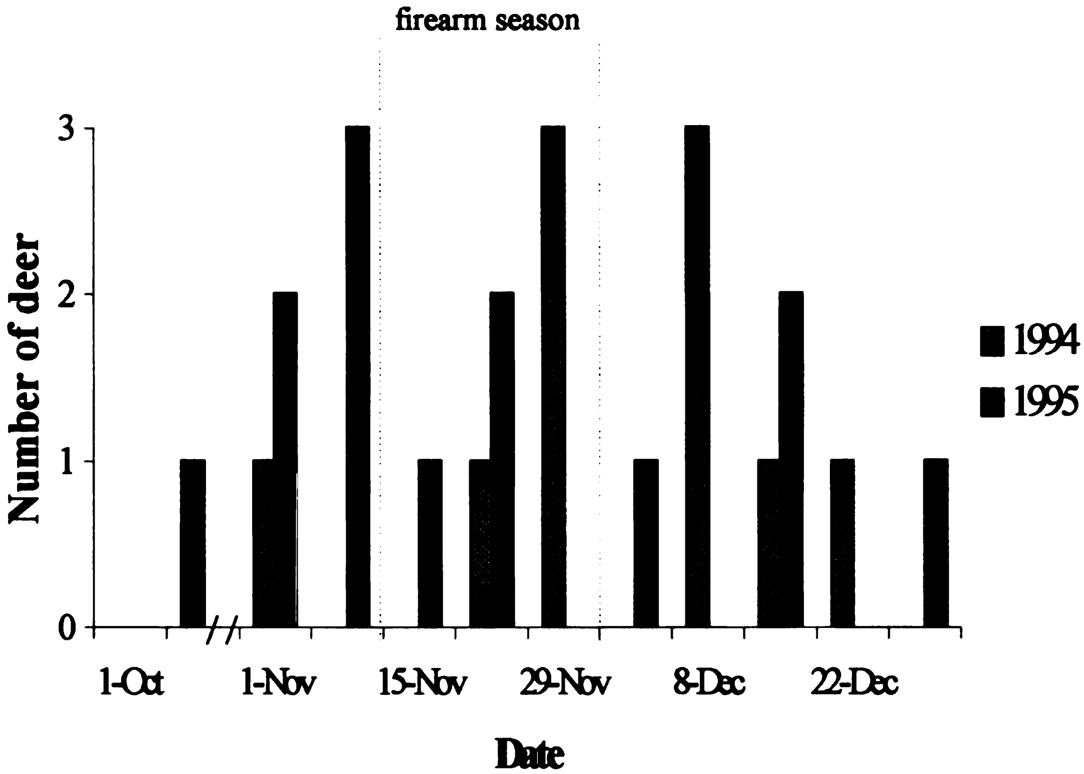


Figure 9. Initiation of fall migration for collared deer in 1994 and 1995.

Table 4. Sex and age classification of fall migrating collared deer in 1994 and 1995.

Year	Age category	Male	Female	Total
1994	Adult	1	7	8
	Yearling	2	2	4
1995[a]	Adult	0	10	10
	Yearling	0	1	1
Total		3	20	23

[a] includes deer collared in both years.

Table 5. Average home range size (ha) of collared deer in 1994 and 1995.

	1994				1995			
Classification	Average (ha)	SE	N	Range	Average (ha)	SE	N	Range
Migratory	302.8	30.7	27	52.4-774.4	336.6	36.6	28	80.6-771.9
Non-migratory	424.0	26.1	12	292.3-579.3	355.8	36.8	23	50.2-667.1
Male	293.3	38.0	12	52.4-468.9	340.7	30.1	16	31.1-771.9
Female	367.9	33.5	28	71.8-833.0	335.7	57.3	39	30.8-764.9
Migratory-winter	201.8	64.1	4	75.3-316.0	353.6	56.5	9	164.0-657
Migratory-summer	336.9	32.9	22	71.8-774.4	328.6	47.8	19	80.6-771.9
Migratory-agriculture	264.2	46.1	16	52.4-316.0	296.0	44.2	15	105.1-657
Migratory- non-agriculture	354.3	30.4	12	179.0-474.7	383.6	59.5	13	80.6-771.9

Table 6. Analysis of variance results of main effects and interactions of home range size by year, migratory status[a], and sex.

		df	F value	P value
Main Effects				
	Year	1	0.00	0.9566
	Migratory status	1	0.69	0.4074
	Sex	1	1.37	0.8016
Interaction				
	Year x Migratory status	1	0.06	0.2454
	Year x Sex	1	0.1	0.4772
	Migratory status x Sex	1	1.00	0.3213
	Year x Migratory status x Sex	1	0.27	0.6044

[a] migratory or non-migratory

Migratory deer tended to have smaller winter ranges than summer ranges in 1994. In 1995, the average size of migratory deer winter ranges was larger than summer ranges (Table 5). Furthermore, deer migrating to non-agricultural, forested regions established larger home ranges than deer migrating to agricultural areas during both years. However, these differences were not significant and no significant interactions were detected for home range sizes of migratory deer between seasons or migratory destinations (Table 7). In addition, there were no significant interactions between year and season (df = 1, F = 2.34, P = 0.1322). However, pairwise comparisons of seasonal ranges of individual deer in 1994 resulted in 72.7% (N = 11) of evaluated deer having smaller winter than summer ranges. The Wilcoxin signed-ranks test determined 1994 seasonal ranges to be significantly different from each other (P = 0.0332). However, while 72.7% (N = 11) of individuals in 1995 had larger winter ranges, seasonal ranges were not significantly different (P = 0.2060).

Approximately 49% (N=18) of migratory radio collared deer survived to be evaluated for traditional use of seasonal ranges. Winter ranges in successive years overlapped for 72.2% (N=13) of the evaluated deer, indicating traditional use. In addition, one ear-tagged deer, known to be migratory, used the same winter range in successive years. Four collared yearlings (three males and one female) did not return to winter ranges in 1995; two remained on summer ranges established as fawns and two migrated part of the return distance. Furthermore, one adult female collared in 1994, wintered 19

Table 7. Analysis of variance results of main effects and interactions of home range size by season and migratory destination[a] of deer.

	Category	df	F value	P value
Main Effect				
	Season	1	0.85	0.3614
	Migratory destination	1	0.38	0.5840
Interaction				
	Season x Migratory destination	1	2.25	0.1394

[a] agricultural or non-agricultural (forested)

km beyond her original winter range in the following year. Thirteen collared deer were evaluated for traditional summer range use. Traditional summer range use was higher (92.3%) than for winter ranges with all but one adult male returning to the same summer range in successive years.

Habitat use

Habitat use was significantly different across sampling periods of the day (df = 14 $\chi^2 = 89.7$, $P < 0.002$). Unequal sampling intensity among periods resulted in under-estimation of cropland use during the night period (0000 - 0759 hours) (Appendix Table 5). Therefore, a random sub-sample of 400 deer locations taken within each time period was used to make habitat use comparisons. Habitat categories in several of the individual comparisons had to be combined to meet the assumptions of the Chi square test, thus reducing the degrees of freedom. Most of these combinations involved pooling cedar and pine categories or 'other' with lowland hardwoods or cropland categories. Table 8 lists the percent of deer locations in each habitat type by sampling period of the day, season, migratory status and destination, and sex.

The habitat use patterns of all deer pooled were significantly different between years. Seasonal habitat use was not significantly different at $\alpha = 0.05$ however, differences were significant at $\alpha = 0.10$ (Table 9). Differences in use patterns were significant between years for non-migratory deer, and between migratory and non-migratory deer in 1994 (Table 9). While there were differences in habitat use patterns of migratory and non-migratory deer in 1995, they were not statistically significant (P =

Table 8. Percent of deer locations within each habitat type by sampling period [a], season, migratory status, migratory destination[b], and sex in 1994 and 1995.

			Habitat types							
Yr	Category		Agri.	Open	Upl. Hdwd	Asp/Bir	Lowl. Hdwd	Pine	Cedar	Other
94	Sampling period	Day	14.4	5.0	15.0	32.8	9.4	2.8	13.3	7.2
		Evening	13.7	6.1	21.7	33.5	6.1	3.8	9.9	5.2
		Night	24.3	8.4	18.2	29.0	2.8	3.7	9.8	3.7
	Season									
		Winter	20.0	7.2	12.8	28.8	10.4	0.8	16.0	4.0
		Summer	17.0	6.4	20.0	32.4	4.8	4.2	9.6	5.6
	Migr. status									
		Migratory	16.6	5.2	18.4	35.8	6.2	5.2	9.8	2.8
		Non-migrat	19.5	9.1	18.6	24.5	5.5	0.5	12.7	9.5
	Destination									
		Non-agric.	0.9	2.4	18.0	55.3	4.4	7.8	10.2	0.9
		Agric.	34.4	8.3	18.9	13.3	8.3	2.2	9.4	5.0
	Sex									
		Male	5.4	4.3	18.5	42.4	4.3	8.7	15.2	1.1
		Female	23.0	7.6	18.5	27.0	6.6	1.2	9.0	7.1
95	Sampling period	Day	8.2	7.7	15.5	30.0	11.4	4.1	19.5	3.6
		Evening	10.6	4.3	21.8	33.0	4.8	1.6	20.7	3.2
		Night	17.9	7.1	21.2	26.6	10.9	1.6	12.5	2.2
	Season									
		Winter	12.2	6.1	18.9	34.4	5.6	2.2	2.8	17.8
		Summer	12.3	6.8	20.7	29.0	11.1	2.8	14.1	3.8

Table 8 (cont'd).

Yr	Category		Habitat types Agri.	Open	Upl. Hdwd	Asp/Bir	Lowl. Hdwd	Pine	Cedar	Other
	Migr. status									
		Migratory	10.8	6.4	22.4	28.8	9.2	3.7	14.2	4.4
		Non-migrat	13.0	6.4	16.1	30.8	9.0	1.3	21.1	2.3
	Destination									
		Non-agric.	1.9	2.6	20.9	37.9	7.2	5.9	19.0	4.6
		Agric.	22.1	11.5	19.8	19.1	12.2	0.8	9.9	4.6
	Sex									
		Male	4.3	5.6	14.3	33.5	9.9	4.3	27.3	0.6
		Female	14.8	6.7	21.0	28.4	8.8	18	14.1	4.4

[a] day = 0800-1559 hours, evening = 1600-2359 hours, night = 0000-0759 hours
[b] winter and summer locations combined

Table 9. Results of Chi square analysis of habitat use of radio collared deer. Asterisks indicate significance.

Type[a]	Comparison	df	Chi Square value	P value
Year	1994 vs. 1995	7	24.11	0.0022*
Season	1994: winter vs. summer	7	16.50	0.0441
	1995: winter vs. summer	7	16.06	0.0505
Migratory status	1994: migratory vs. non-migratory	7	31.64	<0.0001*
	1995: migratory vs. non-migratory	7	13.05	0.1496
	1994 winter: migratory vs. non-migratory	5	10.91	0.1089
	1994 summer: migratory vs. non-migratory	7	35.58	<0.0001*
	1995 winter: migratory vs. non-migratory	5	6.34	0.6736
	1995 summer: migratory vs. non-migratory	7	18.97	0.0173
	Migratory: 1994 vs. 1995[b]	7	19.02	0.0170
	Non-migratory: 1994 vs. 1995[b]	7	35.50	<0.0001*
Migratory destination	1994: agriculture vs. non-agriculture	7	132.50	<0.0001*
	1995: agriculture vs. non-agriculture	7	56.35	<0.0001*
	1995 winter: agriculture vs. non-agriculture	3	6.02	0.2476
	Agriculture: 1994 vs. 1995[b]	3	7.40	0.1265
	Non-agriculture: 1994 vs. 1995[b]	5	14.18	0.0290

Table 9 (cont'd).

Type[a]	Comparison	df	Chi Square value	P value
Sex	1994: male vs. female	7	69.28	<0.0001*
	1995: male vs. female	7	34.39	<0.0001*
	1994 summer: male vs. female	7	68.19	<0.0001*
	1995 winter: male vs. female	5	12.21	0.0678
	1995 summer: male vs. female	6	20.37	0.0047*
	Female: 1994 vs. 1995	7	18.14	0.0241
	Male: 1994 vs. 1995	7	15.69	0.0570

[a] Bonferroni level of significance determined by α / number of comparisons per type (α= 0.05)
[b] includes deer collared in 1995 only

0.1496). Furthermore, no significant differences were detected between seasonal habitat use patterns of migratory and non-migratory deer in either year except for summer 1994 (Table 9).

Deer migrating to agricultural and non-agricultural areas used habitats differently within years but no significant differences in habitat use patterns were detected for either deer group between years (Table 9). Likewise, seasonal habitat use patterns of agricultural and non-agricultural migrating deer were not detected to differ for winter 1995 (sample size for 1994 was insufficient to statistically test). However, summer habitat use patterns of deer migrating to agricultural or non-agricultural areas were inherently different because non-agricultural migrating deer were never located in croplands and deer with home ranges established in agricultural lands were frequently located within crop fields.

Differences in habitat use patterns of male and female collared deer within years were statistically significant, however, habitat use patterns between years for both sexes were not significantly different (Table 9). Seasonally, male and female deer used summer habitats differently in both years, however, 1995 winter habitat use patterns were not significantly different (1994 winter sample sizes were too small to test statistically) (Table 9).

Individual deer habitat use patterns were compared with availability of habitats for 88 yearly or seasonal home ranges during the study. Deer used habitats as expected in 39.77% (N = 35) of comparisons whereas habitat use differed significantly from random selection of available habitats for 60.23% (N = 53) of all comparisons. The test for overall significance of non-random habitat use by all deer was highly significant at P < 0.0001 (Table 10). Within years, 52.63% of comparisons in 1994 (N = 38), and 66.00% of comparisons in 1995 (N = 50), rejected the null hypothesis of random habitat use. Combined probability tests indicated overall statistical significance of non-random habitat use patterns of deer in both years (Table 10). Furthermore, 89.77% (N = 79) of all comparisons between deer use patterns and availability of habitats within the extended home range area concurred with comparison results using the original home range. Results during individual years were similar with 86.84% of extended home range comparisons corresponding with original home range comparisons in 1994 and 92.00% agreeing in 1995. Therefore, only habitat use vs. availability results from original home range comparisons will be presented due to the strong concurrence between extended and original home range comparison results.

Deer home ranges included an average of 6.88 habitat types (SE = 0.11, Range = 4 - 8). Most non-migratory deer (81.3%) used habitats significantly different from their availability while only 48.2% of migratory deer had habitat use patterns significantly different from availability. Furthermore, deer migrating to non-agricultural, forested areas used habitats as expected more frequently (59.3%) than deer migrating to agricultural areas (44.8%). Likewise, deer on winter ranges used habitats randomly more frequently (61.5%) than did deer on summer ranges (48.8%) and female deer tended to select or avoid habitats more regularly (63.5%) than male deer (52.0%). Statistical tests of overall significance concluded that deer used habitats significantly

Table 10. Results of combined probability analysis of habitat use vs. availability comparisons by deer group.

Deer group	Chi square value	df[a]	P < value[b]
All deer	2307.32	174	0.0001
1994: all deer	703.69	74	0.0001
1995: all deer	1603.60	50	0.0001
Non-migratory	1097.32	64	0.0001
Migratory	1210.00	110	0.0001
Migratory - agricultural	739.67	58	0.0001
Migratory - non-agricultural	470.33	54	0.0001
Winter	292.35	26	0.0001
Summer	954.89	84	0.0001
Male	467.75	50	0.0001
Female	1839.57	124	0.0001

[a] degrees of freedom equals 2(# of comparisons)
[b] Chi square combined probability test

different from their availability within each of the above deer groups ($P < 0.0001$ for all groups) (Table 10).

Table 11 lists the percentages of deer, exhibiting non-random habitat use patterns, that selected or avoided various habitat types. All percentages discussed below, in this section, refer to percentages of deer with non-random habitat selection patterns. 'Other' and aspen/birch habitat types were the most frequently selected (35.8% and 26.4% respectively) by all deer. Agricultural land was selected by 18.9% of deer and avoided by 24.5% of deer and cedar was selected or avoided by 35.9% of deer. In addition, aspen/birch types were avoided by 20.8% of deer (Table 11).

Non-migratory and migratory deer both selected 'other' habitat types most frequently. More than half of non-migratory deer (53.9%) selected or avoided aspen/birch and large percentages of non-migratory deer selected or avoided cedar (34.6%), and upland hardwoods (30.8%) (Table 11). In addition, agricultural areas were selected by 18.9% and avoided by 24.5% of non-migratory deer. Migratory deer also selected or avoided aspen/birch (40.7%) and cedar (37.0%) types, however, 44.4% of migratory deer selected openings or lowland hardwoods compared to 26.9% of non-migratory deer. Migratory deer selected agricultural areas 14.8% of the time and avoided agricultural fields 29.6% of the time.

Habitat selection and avoidance patterns were very different between deer migrating to agricultural or non-agricultural habitats. Deer with summer ranges within agricultural areas selected agriculture (50.0%) and 'other' (50.0%) habitat types most often and aspen/birch types with low frequency (12.5%). Deer with summer ranges

Table 11. Percent of deer with non-random habitat use patterns that significantly selected or avoided various habitats within their home ranges.

Deer group (# of comparisons)	Type of use	Habitat type							
		Agriculture	Open	Upl. hdwd	Aspen/birch	Lowl. hdwd	Pine	Cedar	Other[a]
All deer (N = 53)	Selection	18.9	20.8	15.1	26.4	15.1	17.0	18.9	35.8
	Avoidance	24.5	1.9	9.4	20.8	0	3.8	17.0	3.8
Non-migratory (N = 26)	Selection	23.1	19.2	15.4	30.8	7.7	19.2	15.4	42.3
	Avoidance	19.2	3.8	15.4	23.1	0	0	19.2	3.8
Migratory (N = 27)	Selection	14.8	22.2	14.8	22.2	22.2	14.8	22.2	29.6
	Avoidance	29.6	0	3.7	18.5	0	7.4	14.8	3.7
Migratory - agricultural (N = 16)	Selection	50.0	25.0	12.5	12.5	25.0	12.5	18.8	50.0
	Avoidance	18.8	0	6.3	12.5	0	0	18.8	0
Migratory - non-agricultural (N = 10)	Selection	0	20.0	20.0	40.0	20.0	20.0	30.0	0
	Avoidance	0	0	0	30.0	0	20.0	0	10.0
Winter (N = 5)	Selection	40.0	20.0	0	0	0	0	0	60.0
	Avoidance	20.0	0	20.0	0	0	0	60.0	0

Table 11 (cont'd).

Deer group (# of comparisons)	Type of use	Habitat type							
		Agriculture	Open	Upl. hdwd	Aspen/birch	Lowl. hdwd	Pine	Cedar	Other[a]
Summer	Selection	31.8	22.7	22.7	27.3	27.3	18.2	31.8	22.7
	Avoidance	4.5	0	0	27.3	0	9.1	4.5	4.5
Male	Selection	23.1	30.8	23.1	30.8	15.4	15.4	30.8	7.7
	Avoidance	23.1	0	7.7	23.1	0	15.4	0	7.7
Female	Selection	22.5	17.5	12.5	25.0	15.0	17.5	15.0	45.0
	Avoidance	25.0	2.5	10.0	20.0	0	0	22.5	12.5

[a] includes scrub-shrub forested wetlands, non-forested wetlands, pasture land, and old meadow.

established in non-agricultural, forested areas selected aspen/birch habitat types (40.0%) most often and never selected 'other' or agricultural areas (Table 11). In addition, non-agricultural migrating deer selected or avoided pine stands 40.0% of the time while agricultural migrating deer only selected pine 12.5% of the time.

'Other' (60.0%), agriculture (40.0%), and openings (20.0%) were the only habitat types selected by deer in the winter and cedar (60.0%), agriculture (20.0%), and upland hardwoods (20.0%) were the only habitats under utilized during winter (Table 11). However, all habitats types were selected by at least 18.0% of deer in the summer with agricultural and cedar habitat types selected most frequently. Aspen/birch habitat types were selected or avoided by 54.6% of the deer in the summer whereas they were used according to availability during the winter (Table 11).

Male deer selected open, aspen/birch, and cedar habitat types most often and female deer selected 'other' and aspen/birch types most frequently. Agricultural land was selected by 23.1% of males and 22.5% of females and avoided by 23.1% of males and 25.0% of females. Aspen/birch habitat types, in addition to being commonly selected, were avoided by both sexes approximately equally (Table 11).

Population parameters

Abundance

The CAPTURE program selected the null model (M_o) as the best estimator of deer abundance using the mark-recapture data. This model assumes equal probability of capture on each trapping occasion for all individuals in the population. The 1994 null model abundance estimate for the trapping region was 77 individuals (SE = 8.14) and the 1995 estimate was 95 individuals (SE = 13.65). A t-test did not detect any significant difference between the yearly estimates ($t = -1.132$, $P = 0.2682$). Since winter daily deer movements were seldom greater than 0.8 km, traps were thought to attract deer from an area as large as 2.01 km^2. Mark-recapture data originated from 13 traps in 1994 and 11 traps in 1995 (Appendix Table 1). Therefore, deer densities in trapping areas were estimated to be 2.95 deer per km^2 in 1994 and 4.30 deer per km^2 in 1995.

A second model, which assumes that capture probabilities vary by animal (M_h), was also used to estimate abundance because the social dominance structure of deer may have resulted in varying capture probabilities by age and sex. Abundance estimates from the M_h model were 104 individuals (SE = 17.81, density = 3.98 deer / km^2) in 1994 and 144 individuals (SE = 26.16, density = 6.51 deer / km^2) in 1995. No significant difference was detected between 1994 and 1995 M_h abundance estimates ($t = 1.264$, $P = 0.2082$).

Overwinter deer densities estimated from pellet-group counts ranged from 8.94 - 34.86 deer per km^2 across the study area and were highest in Presque Isle county in 1994 and highest in Montmorency county in 1995 (Table 12). There were no significant differences in deer densities between years for any county.

The number of deer counted during road surveys peaked in March and April during both years (Figure 10). Similar patterns in monthly total counts occurred during the two years with the number of deer counted increasing from May through early fall

Table 12. Estimated overwinter deer densities and standard errors (SE) for Presque Isle, Montmorency and Alpena counties in 1994 and 1995.

County	1994		1995		P value[a]	Average deer / km^2
	Deer / km^2	SE	Deer / km^2	SE		
Presque Isle	3.54	7.94	1.33	2.04	0.9999	2.44
Montmorency[b]	1.53	2.00	5.20	4.14	0.2222	3.37
Alpena[c]	2.99	0.94	1.60	0.99	0.9999	2.30

a Wilcoxin-Mann-Whitney test
b includes the northern half of the county
c includes four northwestern townships of the county

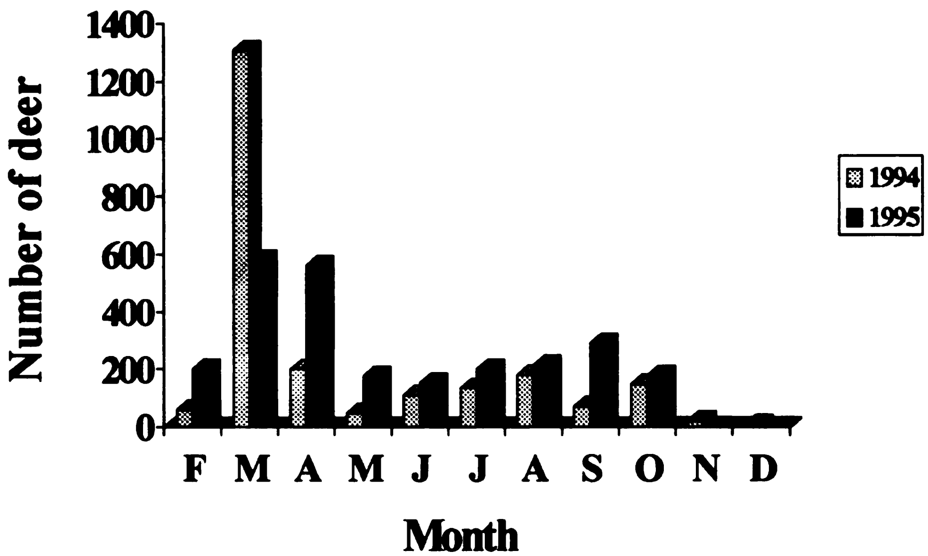


Figure 10. Total number of deer counted in monthly road surveys (June, July and August are average counts for two surveys) in 1994 and 1995.

and decreasing during the fall and early winter. More deer were counted along monthly surveys in 1995 than in 1994 except during the month of March. Male and female deer were distinguishable during summer and fall monthly surveys. Counts of females were greater than counts of males during each month and both sexes followed the same general trends as total deer counts by increasing over summer months and decreasing in the fall (Figure 11). Adult deer were distinguishable from sub-adult deer (< one year old) during winter and early spring (although deer of unknown status were still encountered) and from newborn fawns during summer and fall. Counts of sub-adults tended to peak in late spring and early fall of the year and were usually less than adult counts (Figure 12). The largest differences in the number of adults and sub-adults counted occurred during the summer months of each year and the smallest differences in observed counts occurred during late fall and winter.

Survival

Annual survival estimates ($\pm$ 95% confidence intervals) for non-migratory deer in 1994 (0.814 ± 0.23) were not significantly different ($\alpha = 0.05$) from annual estimates for migratory deer (0.500 ± 0.18) although differences were significant at $\alpha = 0.10$ ($P = 0.0948$). Annual survival estimates of non-migratory (0.583 ± 0.19) and migratory (0.636 ± 0.19) deer in 1995 were not statistically different ($P = 0.9999$). Furthermore, while summer and fall period survival of non-migratory deer (summer = 0.91 ± 0.17, fall = 0.90 ± 0.19) was greater than survival of migratory deer (summer = 0.73 ± 0.17, fall =

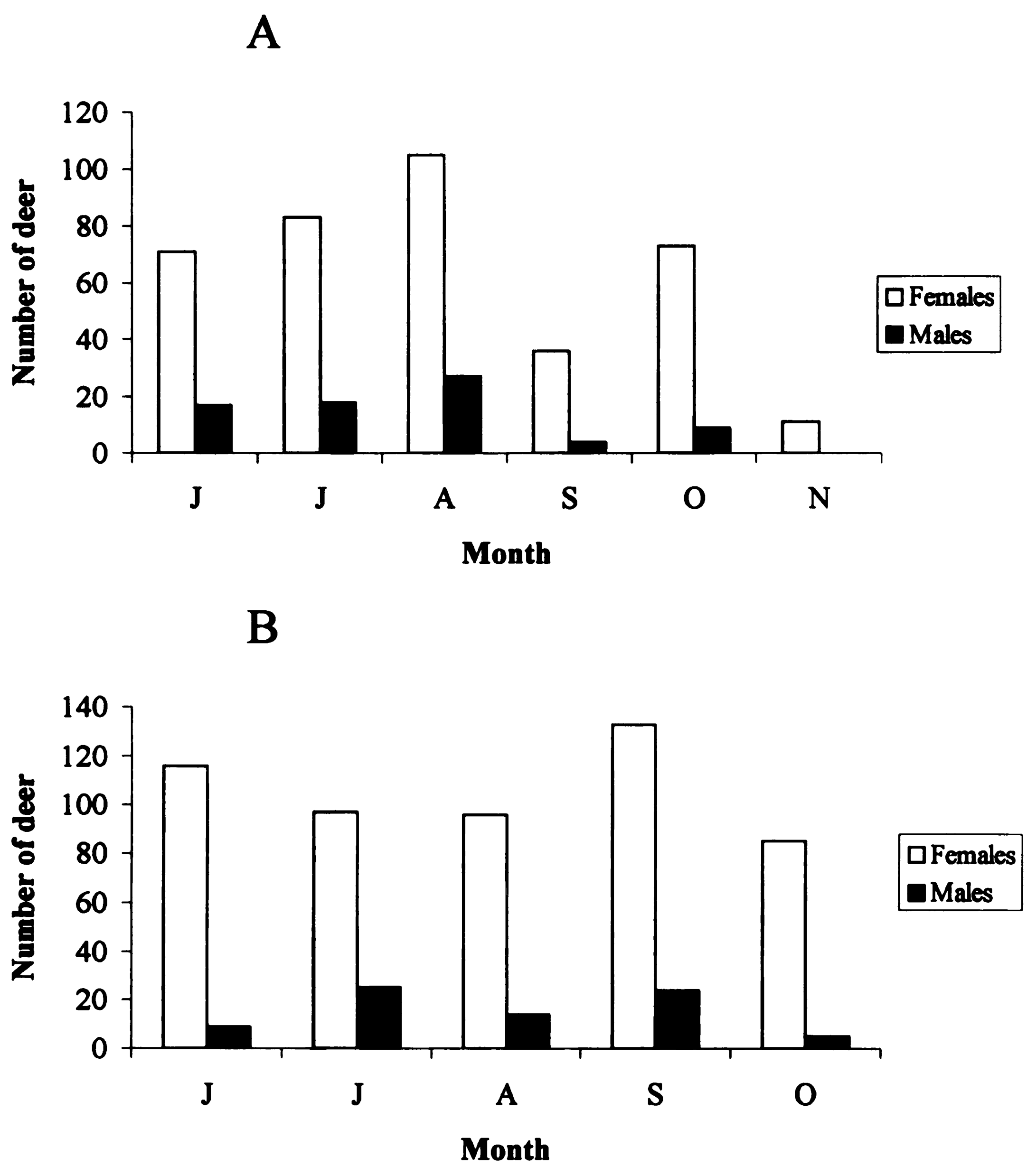


Figure 11. Total counts of female and male deer from June through November 1994 (A) and June through October 1995 (B) road surveys.

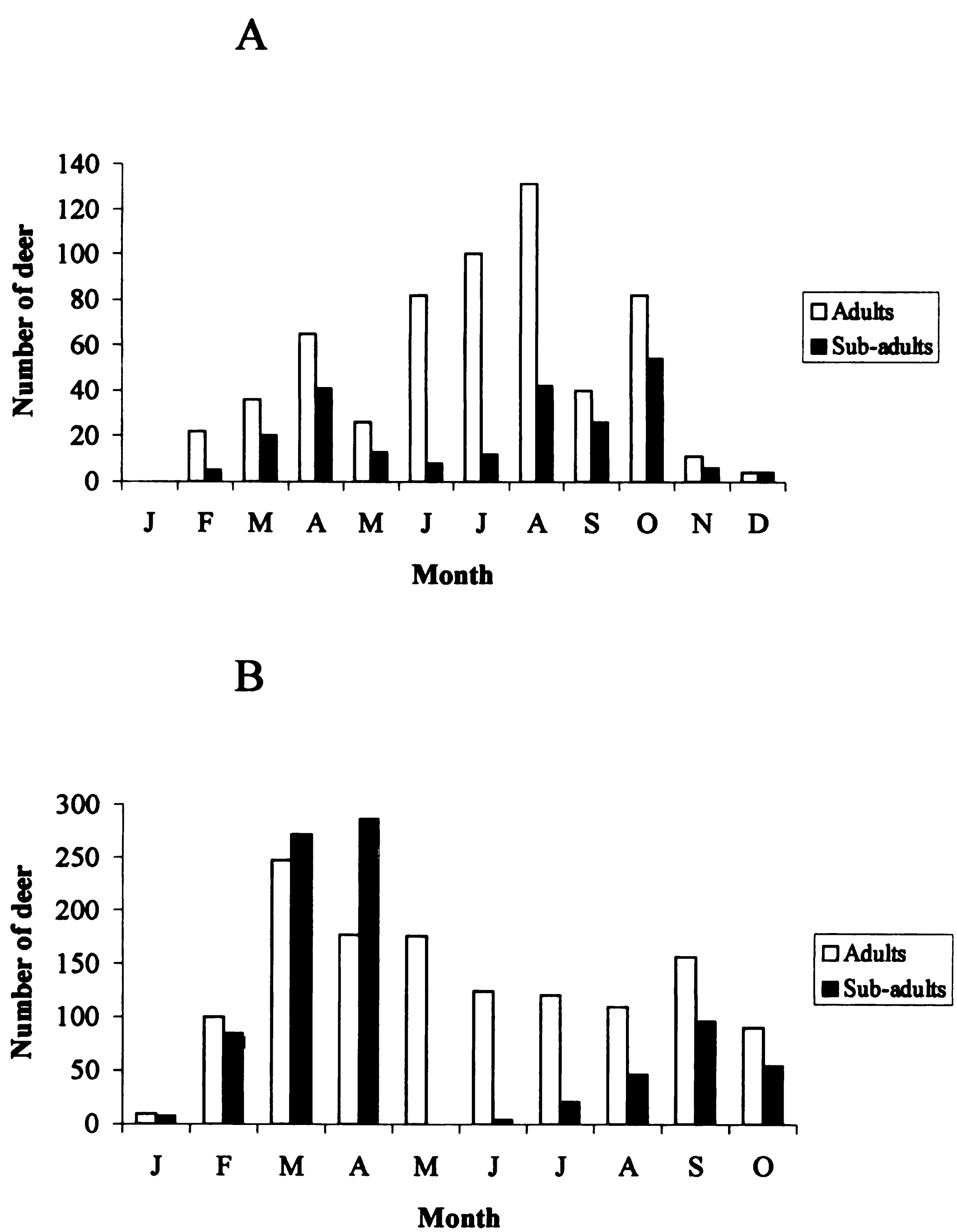


Figure 12. Total counts of adults and sub-adults from February through December 1994 (A) and from January through October 1995 (B) road surveys.

0.69 ± 0.20) no significant differences were detected ($P_{summer} = 0.9999$, $P_{fall} = 0.9999$).

Annual and period survival rates for each age category and year are given in Table 13. Differences in annual and period survival rates between years for pooled age categories of deer were not significant (Table 14). Likewise, 1994 annual adult survival was not different from 1995 annual survival (P = 0.2636) of adults. In addition, annual survival of yearlings was not statistically different between years (P = 0.9999) (Table 14).

Adult deer had higher survival rates than yearlings during all periods in both years. However, differences in annual or period survival rates of adults and yearlings were not significant in either year (Table 14). Adult and yearling survival differed most during the 1994 fall period (adults = 0.93, yearlings = 0.55, P = 0.0367) and annually in 1994 (adults = 0.71, yearlings = 0.36, P = 0.0417).

During the two years, 45 radio collared deer died, four were censored and 24 were alive at the end of the study (Appendix Table 6). In addition, the fate of six ear-tagged deer was known (Appendix Table 7) and their causes of death were pooled with collared deer. Legal harvest (14 collared, 5 ear-tagged) and natural mortality (12 deaths) accounted for most deaths over the two years (Table 15). Six deer (4 males, 2 females) were illegally harvested, or poached and five deer (4 collared, 1 ear-tagged) were hit by vehicles. One fawn died of starvation during the first winter and one adult doe was harvested with a crop damage permit. Unknown causes of mortality were attributed to seven of the collared deer. Males made up 84% of the legal harvest mortalities and 67%

Table 13. Mayfield survival estimates ($\hat{S}$) for collared and tagged deer in 1994 and 1995.

Classification	1994				1995			
	$\hat{S}$	SD	N	95% confidence interval	$\hat{S}$	SD	N	95% confidence interval
Age classes pooled: annual[a]	0.498	0.076	45	0.498 ± 0.15	0.484	0.065	56	0.48 ± 0.13
Age classes pooled: winter[b]	0.852	0.068	45	0.85 ± 0.13	0.819	0.052	57	0.82 ± 0.10
Age classes pooled: summer[c]	0.772	0.067	40	0.77 ± 0.13	0.859	0.054	42	0.86 ± 0.11
Age classes pooled: fall[d]	0.737	0.079	31	0.74 ± 0.16	0.646	0.078	37	0.65 ± 0.15
Adults: annual	0.711	0.108	19	0.71 ± 0.21	0.531	0.082	35	0.53 ± 0.16
Adult: winter	0.913	0.083	19	0.91 ± 0.16	0.849	0.057	36	0.85 ± 0.11
Adults: summer	0.834	0.088	18	0.83 ± 0.17	0.932	0.046	29	0.93 ± 0.09
Adults: fall	0.933	0.064	15	0.93 ± 0.13	0.693	0.090	26	0.65 ± 0.18
Yearlings[e]: annual	0.355	0.092	26	0.36 ± 0.18	0.289	0.100	19	0.29 ± 0.19
Yearlings: winter	0.808	0.099	26	0.81 ± 0.19	0.744	0.110	20	0.74 ± 0.22
Yearlings: summer	0.719	0.097	22	0.72 ± 0.19	0.769	0.128	13	0.77 ± 0.25
Yearlings: fall	0.551	0.124	16	0.55 ± 0.24	0.534	0.150	11	0.53 ± 0.29

[a] January 1 - December 31
[b] January 1 - April 15
[c] April 16 - September 30
[d] October 1 - December 31
[e] deer born in June of the year

Table 14. Results of survival analysis of collared and tagged deer in 1994 and 1995.

Type	Survival comparison	df	Chi Square value	P value[a]
Ages pooled	Annual: 1994 vs. 1995	1	0.262	0.9999
	Winter[b]: 1994 vs. 1995	1	1.591	0.5963
	Summer[c]: 1994 vs. 1995	1	0.925	0.8330
	Fall[d]: 1994 vs. 1995	1	0.688	0.9172
Adults	Annual: 1994 vs. 1995	1	2.527	0.2636
	Winter: 1994 vs. 1995	1	1.456	0.6442
	Summer: 1994 vs. 1995	1	1.115	0.7654
	Fall: 1994 vs. 1995	1	3.225	0.1450
Yearlings[e]	Annual: 1994 vs. 1995	1	0.227	0.9999
	Winter: 1994 vs. 1995	1	0.627	0.9389
	Summer: 1994 vs. 1995	1	0.049	0.9999
	Fall: 1994 vs. 1995	1	0.008	0.9999
1994	Annual: adult vs. yearling	1	5.472	0.0386
	Winter: adult vs. yearling	1	0.534	0.9719
	Summer: adult vs. yearling	1	0.639	0.9346
	Fall: adult vs. yearling	1	5.560	0.0367
1995	Annual: adult vs. yearling	1	2.889	0.1839
	Winter: adult vs. yearling	1	0.097	0.9999
	Summer: adult vs. yearling	1	4.178	0.0857
	Fall: adult vs. yearling	1	0.731	0.9019

[a] Bonferroni level of significance ($\alpha = 0.05$) = 0.012, ($\alpha = 0.1$) = 0.025
[b] Winter = January 1- April 15
[c] Summer = April 16 - September 30
[d] Fall = October 1 - December 31
[e] deer born in June of the year

Table 15. Yearly causes of mortality for radio collared and ear-tagged deer.

Category	1994	1995	Total
Legal harvest	6	13	19
Illegal harvest	4	2	6
Natural[a]	4	8	12
Road killed	2	3	5
Starvation	1	0	1
Crop damage permit	1	0	1
Unknown	3	4	7
Total	21	30	51

[a] includes predator and drowning.

of the illegal harvest mortalities. Natural mortality resulted from 11 predator kills (coyote or dog) and one drowning.

Productivity

The technique of observing collared does with their fawns was not perfected until the second year of the study. Only 63% of collared does were observed on single occasions in 1994, whereas 100% of collared does were observed repeatedly in 1995. Therefore, only productivity data from 1995 observations will be discussed. Collared does observed in 1995 ranged from 2 to 7^+ years of age (Appendix Table 8). Does having fawns (N = 13, 59.1%) were observed an average of 2.3 times before sighting the fawn and does without fawns (N = 9, 40.9%) were sighted an average of 4.2 times. The 1995 average productivity ratio estimated from collared does was 1.08 fawns per doe (SE = 0.08).

Observed and adjusted fawn to doe ratios estimated from monthly road surveys are listed in Appendix Table 9. The 1994 average adjusted survey productivity ratio (0.49 fawns per doe) was not significantly different from the 1995 average adjusted survey ratio (0.51 fawns per doe) (Table 16). Productivity ratios from incidental observations were higher than other estimates with an average of 1.36 fawns per doe (N = 115 observations) in 1994 and 1.30 fawns per doe (N = 98 observations) in 1995 (Table 16). A t-test did not detect any statistically significant differences between years ($t = 0.924$, $P = 0.3628$).

Table 16. Average fawn to doe productivity, fall-recruitment and post-hunting season recruitment ratios for 1994 and 1995 and statistical significance of yearly differences.

Estimate/method	1994	SE	1995	SE	P value[a]
Productivity					
Collared does	-	-	1.08 : 1	0.08	-
Road surveys (adjusted)[b]	0.49 : 1	0.10	0.51 : 1	0.08	0.945
Incidental sightings	1.36 : 1	0.04	1.30 : 1	0.05	0.363
Recruitment - fall					
Collared does	-	-	1.08 : 1	0.08	-
Road surveys[c]	0.68 : 1	0.08	0.67 : 1	0.09	0.999
Recruitment-post season					
Trapped deer	2.28 : 1	-	2.06 : 1	-	

[a] Wilcoxin-Mann-Whitney test
[b] doe counts decreased 10%, July - November surveys
[c] August - November surveys

Fall-recruitment ratios averaged 1.08 fawns per doe from collared does, 0.68 fawns per doe from 1994 monthly fall surveys and 0.67 fawns per doe from 1995 monthly surveys. The post-hunting season recruitment ratios from the captured deer were 2.28 fawns per doe in 1994 and 2.06 fawns per doe in 1995 (Table 16).

Sex ratio and age structure

Road survey deer counts during July - October resulted in an average buck-doe ratio of 0.256 : 1 (1 buck per 3.91 does) in 1994 (SE = 0.015, N = 7) and 0.214 : 1 (1 buck per 4.67 does) in 1995 (SE = 0.018, N = 7) (Appendix Table 10). Differences between the two years were not significant (Wilcoxin-Mann-Whitney statistic (WMW)= 55, P = 0.8048). Sex ratios estimated from the captured deer resulted in 0.46 bucks per doe (1 buck per 2.16 does) in 1994 and 0.63 bucks per doe (1 buck per 1.59 does) in 1995.

The winter age compositions of 1994 and 1995 trapped deer were similar with greater than 60% of the captured deer classified as fawns in each year. No other age category constituted more than 18% of the trapped deer in either year (Table 17). The age composition of captured females was similar to the overall age structure of the trapped deer with 53.5% of females aged as fawns in 1994 and 48.6% aged as fawns in 1995. However, the 2 - 3 year old age category was larger, encompassing 25.6% of the trapped females in 1994 and 20.0% in 1995. No males older than yearlings were trapped in either year, therefore the age composition of trapped males was highly skewed

Table 17. Age structure of deer determined by the age composition of trapped deer, deer aged at the study area check station, and road killed deer in 1994 and 1995. Table values are percentages of deer classified in each age category.

	Trapped deer		Check station		Road killed		Combined	
Age category	94	95	94	95	94	95	94	95
Fawn	66.13	67.27	3.13	7.07	30.00	11.11	24.30	27.61
Yearling	6.45	9.09	52.34	43.43	20.00	44.45	35.72	31.90
2-3 year old	17.74	9.09	37.50	40.40	40.00	0	31.91	27.61
4-5 year old	4.84	3.63	4.69	5.05	10.00	33.33	5.24	6.13
6 years and older	4.84	10.92	2.34	4.05	0	11.11	2.86	6.75
Total	100	100	100	100	100	100	100	100
N	62	55	128	99	20	9	210	163

towards younger age classes in both years (Table 18).

Most deer aged at the study area check station in 1994 and 1995 were in the yearling and 2 - 3 year old age categories (Table 17). Males made up 93.8% of the deer aged at the check station in 1994 and 85.9% of the deer aged at the station in 1995. Therefore, the age composition of male deer followed the overall age structure of check station deer closely (Table 18).

Fawn and yearling age categories made up 50.0% of the road killed deer in 1994 and 55.6% of road kills in 1995. In addition, 2 - 3 year old deer constituted 40.0% of 1994 road kills and 4 - 5 year old deer comprised 33.3% of 1995 road kills (Table 17). Samples of road killed deer were small and insufficient to determine age composition by sex.

The combination of age structure data from all 3 sources resulted in a more even distribution of deer across the first three age classes in both years. The 4-5 year old and the older than 6 year old age classes were also well represented (Table 17).

Table 18. Age structure of male and female deer determined by the age composition of trapped deer and deer aged at the study area check station in 1994 and 1995. Table values are percentages of deer classified in each age category.

	Trapped deer				Check station			
	1994		1995		1994		1995	
Age category	M	F	M	F	M	F	M	F
Fawn	94.74	53.49	90.91	48.57	1.67	25.00	4.71	21.43
Yearling	5.26	6.98	9.09	8.57	53.33	37.50	48.23	14.28
2-3 year old	0	25.58	0	20	37.50	37.50	43.53	21.43
4-5 year old	0	6.98	0	5.72	5.00	0	2.35	21.43
6 years and older	0	6.98	0	17.14	2.50	0	1.18	21.43
Total	100	100	100	100	100	100	100	100
N	19	43	22	35	120	8	85	14

DISCUSSION

The average radio telemetry bearing standard deviation in this study (9.4°) was similar to the 10° bearing error reported by Mooty et al. (1987) and the 7° bearing error reported by Van Deelan (1995). The mean 95% confidence ellipse area for deer locations in this study (37.2 ha) was larger than the 0 - 2 ha confidence area reported in one Minnesota study (Nelson and Mech 1984) and the 10.5 ha ellipse area reported in one Michigan study (Van Deelan 1995). However, the mean habitat size, 23.8 ha (SE = 22.2 ha), was 64% of the average 95% confidence ellipse area, indicating little potential bias in habitat use detection (Nams 1989).

Migration

Approximately half of the radio collared deer were migratory during each year (Table 2). Other midwestern studies have reported similar findings of migratory behavior from at least part of a deer herd (Hoskinson and Mech 1976, Larson et al. 1978, Nixon et al. 1991, Van Deelan 1995), however, the percent of migratory deer ranged from as high as 88.2% (Hoskinson and Mech 1976) to as low as 33.0% (Kufeld and Bowden 1995). Similar migratory patterns were reported for mule deer with 74.0% of mule deer migrating between seasonal ranges in Idaho (Brown 1992) and only 27.0%

of Colorado mule deer exhibiting migratory behavior (Kufeld and Bowden 1995). Our results agreed closely with the findings of one study in Michigan's upper peninsula (Van Deelan 1995) where approximately half of the deer herd was migratory. Some studies have indicated that migratory behavior of deer in the fall is lower in years with mild winters (Nixon et al. 1991, Nelson 1995), increasing the relative presence of non-migratory deer on winter ranges.

The winter range departure dates reported in this study (March 15 - March 30) agreed with results of other midwestern studies in Wisconsin (Hammerstrom and Blake 1939), Minnesota (Rongstad and Tester 1969, Hoskinson and Mech 1976), South Dakota (Sparrowe and Springer 1970), Illinois (Nixon et al. 1991), and Michigan (Van Deelan 1995) where initiation of spring migration began from early March to late April. Loss of snow cover (Hoskinson and Mech 1976, Tierson et al. 1985) or warming temperatures (Ozoga 1968, Drolet 1976, Beier and McCullough 1990) are thought to trigger spring migrations of deer (Nelson 1995). Initiation of spring migration in this study seemed to be related to reduced snow cover since spring migrations began later in 1994 (when snow continued to cover cropfields until late March) than in 1995 (when snow had melted from fields by the second week in March). Van Deelan (1995) also reported that snow depth influenced the initiation of spring migration in Michigan's upper peninsula with deer migrating earliest in the year with the least snow cover in March, despite it being intermediate to other years in temperature and overall winter severity. This study, as with others (Rongstad and Tester 1969, Sparrowe and Springer

1970, Hoskinson and Mech 1976, Van Deelan 1995) reported the majority of spring deer migrations to have been completed by early May (Figure 3).

Spring migrations of deer in this study were mostly in a northwestern to southwestern direction during each year. Other studies have also reported directional migrations of deer from winter yards in South Dakota (Sparrowe and Springer 1970), Minnesota (Hoskinson and Mech 1976), and Michigan (Verme 1973, Van Deelan 1995). These directional migrations of deer are often associated with stream drainages or other landscape features (Tierson et el. 1985, Van Deelan 1995), however, the direction of most deer migrations in this study tended to be toward heavily forested areas and away from open, agricultural land.

The range of migration distances of deer reported in this study (1.6 km - 37.0 km) was consistent with the results of other studies in Minnesota (Carlson and Frames 1957, Rongstad and Tester 1969, Hoskinson and Mech 1976, Nelson and Mech 1984), New York (Tierson et al. 1985), South Dakota (Sparrowe and Springer 1970), and Michigan (Verme 1973, Van Deelan 1995). Average migration distances of Michigan deer were 13.6 km in one study (Verme 1973), and 5.45 km in another (Van Deelan 1995), while deer in Illinois averaged 13 km (Nixon et al. 1991), and deer in Minnesota averaged 17 km migrations in one study (Nelson and Mech 1984), and ranged from 10 - 38 km in a second study (Hoskinson and Mech 1976). The average migration distance of deer in this study, 9.62 km, is consistent with these studies.

Male deer tended to travel greater distances between seasonal ranges than female deer in this study, however, differences were not significant. Other studies (Carlsen and

Farmes 1957, Verme 1973) also recorded greater movements of male deer than for female deer with differences only approaching statistical significance. The lack of significant difference is not unexpected since migrations are thought to be passed along from doe to fawn (Marchington and Hirth 1984, Nelson and Mech 1984) and since the doe-fawn bond is still strong at the time of migration (Ozoga 1972), male fawns probably migrate to summer ranges with their mother (Verme 1973, Nelson 1994), reducing differences in migration distance by sex.

More than half of the migratory deer traveled to non-agricultural, forested areas to establish summer ranges, often migrating 3.5 times further than deer migrating to neighboring agricultural areas (Figure 7, Figure 8). These forested areas tend to be less populated, have lower road densities than agricultural regions, and are comprised largely of aspen/birch, lowland and central hardwoods, cedar, and pine habitats.

The shorter distance of deer migrations between agricultural areas can be partially explained by the composition of the study area. There are several large regions comprised of mostly agriculture that are almost entirely surrounded by wooded habitats (primarily cedar and upland hardwoods). These agricultural "islands", although having less diversified habitats, would be highly conducive to providing both winter thermal requirements and nutritious summer forage in close proximity. It is not unexpected then that some deer migrate only short distances to nearby abundant, nutritious, summer forage.

Verme (1973) reported that deer migrations were greater in the eastern regions of Michigan's upper peninsula where habitat interspersion was low, compared to the western region, where habitats were more diversified. Longer distance migrations may therefore, be an attempt, among other things, to reach areas of greater habitat interspersion.

The average fall migration departure dates of migratory deer in this study (mid-to late November) are consistent with dates reported in other studies (Hammerstrom and Blake 1939, Rongstad and Tester 1969, Sparrowe and Springer 1970, Hoskinson and Mech 1976, Nixon et al. 1991, Van Deelan 1995) although only Nixon et al. (1991) and Nelson (1995) reported initiation of migration beginning in early October, as reported in this study (Figure 9).

An important finding in this study is the relationship of the timing of deer arrival on winter ranges with the ability of block permits to successfully target deer responsible for crop damage. Most block permits are used during the firearm deer season (T. Carlson, MDNR, pers. commun.) which occurs from November 15 - November 30. Non-migratory deer and deer migrating between agricultural areas are susceptible to harvest by crop damage permits since their yearly or seasonal home ranges are located in agricultural areas. However, deer with summer ranges in non-agricultural areas, are only vulnerable to harvest by crop damage permit if they arrive on winter ranges (agricultural areas in this study) before the end of firearm season. In 1994, 50.0% (N = 6) of fall migrating deer with non-agricultural summer ranges returned to winter ranges before the end of the firearm season. In 1995, 85.7% (N = 7) of migrating deer with non-agricultural summer ranges arrived on winter ranges before the end of firearm season. Overall, 54.5% of 1994 fall migration and 66.7% of 1995 fall migration was completed before the end of firearm season. These high percentages suggest that many deer that do not forage on agricultural crops during the summer are susceptible to harvest by fall block permits.

Small sample sizes of fall migrating deer may seemingly limit our ability to describe the overall probability of block permits to successfully target depredating deer, however, the range of migration dates was extensive and although a more concentrated period of fall migration may be detected with larger sample sizes, the range would probably increase. Although detection of a concentrated period of fall migration would enable block permit use to be adjusted accordingly, the probability of harvesting non-depredating deer will likely still exist.

Home range

Home range size estimates of non-migratory deer in this study were larger than for migratory deer, although differences were not significant. Kufeld and Bowden (1995) also reported similar home range sizes of migratory and non-migratory deer in the plains river bottoms of Colorado. Comparisons of home range size estimates with other studies is difficult because of the number of different estimators used in the literature. A second confounding factor is how several estimators vary with sampling intensity. Furthermore, many estimators have various calculation options that generate different estimates. In this study, home ranges were calculated for deer having 10 or more seasonal locations. Beier and McCullough (1990) required 20 locations for home range determination and Nixon et al. (1991) required 30 seasonal locations for home range calculation, however, both of these studies used the minimum convex polygon estimator (MCP) which is more severely affected by sampling intensity (White and Garrott 1990).

Average winter range estimates (201.8 - 353.6 ha) in this study were comparable to the findings of other studies. Winter ranges of deer in Minnesota averaged 264.6 - 353.2 ha using grid cell counts, (Rongstad and Tester 1969), 178 ha for Wisconsin deer (MCP, Larson et al. 1978), 341 ha in an average winter in New Brunswick (MCP, Drolet 1976) and 368.7 ha for Illinois deer (MCP, Nixon et al. 1991). Winter range estimates in this study were larger than winter estimates of 43 ha (MCP) in one Minnesota study (Mooty et al. 1987), estimates of 132-150 ha (MCP) for deer in New York (Tierson et al. 1985), and smaller than estimates of winter ranges (774 ha, MCP) in Colorado (Kufeld and Bowden 1995) and South Dakota (698 ha, estimator unknown) (Sparrowe and Springer 1970).

Drolet (1976) and Rongstad and Tester (1969) recorded an increase in the winter range sizes of deer in snow-free winters compared to range sizes in deep snow winters. The findings of this study supported this tendency with smaller winter ranges (201.8 ha) in the heavy snow winter than in the light snow winter (353.6 ha), although differences between years were not significant ($P = 0.1322$).

Summer ranges recorded in this study (328.6 - 336.9 ha) were larger than estimates of 83 - 319 ha (MCP) for deer in northeastern Minnesota (Nelson and Mech 1984), 219.4 ha (MCP) for deer in north-central Minnesota (Kohn and Mooty 1971), 221 -233 ha (MCP) for deer in the Adirondacks of New York (Tierson et al. 1985), 258 ha (estimator unknown) for deer in South Dakota (Sparrowe and Springer 1970), and

266 ha (MCP) in New Brunswick (Drolet 1976). Areas with high habitat interspersion support smaller seasonal ranges (Sanderson 1966, Dusek et al. 1988, Beier and McCullough 1990) whereas home ranges in areas of low habitat interspersion or diversity tend to be larger. Habitat interspersion in our study area may, therefore, be low as suggested by the large summer range size of radio collared deer in this study.

In general, winter ranges of deer in northern areas tend to be smaller than summer ranges (Hoskinson and Mech 1976, Tierson et al. 1985, Mooty et al. 1987, Van Deelan 1995) due to reduced activity levels associated with wintering deer (Silver et al. 1969, Moen 1976, 1978, Marchington and Hirth 1984). However, one southern Michigan study (Beier and McCullough 1990) and one northeastern Montana study (Dusek et al. 1988) recorded larger winter ranges than summer ranges for non-migratory deer. These differences were attributed to a high degree of habitat interspersion which allowed for small summer ranges because of short distances between forage and protective cover (Dusek et al. 1988, 1989, Beier and McCullough 1990).

Although no differences in seasonal range sizes were detected in this study (P = 0.3614), summer ranges of migratory deer were larger than winter ranges during the heavy snow winter but smaller than winter ranges during the light snow winter. In addition, pairwise comparisons of an individual's seasonal ranges in the heavy snow winter year (1994) indicated significantly smaller winter ranges (P = 0.0332), while comparisons in the light snow winter year (1995) were not significant despite 72.7% of the individuals having larger winter ranges than summer ranges. Since summer range sizes were very similar between years (336.9 ha vs. 328.6 ha), this suggests that while many factors influence home range size, the severity of winter (however indicated) is important in determining which seasonal range is larger.

In addition, seasonal ranges of deer migrating between agricultural areas were smaller than seasonal ranges of deer migrating to non-agricultural regions. This result is not unexpected since deer in agricultural areas are likely to have abundant forage in close proximity to security cover whereas deer in forested regions are less likely to have plentiful nutritious forage within security cover areas.

Many studies report traditional use or fidelity to seasonal ranges (Rongstad ad Tester 1969, Verme 1973, Nelson and Mech 1984, Tierson et al. 1985, Nixon et al. 1988, Beier and McCullough 1990, Van Deelan 1995). Furthermore, many studies indicate greater traditional use of summer ranges due to variation in winter severity (Drolet 1976, Tierson et al. 1985, Dusek et al. 1989, Beier and McCullough 1990). Findings in this study agreed with traditional use of winter ranges by 72.7% of deer and fidelity to summer ranges by 92.3% of deer. Decreased traditional use of winter ranges was due to two deer that remained on summer ranges during the light snow winter and two deer that returned to areas adjacent to winter ranges for approximately one week at the end of the light snow winter.

Nelson and Mech (1981) also reported traditional use of intermediate (spring or fall) ranges. In this study, six deer established distinct spring home ranges; four located between winter and summer ranges and two appearing to be distinct fawning ranges. However, only one deer survived to be evaluated for traditional use of intermediate ranges. This adult doe traveled approximately 4 km to an area where she had her fawn and then returned to her previous winter range during each year.

Studies in Minnesota (Nelson and Mech 1984), Michigan (Beier and McCullough 1990, Van Deelan 1995), New York (Tierson et al. 1985), and Montana (Dusek et al. 1989) reported a tendency of males to have larger home ranges sizes than those of females. However, Rongstad and Tester (1969) reported females to have larger home ranges than those of males. The results of this study indicate no significant differences between home range sizes of different sexes.

Habitat use

Habitat use in this study differed throughout a 24-hour period with use of open habitat types increasing and use of forested habitat types decreasing from day to night (Table 8). Fluctuations in diel patterns of habitat use by deer have also been reported in other studies (Rongstad and Tester 1969, Kohn and Mooty 1971, Drolet 1976, Larson et al. 1978, Murphy et al. 1985, Dusek et al. 1989, Kufeld and Bowden 1995) with some studies also reporting greater use of forested types during the day and greater use of open habitat types (including agriculture) at night (Montgomery 1963, Larson et al. 1978, Suring and Vohs 1979, Beier and McCullough 1990, Dusek et al. 1989). This fluctuation in diel use is possibly due to deer use of concealment habitats (closed forests) during the day which decreases visibility to predators (Beier and McCullough 1990). This finding is also likely related to the crepuscular foraging activity of deer

(Montgomery 1963, Beier and McCullough 1990) since both dawn and dusk hours fall in the evening (1600 - 2359 hours) and night (0000 - 0759 hours) periods.

Few studies report random use of habitats by deer (Kohn and Mooty 1971, Beier and McCullough 1990). More commonly habitats are utilized in excess of availability or less than availability either seasonally (McCaffery and Creed 1969, Drolet 1976, Murphy et al. 1985, Mooty et al. 1987, Dusek et al. 1988, 1989, Nixon et al. 1988, 1991) or by different sexes (Beier 1987, Dusek et al. 1989, McCullough et al. 1989).

Wooded habitat types are more commonly used by deer during winter than summer months (Rongstad and Tester 1969, Larson et al. 1978, Murphy et al. 1985, Dusek et al. 1989, Nixon et al. 1991, Kufeld and Bowden 1995). Furthermore, deer in Wisconsin (Murphy et al. 1985), Montana (Dusek et al. 1988, 1989), and Minnesota (Mooty et al. 1987) tended to use wooded habitats more than expected during winter and only Drolet (1976) reported winter use of forested swamps in New Brunswick to be less than expected. In this study, 60.0% of deer with non-random winter habitat use patterns selected forested wetlands, however, no other forested types were selected. Furthermore, cedar was used less than expected by 60.0% of wintering deer with non-random habitat use. This result is consistent with the findings of Drolet (1976) and is probably due to the proximity of agricultural fields to cedar swamps. The decreased energy expenditure associated with reduced travel distances between food and cover would facilitate more frequent feeding and consequently, under utilization of wooded cover.

Furthermore, agricultural and open habitat types are more heavily utilized during spring and summer months than during winter months (Kohn and Mooty 1971, Dusek et al. 1989, McCullough et al. 1989, Nixon et al. 1991, Austin and Urness 1993, Kufeld and Bowden 1995). Studies in Illinois (Nixon et al. 1991), Wisconsin (Murphy et al. 1985), and Montana (Dusek et al. 1988) report avoidance of agricultural and open range habitat types by deer in the winter. The findings of this study are not wholly consistent with these results. Winter use of openings and agricultural areas by all deer (27.2%) in 1994 was greater than summer use of these habitats (23.4%), and although differences were not significant at $\alpha = 0.05$, there were significant seasonal differences at $\alpha = 0.10$. In addition, 40.0% of deer with non-random winter habitat use patterns selected agricultural fields and 20.0% selected openings while only 20% avoided agricultural areas during the winter. This selection can be explained by the relative proximity of agricultural fields and openings to winter yarding areas which would result in more opportunistic foraging. Suring and Vohs (1979) reported use of openings to be greatest when they were close to habitats providing cover. In addition, Moen (1968) noted that winter cover is less critical if high quality forage is available and Kohn and Mooty (1971) argued that available forage was one of the most important factors determining habitat use. Sparrowe and Springer (1970) also reported frequent use of agricultural areas by deer in the winter as a source of food (waste or residue crops).

Our findings may also reflect the relative mildness of northern Michigan winters. Van Deelan (1995) recorded below average winter severity for three recent winters (including the most severe winter during this study) in Michigan's upper peninsula.

Other studies in Michigan (McCullough et al. 1989, Beier and McCullough 1990) and Minnesota (Rongstad and Tester 1969) reported increased use of swamps during more severe winters and greater use of openings during less severe winters.

During spring and summer months, deer tend to increase use of agriculture, (Kohn and Mooty 1971, Dusek et al. 1988, 1989, Kufeld and Bowden 1995) openings, (McCaffery and Creed 1969, Suring and Vohs 1979) and grasslands (McCullough et al. 1989), however, despite increased use, these habitats tended to be used less than expected for deer in Montana (Dusek et al. 1988,1989). In this study, only 4.5% of deer with significantly different summer habitat use patterns avoided agricultural areas while 31.8% selected agriculture and 22.7% selected openings. This finding may reflect the preferential use of nutritious food sources that are close to cover providing habitats.

Furthermore, deer tend to heavily use forested areas during summer (Kohn and Mooty 1971, Murphy et al. 1985, Mooty et al. 1987, Dusek et al. 1989, Nixon et al. 1991) and often use these areas in greater proportion than their availability (Mooty et al. 1987, Dusek et al. 1988, 1989). The results of this study were consistent, with greater than 70% of deer locations occurring in forested habitat types during summer months. In addition, all wooded habitat types were selected by at least 18.2% of deer with non-random summer habitat use patterns. Cedar and aspen/birch habitat types were selected by 31.8% and 27.3% of deer respectively, which agrees with summer selection of aspen/birch and lowland conifers by deer in Minnesota (Mooty et al. 1987). Most wooded habitat types provide some natural forage and supply adequate to excellent security cover. Habitats that provide both cover and forage are beneficial to meeting energy demands.

Migratory and non-migratory deer differed in their summer habitat use patterns in this study (Table 9). Migratory deer tended to select lowland hardwood and cedar habitat types more and aspen/birch and 'other' types less frequently than non-migratory deer (Table 11). In addition, non-migratory deer selected agriculture more frequently and avoided it less than migratory deer did. Non-migratory deer, being year-round residents of an agricultural area, may possess an increased knowledge of their surroundings and escape routes that might allow them to forage in higher risk habitats (such as agricultural fields) more frequently than migratory deer.

Deer migrating between agricultural areas and deer migrating to non-agricultural areas also differed significantly in overall habitat use patterns (Table 9). Winter habitat use was not significantly different ($P = 0.2476$), however, differences in summer habitat use were significant because deer with summer ranges in non-agricultural areas do not use agricultural habitats at all and deer with summer ranges in agricultural areas frequently utilize croplands. Furthermore, non-agricultural migrating deer selected wooded habitats more and 'other' habitats less than agricultural migrating deer (Table 11). Agriculture was selected by 50.0% of deer migrating between agricultural areas with non-random habitat use patterns. The implications of such large percentages of deer selecting agriculture (in addition to non-migratory deer selection of agricultural fields) regarding potential crop damage is readily apparent.

Differential habitat use by sexes was reported for deer in Michigan (Beier 1987, Beier and McCullough 1990, McCullough et al. 1989) and Montana (Dusek et al. 1989), however, male and female deer in Washington (Suring and Vohs 1979), Illinois (Nixon et al. 1991), and Colorado (Kufeld and Bowden 1995) did not differ in habitat use patterns. Habitat use patterns of male and female deer were significantly different in this study ($P < 0.0001$), and although both sexes used winter habitats similarly, summer habitat use differed between sexes ($P < 0.0001$). Female deer in Michigan (Beier 1987, Beier and McCullough 1990, McCullough et al. 1989) have been reported to use grasslands more and forested habitat types less than males. The results of this study were similar, with females averaging more locations than males (26.1% vs. 9.8%) in agricultural fields and openings in the summer. Likewise, females were located less often than males (73.9% vs. 89.2%) in wooded cover types.

Population parameters

Abundance

Estimates of deer density determined from pellet group counts were lower than MDNR pellet group density estimates of 7.08 deer / km^2 in 1994 and 8.48 deer / km^2 in 1995 (H. Hill, MDNR, pers. commun.). This difference maybe attributed to differences in design and calculations used by the MDNR. The MDNR stratification method is based on assumed deer density which may introduce some bias into their estimates. In addition, their estimates are based on district-wide data vs. on a per county basis. Thus, high densities in some counties may erroneously increase district-wide estimates.

Our average winter deer densities of 2.30 - 3.37 deer / km^2 are smaller than winter deer yard densities of 16 - 39 deer / km^2 reported in Minnesota (Nelson and Mech 1981), 30 - 40 deer / km^2 reported in Wisconsin (Larson et al. 1987), 21.3 - 30.0 deer / km^2 in Washington (Gavin et al. 1984), 17.5 deer / km^2 in Quebec (Messier and Barrette 1985), 24.6 - 65.2 deer / km^2 reported for two historic deer yards in Michigan's upper peninsula (Van Deelan 1995) and similar to 2.3 - 10.4 deer / km^2 in New York (Tierson et al. 1985).

Deer counts on road surveys peaked during March and April of each year (Figure 3). This was consistent with the time that snow began to melt from cropfields. The March 1994 road survey, conducted on March 30 - 31, coincided with the first day of spring migration in 1994. Likewise, the 1995 March road survey was conducted from March 14 - 16 and the first day of spring migrations of collared deer in 1995 was March 15th.

Deer counts increased over summer months and decreased during the fall. Similarly, deer use of agricultural fields and openings was high (21.5%) during the summer in this study and use of openings was reported to increase from early to late summer and decrease during the fall in other studies (Kohn and Mooty 1971, Dusek et al. 1989, Kufeld and Bowden 1995). The decrease in deer counts from summer to fall, however, is confounded since corn and other crops were maturing during this time and were fully mature and able to hide deer, reducing observability, in the fall.

Differences in feeding and bedding related behaviors of different sex or age deer are likely to influence total deer counts and sex and age ratios of observed deer. The change in the driven route from two nights in 1994 to three nights in 1995 would alleviate some behavioral bias since most of the three night survey was driven within the hour around sunset when observability of deer is highest (Zagata and Haugen 1974).

Survival

No differences in survival of migratory and non-migratory deer were detected in this study. Van Deelan (1995) reported a similar finding for deer in Michigan's upper peninsula. While differences in adult and yearling survival were not significant, adult deer had higher annual and period survival than yearling deer during all periods. Results of survival analysis for deer in this study agree with findings reported in other studies (Nelson and Mech 1986, White et al. 1987, Dusek et al. 1989, Fuller 1990, Nixon et al. 1991). Winter survival was probably high due to the relative mildness of winters and nearby agricultural fields providing winter forage.

Sources of mortality for deer reported in this study were similar to other studies (Ozoga 1972, Gavin et al. 1984, Fuller 1990, Van Deelan 1995). Legal harvest was the greatest source of mortality in this study and in other hunted populations of deer (Dusek et al. 1989, Nixon et al. 1991, Van Deelan 1995). Predator kills were also a large source of deer mortality in this study while overwinter starvation was minor. Starvation was reported to be a minor source of mortality in other studies of northern deer in Minnesota

(Nelson and Mech 1986) and Montana (Dusek et al. 1989) although it has been frequently documented as a greater source of mortality in Michigan (Ozoga and Harger 1966, Ozoga 1972), Washington (Gavin et al. 1984), and Wisconsin (Dahlberg and Guettinger 1956).

Productivity

In this study, 59.1% of radio collared does produced fawns with an average ratio of 1.08 fawns per doe. Productivity estimates from observed counts of fawns and does in late summer and fall road surveys were lower and estimates from incidental sightings were higher than collared doe observations (Table 16). Productivity estimates from collared doe observations in this study agree with the productivity estimates of other studies (Ransom 1967, Coe et al. 1980, Gavin et al. 1984, Dusek et al. 1989), however, estimates were lower than productivity estimates of 1.88 fawns per doe in southern Illinois (Roseberry and Klimstra 1970), 1.6 fawns per doe in Wisconsin (Dahlberg and Guettinger 1956), 1.63 fawns per doe in Iowa (Haugen 1975), and 1.82 - 2.1 fawns per doe in an extensively farmed region of Illinois (Nixon et al. 1991). Fall-recruitment fawn to doe ratios of deer in this study were similar to results reported in other studies (Dusek et al. 1989, Nixon et al. 1991).

Although collared doe observations seem to be a good method for determining productivity estimates, precautions must be taken to observe does on numerous occasions and at various times of the day. Approximately 60% of 1995 collared does in this study produced fawns as compared to much higher percentages in other studies (Roseberry and Klimstra 1970, Dusek et al. 1989). Our estimates of productivity may therefore, be conservative, especially if collared does lost their fawns before we were able to observe them together.

Downing et al. (1977) reported that fawns were not as visible as adult deer during July and August when they were most easily discernible. This accounts for the low productivity and fall-recruitment fawn to doe ratios estimated from road surveys. Nixon et al. (1991) also reported fawn to doe ratios from observed counts approximately 16% lower than those estimated from observations of marked deer.

Productivity estimates from incidental sightings agree with estimates from collared doe observations. It is logical that recordings of incidental sightings would be a favorable method to determine fall-recruitment fawn to doe ratios since behavioral differences in feeding and bedding behaviors between fawns and does (which directly influence observability) are less pronounced in the fall.

Fall-recruitment ratios estimated from trap-related data overestimated actual fawn to doe ratios since they were higher than all productivity estimates for this study. In addition, reports of sex and age trapping bias in a mule deer population (Garrott and White 1982) and sex bias towards females during trapping in New York (Mattfeld et al. 1974) indicate that fawn to doe ratios or sex ratios determined from capture data would be misleading.

Sex ratio and age structure

Buck to doe ratios estimated from road surveys were comparable to those reported by Gavin et al. (1984), Dahlberg and Guettinger (1956), and Dusek et al. (1989) although our estimates used July - October road survey counts whereas Gavin et al. (1984) utilized October - December counts and Dusek et al. (1989) used March and April counts. Male and female deer were reported to be equally visible during August and November (Downing et al. 1977) although Zagata and Haugen (1974) reported male deer to be the most difficult to observe at all times. Male deer in our study used wooded habitats more than females, decreasing their observability and causing an underestimation of buck to doe ratios. Ratios estimated from the captured deer most likely overestimate adult buck to doe ratios due to the numerous captures of male fawns that will probably not survive to adult status.

The age structure of the trapped deer was skewed toward younger age classes (fawn and yearling) in both years with an average of 74.5% of trapped deer in these segments of the population. Males were more highly skewed with 100% of deer in the two youngest age classes while only 60.5% of females were in these age classes. The winter age structure of a hunted population in Michigan (Van Deelan 1995) and the fall age structure of a hunted population in Montana (Dusek et al. 1989) closely resembled the results of this study.

The age structure of male and female deer voluntarily brought to the study area check station were skewed more towards middle age classes (Table 18). Coe et al. (1980) indicated that hunters tended to shoot antlered or large deer when groups of deer were encountered. In addition, hunters often passed up shots to get a bigger or antlered deer later. These hunter biases create skewed sex or age structures typical of hunted populations.

The age structure of road killed deer is probably the least age biased source, however, small sample sizes in this study limited its use. Combining age structure data from all three methods could provide the most representative sample because the age biases associated with capture and hunting potentially cancel one another.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Crop damage control permits (summer shooting and fall issued block permits) attempt to control damage on a localized level, however, their effectiveness is greatly influenced by seasonal deer movements. The migratory nature of deer as well as the distance, destination, and timing of deer migrations greatly influence potential crop damage to individual fields. Deer movements in and around agricultural areas and seasonal habitat use patterns also impact potential crop damage levels.

Non-migratory deer reside in the habitats surrounding agricultural lands and frequently utilize crop fields during the summer growing season. These deer are most vulnerable to harvest by crop damage control permits since they establish yearly home ranges in agricultural areas. Migratory deer, however, fall into two categories; those susceptible to harvest by both types of damage control permits because they migrate between winter and summer ranges that are both within agricultural regions, and those migratory deer that are not vulnerable to harvest with summer shooting permits because their summer ranges are in non-agricultural, forested regions. The latter group of deer is, however, vulnerable to harvest by block permits if they return to winter ranges in the fall during any period in which block permits are used.

The timing of fall deer migration in relation to the use of block permits becomes crucial to the effectiveness of block permits to successfully target the deer responsible for damage. Most fall deer migrations were completed by the end of firearm season. Therefore, to be most successful at harvesting depredating deer, block permits should be filled before the start of firearm season. Otherwise, the probability of block permits harvesting deer that summer away from agricultural areas increases and the likelihood of harvesting depredating deer that migrate from one agricultural area to another decreases. Block permits could be issued with the stipulation that most be filled prior to the start of firearm season. The initiation of fall migration however, is influenced by falling temperatures and increasing snow fall. Therefore, the effect of adjusting the time period for block permit use will likely be inconsistent from year to year. Most block permits are currently filled during firearm season, therefore convincing landowners to alter their hunting habits would be difficult at best.

The MDNR also utilizes variable antlerless harvest quotas within Deer Management Units (DMUs) to reduce deer numbers in areas with high densities. Over the years, the tendency has been to decrease the size of DMUs to manage populations on a localized scale (T. Carlson, MDNR, pers. commun.) The alteration of DMU boundaries to reflect and incorporate the direction and magnitude of deer migrations may aid in resolving problems of deer migrating between seasonal agricultural areas. Smaller DMUs, which enable managers to react to local "hot spots", could still be enclosed within these larger DMUs. Harvest quotas could be adjusted accordingly so that the harvest regime of one management unit would have less impact on neighboring DMUs.

Expanding DMUs may also create easier consecutive management of summer densities with desired winter yard densities.

Scare tactics are aimed at reducing deer use of crop fields and some landowners suggest using them earlier in the spring before damage occurs, to try to get deer to migrate earlier or entice resident deer to migrate. The traditional nature of migratory behavior and its initiation which is closely associated with distinct weather patterns suggests that this type of action will not be effective.

Summer shooting permits are potentially the most effective at reducing deer that forage on crops because they are used during the growing season when foraging is most detrimental to crop production and when deer are established in summer ranges. The efficacy of summer shooting permits should be maximized to provide the greatest damage control. Currently, summer shooting permits are issued for use on a single crop field, although a landowner may have permits for multiple fields. Block permits are more commonly issued for the harvest of antlerless deer on all of the landowner's property and occasionally may be extended to the adjoining private property. Summer home range sizes of migratory deer and yearly home range sizes of non-migratory deer indicate that deer of either migratory nature probably move between numerous crop fields within their home ranges. Summer shooting permits may be more effective overall if they were adjusted to include all of the landowner's property thereby encompassing more of the deer's home range. With this system, problems associated with changes in deer foraging behaviors or adjustments in diel habitat use patterns as a result of shooting on agricultural fields could be reduced.

Another refinement in the issuance of summer shooting permits that may aid in reducing future damage lies in the timing of permit use. Harvesting antlerless deer earlier in the summer would ensure that fewer newborn fawns would survive being orphaned, whereas fawns orphaned later in the summer have a higher chance of survival (Woodson et al. 1980). Higher fawn survival, as result of orphaning, may lead to a greater incidence of non-migratory deer because of the matriarchal inheritance patterns associated with deer migration. Currently, summer permits are issued once damage becomes noticeable or is considered inevitable. The nature of this adjustment however, would pose difficulties for both landowners and managers.

Other recommendations regarding summer shooting permits involve increasing their effectiveness through increased use. Summer permits are established such that the landowner is not allowed to keep the harvested deer, whereas deer harvested using block permits can be utilized by the landowner. Adjustments in the permit system that allow the landowner to keep a portion of the summer harvested deer may increase the landowner's willingness to harvest deer in the summer. In addition, summer shooting permits are required to have been issued for a landowner to be eligible for block permits in the fall. This requirement could be strengthened by requiring that a certain number of summer shooting permits be filled before becoming eligible for fall block permits. One important consideration regarding increased summer deer harvest involves the potentially high levels of toxins existing within carcasses due to recent pesticide treatment of crops. Summer harvested deer, which are often times donated to charitable organizations, should therefore, be cautiously considered before ingesting.

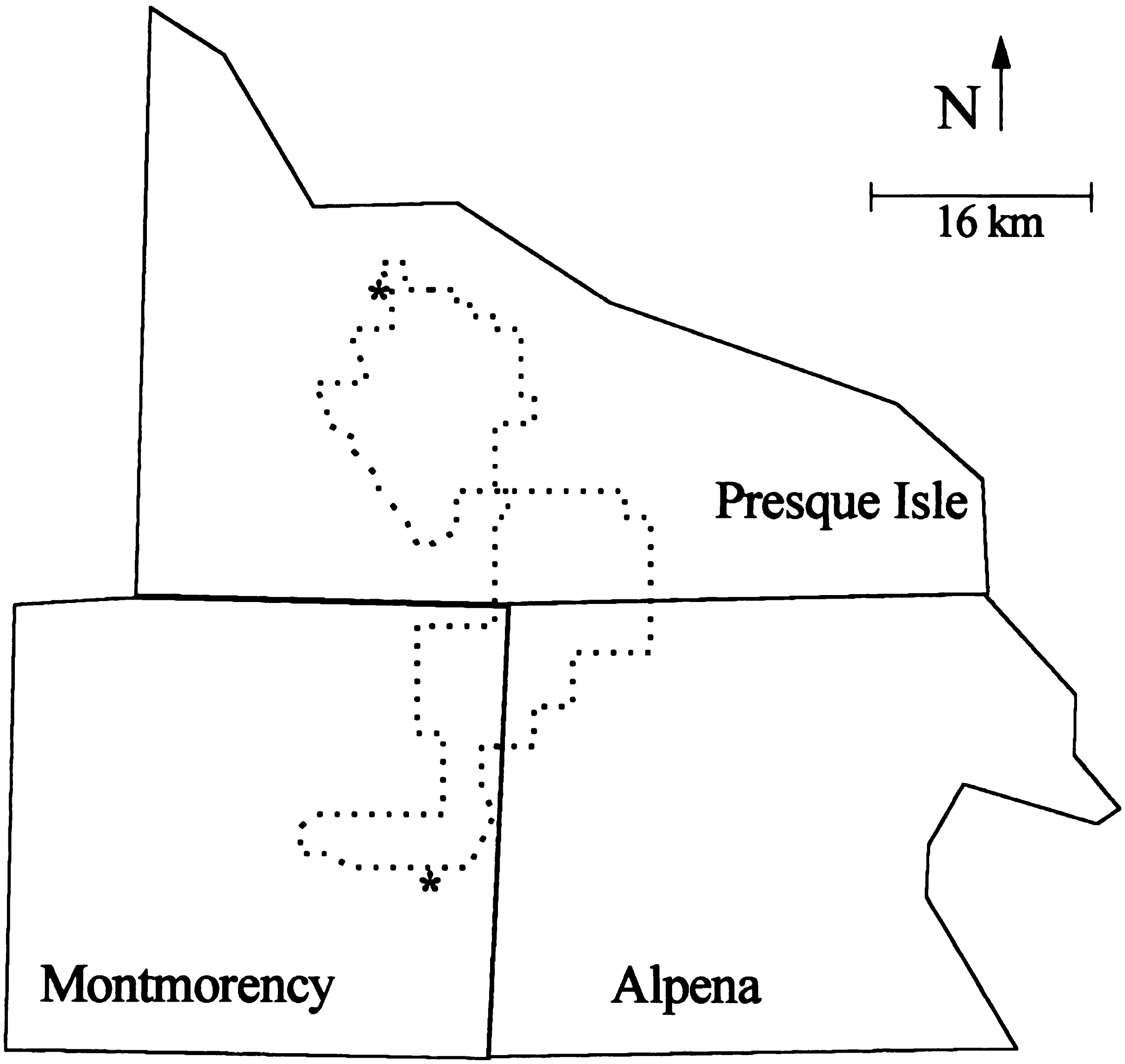
Greater than 75% of summer deer locations were in wooded habitats. In addition, deer are thought to forage in habitats that are close to wooded cover. This suggests that planting crops in areas with non-wooded adjacent edges would decrease foraging by deer. Often times this may not be possible due to landownerships. Under these circumstances, landowners may be able to reduce economic losses by rotating crops such that high value crops are located farthest from wooded edges.

Various reductions in the quality of adjacent wooded habitats may alleviate deer foraging in agricultural fields. Decreasing the habitat quality of preferred adjacent wooded habitats may lessen time spent there by deer and consequently, decrease the amount of foraging in a particular field. Decreasing habitat quality may be as simple as not creating additional quality habitat adjacent to agricultural fields. The consequences to other wildlife species should be carefully evaluated before changes of habitat quality or quantity are made.

In addition, increasing habitat interspersion in wooded areas away from agricultural fields may result in smaller deer home ranges and decreased foraging in agricultural areas. Specifically, creating forest openings that would provide spring and summer forages (McCaffery and Creed 1969) might alleviate some agricultural foraging. This alteration could serve to increase deer densities by increasing available forage, therefore, its design requires careful planning and consideration and would require that farmers cultivate high value crops away from wooded edges whenever possible.

Lastly, additional research indicating the presence of deer that summer in agricultural areas and winter elsewhere, as well as the direction, magnitude, and timing of their movements would allow managers to adjust DMU harvest quotas and increase hunting pressure on this deer group.

APPENDIX



Appendix Figure 1. Monthly road survey route within the study area in 1994 and 1995. Dashed lines depict the driven route and asterisks represent northern and southern starting points.

Appendix Table 1. Trap sites across the study area where deer were successfully marked in 1994 and / or 1995.

County	Trap number	Year 1994	Year 1995
Presque Isle	9	M[a]	N[c]
Presque Isle	10A	M	N
Presque Isle	10B	NM[b]	N
Presque Isle	10C	M	NM
Presque Isle	12	M	NM
Presque Isle	19B	M	N
Presque Isle	30	M	M
Presque Isle	35	M	M
Presque Isle	40	NM	N
Presque Isle	45	M	M
Presque Isle	55	M	M
Presque Isle	60	M	M
Presque Isle	70	N	NM
Presque Isle	95	N	M
Presque Isle	100	N	M
Montmorency	85	N	M
Montmorency	90	N	M
Montmorency	3A	M	NM
Montmorency	50	M	NM
Alpena	65	NM	NM
Alpena	6B	M	N
Alpena	75	N	M
Alpena	80	N	M

[a] M = deer successfully marked
[b] NM = no deer marked
[c] N = trap site not used

Appendix Table 2. Trap night description and trapping success rate for 1994 and 1995.

Trap night description	1994	1995
Number of trap nights	781	585
Number of inoperable trap nights[a]	426	228
Number of operable trap nights[b]	355	357
Number of captures	103	83
Number of escapes[c]	38	25
Overall success rate[d]	33.10%	47.35%

[a] traps that were tripped (closed) by birds, small mammals, or weather conditions.
[b] trap nights - inoperable trap nights.
[c] successfully trapped deer that escaped before handling.
[d] (total captures + total escapes) / total operable trap nights.

Appendix Table 3. Number of deer locations within each time period in 1994 and 1995.

		Time period[a]			
		1	2	3	Total
1994	Number of locations	1930	477	302	2709
	% of 1994 total	71.24%	17.61%	11.15%	100%
1995	Number of locations	1110	203	150	1463
	% of 1995 total	75.87%	13.88%	10.25%	100%
Total	Number of locations	3040	680	452	4172
	% of total	72.87%	16.30%	10.83%	100%

[a] 1 = 0800-1559 hours, 2 = 1600-2359 hours, 3 = 0000-0759 hours.

Appendix Table 4. Number of deer locations by season and year for 1994 and 1995.

Season	1994	1995	Total
Winter	531	817	1348
Summer	1368	1456	2824
Total	1899	2273	4172

Appendix Table 5. Observed (Obs.), expected (Exp.), and partial Chi square values for deer locations[a] in eight habitat types across three sampling periods (years combined).

	Sampling period[b]								
	1			2			3		
	Obs.	Exp.	Partial Chi sq.	Obs.	Exp.	Partial Chi sq.	Obs.	Exp.	Partial Chi sq.
Cropland	275	332.9	10.08	91	76.2	2.86	92	48.8	38.10
Openings	181	181.7	< 0.01	35	41.6	1.05	34	26.7	2.05
Upland hardwoods	472	508.8	2.67	142	116.5	5.58	86	74.7	1.72
Aspen/birch	994	954.4	1.64	204	218.5	0.96	115	140.1	4.49
Lowland hardwoods	279	256.6	1.96	43	58.7	4.22	31	37.7	1.18
Pine	108	102.6	0.30	22	23.5	0.09	11	15.0	1.09
Cedar	531	503.0	1.56	111	115.2	0.15	50	73.8	7.69
Other	165	165.0	< 0.01	40	37.8	0.13	22	24.2	0.20
Subtotal	3005	3005	18.20	688	688	15.06	441	441	56.47

[a] includes winter and summer locations only
[b] 1= 0800-1559 hours, 2 = 1600-2359 hours, 3 = 0000-0759 hours

Appendix Table 6. Sex, age, capture date, migratory status, and fate of radio collared deer as of March 15, 1996.

Sex	Age (months) at capture	Capture date	Migratory status[a]	Fate
F	7	01/25/94	N	Censored 06/26/94
F	19	01/25/94	N	Alive
M	7	01/26/94	N	Legal harvest 11/15/94
F	7	01/26/94	U	Coyote kill 03/09/94
F	175	01/29/94	N	Crop permit harvest 08/06/94
M	7	01/31/94	Y	Legal harvest 11/15/94
F	32	02/01/94	N	Road killed 09/21/95
F	20	02/01/94	N	Alive
F	8	02/01/94	U	Coyote kill 02/17/94
M	8	02/02/94	U	Starvation 03/22/94
F	8	02/04/94	Y	Illegal harvest 10/06/94
M	8	02/06/94	Y	Legal harvest 11/15/95
F	8	02/06/94	Y	Alive
F	32	02/12/94	N	Coyote/Dog kill 01/12/95
M	20	02/17/94	Y	Legal harvest 11/15/95
M	8	02/18/94	Y	Legal harvest 11/15/94
M	8	02/19/94	Y	Legal harvest 11/15/95

Appendix Table 6 (cont'd).

Sex	Age (months) at capture	Capture date	Migratory status[a]	Fate
F	32	02/20/94	N	Dead unknown 10/23/95
F	32	02/22/94	Y	Alive
M	8	02/25/94	Y	Legal harvest 11/15/95
M	8	02/26/94	Y	Legal harvest 11/15/94
F	20	02/27/94	Y	Legal harvest 11/16/94
F	32	02/28/94	Y	Alive
M	9	03/02/94	U	Legal harvest 11/15/94
F	9	03/07/94	Y	Dead unknown 04/18/94
F	9	03/07/94	U	Coyote kill 04/19/94
F	33	03/09/94	N	Alive
F	33	03/09/94	Y	Alive
F	9	03/10/94	N	Legal harvest 11/15/95
F	105	03/10/94	Y	Coyote/Dog kill 05/20/94
F	33	03/10/94	Y	Alive
F	9	03/11/94	N	Censored 06/27/95
F	33	03/12/94	Y	Alive
F	9	03/12/94	Y	Dead unknown 05/14/95

Appendix Table 6 (cont'd).

Sex	Age (months) at capture	Capture date	Migratory status[a]	Fate
M	9	03/12/94	Y	Illegal harvest 07/04/94
F	33	03/15/94	Y	Alive
F	33	03/16/94	Y	Alive
F	9	03/16/94	Y	Alive
M	9	03/16/94	Y	Coyote/Dog kill 04/09/94
F	9	03/19/94	N	Road killed 03/15/95
M	9	03/20/94	Y	Illegal harvest 10/21/94
M	9	03/22/94	Y	Road killed 04/26/94
M	9	03/27/94	Y	Legal harvest 11/25/95
F	46	04/04/94	U	Dead unknown 04/07/94
F	9	04/09/94	Y	Road killed 09/19/94
F	140	04/12/94	Y	Illegal harvest 08/15/94
M	7	1/25/95	N	Alive
M	19	1/25/95	U	Coyote kill 04/03/95
M	7	1/25/95	Y	Illegal harvest 05/24/95
F	7	1/26/95	N	Alive
F	7	1/26/95	Y	Alive

Appendix Table 6 (cont'd).

Sex	Age (months) at capture	Capture date	Migratory status[a]	Fate
M	7	1/27/95	Y	Coyote/Dog kill 04/09/95
F	7	1/27/95	Y	Alive
F	7	1/28/95	Y	Dead unknown 05/05/95
M	7	1/28/95	N	Legal harvest 11/20/95
M	7	1/29/95	N	Legal harvest 10/07/95
F	7	1/29/95	U	Coyote kill 02/16/95
F	79+	1/30/95	U	Coyote kill 02/22/95
M	7	1/30/95	U	Coyote kill 02/09/95
F	31	1/31/95	N	Alive
M	8	2/1/95	U	Coyote kill 02/13/95
F	68	2/2/95	U	Dead unknown 02/13/95
M	20	2/6/95	N	Legal harvest 11/05/95
F	68	2/10/95	Y	Alive
M	8	2/10/95	Y	Legal harvest 10/14/95
F	44	2/13/95	N	Alive
M	8	2/16/95	N	Alive
M	8	2/22/95	Y	Censored 07/25/95

Appendix Table 6 (cont'd).

Sex	Age (months) at capture	Capture date	Migratory status[a]	Fate
F	80	2/24/95	N	Alive
M	8	2/28/95	U	Censored 03/13/95
F	81+	3/3/95	N	Alive
M	9	3/9/95	U	Drowned 03/12/95
F	9	3/19/95	N	Illegal harvest 08/08/95
F	81+	3/24/95	Y	Alive
M	10	4/8/95	N	Alive

[a] Y = migratory, N = Non-migratory, U = migratory status not known.

Appendix Table 7. Sex, age, capture date, migratory status, and fate of ear-tagged deer.

Sex	Age (months) at capture	Capture date	Migratory status[a]	Fate
M	8	02/06/94	Y	Legal harvest 11/15/95
M	9	03/02/94	U	Legal harvest 11/15/94
F	7	1/31/95	U	Legal harvest 12/05/95
F	32	2/5/95	Y	Legal harvest 11/22/95
F	33	3/2/95	U	Road killed 03/05/95
M	9	3/7/95	Y	Legal harvest 11/15/95

[a] Y = migratory, U = migratory status not known.

Appendix Table 8. Doe ages and number of fawns seen with collared does in 1994 and 1995. Dashes represent deer that were not observed due to age or sex during a given year.

	1994[a]		1995	
Frequency	Doe age (years)	# fawns	Doe age (years)	# fawns
151.396[b]	2	0	-	-
151.405	3	1	4	1
151.415	3	1	4	2
151.424	3	0	4	0
151.436	3	0	4	0
151.676[b]	15	0	4	1
151.686	3	0	4	1
151.716	3	0	4	1
151.726[b]	12	0	7+	0
151.735	2	2	3	1
151.915	3	not seen	4	1
151.895	-	-	3+	0
151.205	-	-	2	0
151.774	2+	not seen	3+	0
151.926	-	-	2	1
151.745	3+	not seen	4+	0
151.235	-	-	7	1
151.496	5	not seen	6	1
151.275	-	-	2	0
151.785[b]	4	not seen	6	1
151.176	-	-	2	1
151.444	3	not seen	4	1
151.226	-	-	6	0

[a] individuals never sighted more than once
[b] different individuals between years

Appendix Table 9. Deer counts from 1994 and 1995 road surveys and productivity ratios from actual and adjusted[a] counts.

		Actual			Adjusted		
		# does	# fawns	ratio	# does	# fawns	ratio
1994							
	13 July	103	15	0.146	92.7	15	0.162
	25 July	60	8	0.133	54	8	0.148
	5 August	98	36	0.367	88.2	36	0.408
	15 August	111	47	0.423	99.9	47	0.470
	15 September	36	26	0.722	32.4	26	0.802
	6 October	73	54	0.740	65.7	54	0.822
	16 November	11	6	0.545	9.9	6	0.606
1995							
		83	13	0.157	74.7	13	0.174
	25 July	110	29	0.264	99	29	0.293
	8 August	73	39	0.534	65.7	39	0.594
	21 August	118	53	0.449	106.2	53	0.499
	15 September	133	96	0.722	119.7	96	0.802
	21 October	85	55	0.647	76.5	55	0.719

[a] # of does decreased by 10%

Appendix Table 10. Deer counts from 1994 and 1995 road surveys and buck-doe ratios from actual and adjusted[a] counts.

	Actual			Adjusted		
	# bucks	# does	ratio	# bucks	# does	ratio
1994						
2 July	17	71	0.239	18.7	63.9	0.293
13 July	18	103	0.175	19.8	92.7	0.214
25 July	18	60	0.300	19.8	54	0.367
5 August	32	98	0.327	35.2	88.2	0.399
15 August	21	111	0.189	23.1	99.9	0.231
15 September	4	36	0.111	4.4	32.4	0.136
6 October	9	73	0.123	9.9	65.7	0.151
1995						
21 June	16	77	0.208	17.6	69.3	0.254
12 July	28	83	0.337	30.8	74.7	0.412
25 July	21	110	0.191	23.1	99	0.233
8 August	3	73	0.041	3.3	65.7	0.050
21 August	25	118	0.211	27.5	106.2	0.259
15 September	24	133	0.180	26.4	119.7	0.221
21 October	5	85	0.058	5.5	76.5	0.072

[a] # of bucks increased by 10%, # of does decreased by 10%

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LITERATURE CITED

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