Movement Patterns and Behavior at Winter-Feeding and Fall Baiting Stations in a Population of White-Tailed Deer Infected with Bovine Tuberculosis in the Northeastern Lower Peninsula of Michigan

Mark Stephen Garner

MOVEMENT PATTERNS AND BEHAVIOR AT WINTER FEEDING AND FALL BAITING STATIONS IN A POPULATION OF WHITE-TAILED DEER INFECTED WITH BOVINE TUBERCULOSIS IN THE NORTHEASTERN LOWER PENINSULA OF MICHIGAN.

By

Mark Stephen Garner

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Fisheries and Wildlife

2001

ABSTRACT

MOVEMENT PATTERNS AND BEHAVOIR AT WINTER FEEDING AND FALL BAITING STATIONS IN A POPULATION OF WHITE-TAILED DEER INFECTED WITH BOVINE TUBERCULOSIS IN THE NORTHEASTERN LOWER PENINSULA OF MICHIGAN.

By

Mark Stephen Garner

In 1994 bovine tuberculosis (*Mycobacterium bovis*) was discovered in a single free ranging white-tailed deer (*Odocoileus virginianus*) in northeastern Michigan (Deer Management Unit 452 (DMU 452)). By the end of the 2000 hunting season, 325+ deer within the DMU 452 had been detected with *M. bovis* and it was generally believed that the disease had radiated from a single focus of infection. However, the presence of three TB positive deer discovered in 1999 well outside of DMU 452 suggested that *M. bovis* may be endemic at extremely low levels in Michigan white-tailed deer.

The primary mode of deer-to-deer transmission of *M. bovis* is likely from snout-to-snout (face-to-face) contact and aerosol exposure at feeding and baiting stations. Feeding behavior of white-tailed deer at fall bait and winter feeding stations was observed during 936 observation periods. Throughout two winters (1996/1997 and 1997/1998) of observation periods (355 hours) we recorded over 5,900 face-to-face (F2F) contacts. Throughout two falls (1997 and 1998) of observation periods (404 hours) we recorded over 2,990 F2F contacts.

Fall baiting was restricted in the DMU 452 during the 1998 hunting season and winter feeding and fall baiting were banned altogether in the DMU 452 effective January 1999. There is concern that *M. bovis* will be spread to a larger geographic area by deer

that travel greater distances in response to the reduction of supplemental food. To assess the impacts of restricted baiting, elimination of baiting and banning of winter feeding on deer movement patterns, since December 1996, we have monitored 160+ radio-collared deer trapped at 9 focal sites in the TB infected area. We located each deer 2–3 times per week during the spring and fall and weekly during the summer and winter. Seventeen percent of the radio-collared deer from all the study sites before the feeding ban migrated (mean migratory distance traveled = 8.4 km). There was no significant difference (Kruskal-Wallis test, $x^2 = 0.5$, $P>0.05$) between the winter range sizes of non-migratory deer before and after the winter feeding ban. There was a significant difference (Kruskal-Wallis test, $x^2 = 5.1$, $P<0.05$) between the sizes of summer ranges for non-migratory deer from before and after the winter feeding ban. There was no significant difference between the winter (Kruskal-Wallis test, $x^2 = 1.5$, $P>0.05$) or summer (Kruskal-Wallis test, $x^2 = 1.0$, $P>0.05$) ranges (before and after the winter feeding ban) of the migratory radio-collared deer.

Results indicate that fall baiting and winter feeding of deer and an increased density of deer would maintain as well as enhance the spread of bovine TB in DMU 452. The practices of baiting and feeding attract or lure deer time after time to a given location increasing the chances of bovine TB being spread by close association of multiple deer. The movement of deer in DMU 452 would enhance the maintenance and spread of bovine TB by the close association of deer, if deer density is not decreased. If and when the deer density is decreased the number of contacts between deer should decrease as well thus decreasing the likelihood that bovine TB will be maintained within the DMU 452.

ACKNOWLEDGEMENTS

I am especially grateful to Dr. Scott Winterstein (my major professor) for allowing me this opportunity to work with him on this research project. His help, advice and guidance during my time here at Michigan State University has been endless. Through the many, many hours of guidance, instruction and advice I have developed a great appreciation and respect for Dr. Winterstein. I also thank Drs. Rique Campa, Angela Mertig, James Sikarskie and Stephen Schmitt for serving on my graduate committee. My committee members are due many thanks because among other things they too gave me many office hours of direction and guidance. I thank Kristie Sitar who stayed around long enough to help me get on my feet and feel comfortable with the responsibilities of this research project. I appreciate the wisdom she shared with me as well as the great example of her work ethic she set while helping me in the beginning of this project.

I thank Dr. Kelly Millenbah, James Brown and fellow graduate students; Ali Felix, Paul Keenlance and Brad Thompson within the Michigan State University Fisheries and Wildlife Department whose technical help was greatly appreciated. I appreciate Mike Larson (a fellow graduate student) who shared the project house and helped me multiple times in field.

The efforts of this project would not be possible without the support of many agencies, organizations and individuals. Primary funding was provided by the Michigan Department of Natural Resources (Wildlife Division) and the Michigan Agriculture Experimental Station at Michigan State University. Additional significant support was provided by the following organizations: Black's Farm (Scott and Judy), Black's Farm (Jim and Sandra), Birch Creek Hunting Club, Canada Creek Ranch, Cordes Hunting Club, Garland AAA Four Diamond Resort, James Hunting Club, Kant Make It Hunting Klub, Leroy Hunting Club, Lockwood Lake Ranch, Lippert's, Michigan Chapter of the Safari International Club, Michigan Chapter (UPNORTH) of Whitetails Unlimited, Nawakwa Hunting Club, Strohschein's Farm (Art and Eleanor) and Turtle Lake Hunting Club. The following individuals have provided invaluable assistance: Scott and Judy Black, Jim and Sandra Black, Randy Casteller, Jason Crawford, Lewis and Kathy Crawford, Jim and Betty Duetsch, Gary Edwards, Mr. Henry Joy and family, Tom Koenig and family, Lawrence and Dorothy Lippert, Raymond Reasner, John Reigle, Dean and Bev Rouleau, David Stebbins, Merle Shepard, Randy Strohschein and Art and Eleanor Strohschein.

All of the property owners and club members of the study sites were very friendly and cooperative during my research. Most were willing to allow us to conduct anything we wished. Some were so excited with the research that they physically helped with our work.

I thank and appreciate the work of those technicians who helped with trapping and other work that was required of me to accomplish my objectives. Those technicians included: Dave Allmacher, Rob Atkinson, Ty Teets, Davis Coye, Rob Hanner, Brandi Hughey, Amy Hickson, Brian Lebel, Don Maxwell, Darian Muzo, Greg Rigney, Ursula Rosauer and Brian Wretchler.

I thank Tom and Elaine Carlson, Tom Cooley, Bill Greene, Jean Fierke, Paul Friedrick, Stephanie Hogle, Rick McKinnon, Joe Valentine and Alex Weinhagen; personnel of the Michigan Department of Natural Resources (wildlife division) who helped me with a variety of different tasks throughout the duration of my research project.

I thank my family Jimmy and Della Garner (my parents), Aletha, Todd, Caleb, Abby and Emilia Bigham (my sister, her husband and family) and Benjamin Garner (my brother) for their support and encouragement. I also thank my wife's family: Gary and Mary Hainley (her parents), Tim, Kris, Gabrielle and Savanah Hainley (her oldest brother, his wife and family), Lisa, Richard, Chelsea and Wendy Wolff (her sister, her sister's husband and family), and Brian and Brad Hainley (her younger brothers) for their support and encouragement.

I thank my wife (Angela Lynn) for all her support, encouragement, patience, and love through the many years of this research project. Angela helped many hours in the field, with reviewing presentations, with class work, with writing advice and with good reason I'm sure to some extent she feels like this was her research project too.

Lastly and most importantly, I thank God for giving me the ability and opportunity to carryout the tasks of this research project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: BACKGROUND INFORMATION

INTRODUCTION

In 1994 bovine tuberculosis (*Mycobacterium bovis*) was discovered in white-tailed deer (*Odocoileus virginianus*) in northeastern Michigan (Schmitt et al. 1997) (Table 1). In 1995 the Michigan Department of Natural Resources (MDNR) began collecting deer that were hunter harvested, roadkilled or died of other sources (e.g. disease) to be examined for bovine tuberculosis. This survey focused on Alcona, Alpena, Montmorency and Oscoda counties (Figure 1). The MDNR found an area within these four counties with a higher density of bovine tuberculosis (TB) positive deer. This area is referred to as the core TB area or core area. The core area includes roughly one fourth of each of the four focal counties, including the intersection of all four.

After finding bovine TB well established in these four counties, in 1996 the MDNR added a fifth county, Presque Isle, to the survey. Bovine TB was found throughout the five county area, so in 1997 more counties were added to the MDNR's survey. The survey area has been expanded each year since. Presently the MDNR is in the second year of a statewide survey. Each year the majority of bovine TB positive deer came from the core area. To date there have been over 340 infected white-tailed deer detected out of 64,292 examined in Michigan's bovine TB deer survey.

Prior to this outbreak there had only ever been 8 recorded cases of bovine TB in deer in North America (Schmitt et al. 1997). Bovine TB is broadly infectious to humans, domestic livestock and other wildlife species (Enarson and Rieder 1995, Meslin and Cosivi 1995). In most industrialized nations, bovine TB in humans has been virtually eradicated with the advent of pasteurized milk. However, these countries have seen a

Table 1. Chronology of relevant biological, political and research events related to bovine TB (1975 - 2000).

DATES	SUBJECT
1975	First documented occurrence of bovine TB in Michigan White-tailed deer (9 year-old female, Alcona County). (Appendix Figure 1)
	Deer Management Unit 452 (DMU 452) was what is now (2000) the TB core area (Figure 1).
1994	Second documented occurrence of bovine TB in Michigan White-tailed deer (4 year-old male, Alpena County). (Appendix Figure 1)
1995	MDNR initiated a bovine TB survey of deer (hunter harvested, roadkilled, or found dead) in the DMU 452 (27 were positive out of 814 deer sampled). (Appendix Figure 2)
	MDA began testing for bovine TB in all cattle, goat and captive deer herds located in the DMU 452.
1996	MDNR expanded the bovine TB survey area to Alcona, Alpena, Montmorency and Oscoda counties which included the DMU 452 (which at this time begins to be referred to as the TB core area).
	MDNR requested a sample of 10 deer per county statewide (excluding the DMU 452) for their bovine TB survey.
1996 December	Trapping (radio-collaring) deer and observation periods of winter feeding stations began for this research project. After radio-collaring, monitoring of deer movement began.
	MDNR found 47 deer were positive out of 4,471 deer sampled during the 1996 survey. (Appendix Figure 3)

Table 1. Cont'd

DATES	SUBJECT
1997	MDNR expanded the bovine TB survey area to 5 counties adding the county (Presque Isle) to the north.
1997 April	Annual trapping and observation periods concluded, but movement monitoring continued.
1997 October	MDA found bovine TB in a captive deer herd in Presque Isle County. (Appendix Figure 4)
1997 December	Fall baiting observation periods and darting (radio-collaring bucks) ended and monitoring deer movement continued.
	MDNR found 73 deer were positive out of 3,705 deer sampled during the 1997 survey. (Appendix Figure 4)
1998 January	Second year of trapping (radio-collaring) deer, observation periods and observations of experimental methods of winter feeding began and monitoring deer movement continued.
1998	Presque Isle, Alcona, Alpena, Montmorency and Oscoda counties are now referred to as the DMU 452 and the old DMU 452 is now referred to as the TB core area.
	MDNR expanded the bovine TB survey area to those counties bordering the DMU 452 (those counties to the east of I-75 and to the north of M-55).
1998 April	Trapping and observation periods concluded, but monitoring movement continued.
1998 July	MDA found first cow positive with bovine TB (in Alpena County).

Table 1. Cont'd

DATES	SUBJECT
1998 August	MDA's new goal was to test all cattle and goats in the DMU 452 by April 1999.
	USDA suspended Michigan's Accredited-Free State Status as of August 13, 1998.
1998 September	Fall baiting observation periods and darting (radio-collaring bucks) began and monitoring deer movement continued. MDNR restricted fall baiting in DMU 452 to 5 gallon amounts of granular feeds.
1998 December	Fall baiting observation periods and darting (radio-collaring bucks) ended and monitoring deer movement continued.
	MDNR found 78 deer were positive out of 9,067 deer sampled during the 1998 survey. (Appendix Figure 5)
1999 January	MDA's winter feeding ban officially began in the DMU 452.
	MDNR expanded the bovine TB survey area to 20 counties (the DMU 452 plus the closest 15 counties surrounding it).
	MDNR requested 25 deer from each county statewide excluding the 20 county survey area.
	MDA found the second and third cows positive with bovine TB (both in Alcona County).
1999 February	Third year (first year on new trap sites) of trapping (radio-collaring) deer, and monitoring deer movement continued.
1999 April	Trapping concluded, but monitoring movement continued.

Table 1. Cont'd

DATES	SUBJECT
1999 September	The monitoring of deer movement continued.
	MDNR banned fall baiting in DMU 452.
1999 October	MDA had tested all cattle and goat herds in the DMU 452.
1999 December	Data collected for this project ceased.
	MDNR found 58 deer were positive out of 19,503 deer sampled during the 1999 survey. (Appendix Figure 6)
2000 January	MDNR expanded the bovine TB survey area to 42 counties (the DMU 452 and the closest 37 counties surrounding it).
	MDNR requested 36 deer from each county statewide excluding the 42 county survey area.

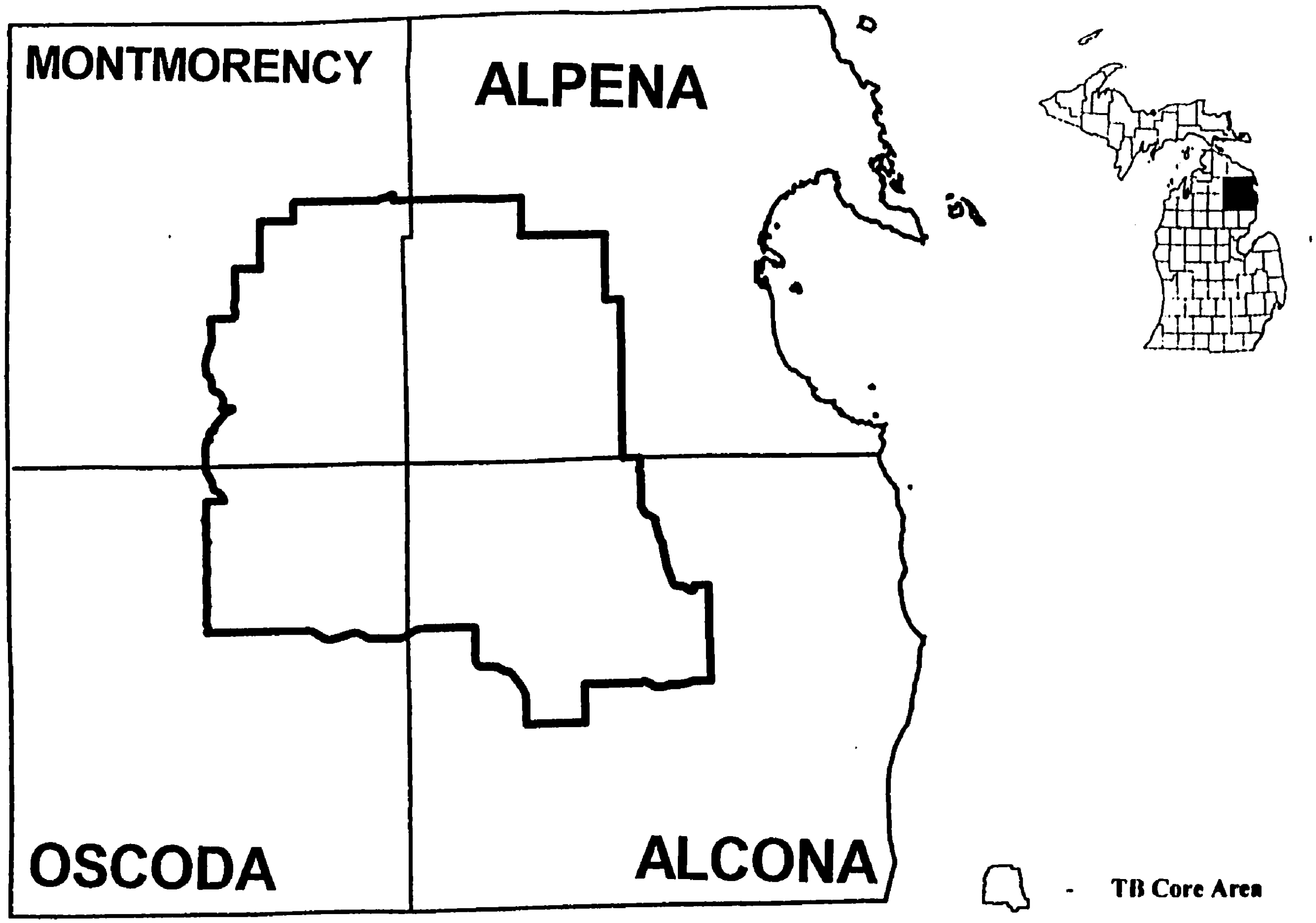


Figure 1. Study area map showing the bovine TB core area.

recent rise in cattle and farmed wildlife infections (Grange 1995). There are documented cases of human infection resulting from working with infected cattle and infection of cattle by infected humans.

Aerosol exposure to *M. bovis* is considered to be the most likely avenue of infection for domestic livestock (Thoen and Bloom 1995). Wild animals can serve as a reservoir of *M. bovis* and can be the foci of infection for domestic cattle (Thoen et al. 1995). Transmission of *M. bovis* to domestic livestock from infected badgers (*Meles meles*) in Ireland (Collins 1995) and Great Britain (Rees and Meldrum 1995), brush-tail possums (*Trichosurus vulpecula*) in New Zealand (O'Hara 1995), and captive elk (*Cervus elaphus*), bison (*Bison bison*), and deer (*Odocoileus virginianus*) in North America (Essey and Vantiem 1995) has been documented as well. There is every reason to believe that wild deer can also infect domestic livestock. In northeastern Michigan there are many small livestock farms. Most are dairy farms with less than 50 head of livestock at each operation. These farms are of major concern because of the number of deer in that area and also because of the number of deer detected with *M. bovis*. In 1995 the Michigan Department of Agriculture (MDA) initiated a survey of livestock in the core area as well as the counties that include the core area. To date the MDA are surveying livestock statewide and have found two dairy herds, thirteen beef herds and one captive deer herd to be infected with *M. bovis* (Table 1).

Wildlife managers with the MDNR hypothesize that the primary mode of deer-to-deer transmission of *M. bovis* is from snout-to-snout (nose-to-nose) contact and aerosol exposure at feeding stations (Schmitt et al. 1997) (Appendix Figure 7). Other possible modes of transmission are via infected saliva left on food and from doe to fawn through milk. Infected saliva left on food is hypothesized to be one avenue for transmission of *M. bovis* from deer to domestic cattle.

Baiting is the practice of attracting deer during the fall hunting seasons to a precise location to enable an easier harvest for the hunter. Fall baiting has been a practice of hunters statewide. Winter feeding is the practice of feeding deer through the winter months following the hunting seasons. In general winter feeding has been a practice of property owners in the more northern counties of Michigan. Bait used during the hunting seasons was typically found in smaller areas (piles) than that which was usually found at winter feeding stations. Usually winter feeding piles were much larger because more deer are being fed than during the fall months. Fall bait piles were usually about 100 pounds and would cover less than 4 feet square. Whereas, winter feeding piles may have weighed in excess of one ton. Some winter feeding piles were larger than 20 tons (approximately 10 feet wide by 20 feet long and 4 feet at the deepest point) (pers. obs.).

In 1998 MDA placed a ban on winter feeding and the MDNR instituted fall baiting restrictions for the five counties which are presently the DMU 452 (Table 1). The ban and restrictions went into effect July, 1998. The MDNR set the fall baiting ban of 1998 so that hunters could only use up to five gallons of bait (granular baits only) at a site during any given time. The MDA's winter feeding ban officially began the winter of 1998/1999 and later in 1999 the MDNR banned fall baiting of any kind in the DMU 452. According to the present feeding ban and bait restrictions that have been passed, fall baiting and winter feeding of any kind are prohibited in this DMU. Furthermore, the MDNR restricted statewide fall baiting (everywhere except the DMU 452 and the upper peninsula) to two gallons of bait at a site during any given time.

Based upon personal observations and discussion with landowners, hunters, MDNR personnel and merchants in and around the study area a number of generalizations can be made about attitudes and beliefs in the area. (1) The northeastern lower peninsula of Michigan has the reputation of being the "club country". This area has many large parcels of property either owned by individuals or club members for the purpose of hunting deer. Many of the property owners in this part of Michigan, in an attempt to increase their hunting success, believe that it is important to keep as many deer as possible on their property. Since Michigan has allowed fall baiting and winter feeding of deer, most land owners did both in an attempt to maintain a desired deer population. In the northeastern Lower Peninsula, large hunt clubs have fed deer for decades to maintain artificially high numbers in lieu of suitable winter habitat (Peyton 2000). Many local individuals in this part of Michigan think there is a need for some type of feeding program and that there should be a large deer herd. Some of these individuals are interested in the health of the animals and use multiple types of feeds to maintain as healthy a herd as possible. Some land owners sincerely think that without fall baiting and winter feeding (especially the winter feeding) many deer in their area would not make it through an average winter. Most argue that it is important to supply food year round so that the desired number of animals will reside on their property. Many landowners also feel that they must bait and feed in order to successfully hunt. To most hunters of this area success is not equal to an occasional harvest of a quality animal but is instead a guaranteed annual harvest. For some of the hunters in this area a harvest is much more important than the quality of the deer or even the health of the herd.

(2) There are individuals and agencies who wish for the size of the deer herd to be

decreased significantly. In general, these individuals/agencies are concerned about the health of the herd. The efforts of wildlife managers to reduce the white-tailed deer population, eliminate feeding and baiting practices have been met with great opposition (Holsman 2000). Insurance companies also wish for the deer herd to be decreased because of vehicle accidents involving deer. Most of the insurance companies are probably only mildly concerned about the issue of deer and crop damage, because few farmers in this area have crop damage coverage. Many landowners of this area believe it is the politics of the insurance companies not the issue of deer herd health (tuberculosis in deer) which is driving the call for a decrease in deer numbers.

(3) There is a minority of property owners that do bait and feed to simply enjoy the aesthetics of deer on their property. These individuals try to keep deer on their property simply so they can be observed and so they are not harvested somewhere else. Keeping an increased concentration of deer in this area seems not to be the best thing for the deer population of the area because experts suspect that the larger deer herd causes bovine TB to spread more rapidly. In contrast, a smaller concentration of deer, which is what the experts say this area needs, is not what most of the landowners want, either hunters or non-hunters (Appendix Figure 8).

(4) A portion of the real estate in this area is owned by individuals or groups of individuals that do not reside in the area. Again, many of these properties are of large acreage, from hundreds to even thousands of acres. This area is low in population and the residents, excluding some large farms, typically own small parcels (less than 40 acres) of property. Therefore, much money comes to this area by way of the recreational users, the club members.

(5) There are many families that depend on the income that the deer baiting and feeding programs created. These include the farmers that grow the feeds, the transporters of the feeds, the merchants that sell the feeds, and the merchants that benefit from the purchases of other items bought by people attracted to this area because of the deer (e.g. bars, hotels, party stores (gas stations), restaurants, etc.). Each year tens-of-millions of dollars were spent in Michigan baiting and feeding deer (Winterstein et al. 1995).

The size and quality of the deer herd in the DMU 452 will directly affect the lives of many individuals that reside and recreate in this area. Therefore, research examining parameters, particularly baiting and feeding, that may influence the well-being of deer is needed. Few data are available on the movements and site fidelity of deer in areas where feeding is common. According to Ozoga (1996) migrations of white-tailed deer tend to differ greatly from one geographic location to another. Also, little is known about close contacts between individuals. Some information can be found on doe/fawn and clan grooming (Marchington and Hirth 1984) but the actual documentation of close contacts made while feeding has not been noted. Because these deer behaviors can have major impacts on the spread of bovine tuberculosis within the deer herd, and potentially to domestic livestock, it was proposed that aspects of deer behavior at fall baiting and winter feeding stations in northeastern Michigan be examined. It is understood that close contacts while feeding at baiting and feeding stations is not something new, but it is a behavior that has not been systematically examined. These data are needed to make adequate management decisions in response to the present problem of bovine TB in the northeastern Michigan deer herd.

PROJECT GOALS AND AIMS

The primary objectives of this project are to determine if:

1. There is face-to-face (F2F) contact between white-tailed deer at winter feed stations (piles). F2F contacts include all contacts at which deer heads (noses) are within three feet or closer to one another. If there is little F2F contact it will suggest that winter feeding is probably a minor avenue for transmission of bovine tuberculosis. If a great deal of F2F contact is observed, it will indicate that winter feeding is a potential avenue for transmission of bovine tuberculosis. (Chapter 2)

2. White-tailed deer visit one and only one feeding station throughout the winter (December - March). If this is true, it will indicate that infected deer come into contact with a limited number of other deer at winter feeding stations. If this is not true, it will mean that infected deer can potentially come into contact with a larger number of other deer. (Chapter 4)

3. White-tailed deer exhibit strong winter feeding site fidelity, returning to the same feeding station each winter. That is, for example, will radio-tagged deer change feeding sites from winter 1996/1997 to winter 1997/1998? If there is high site fidelity, it will indicate that infected deer contact other deer in a restricted geographic area, lessening the likelihood of disease transmission to other areas. If site fidelity is low, an avenue exists to spread the disease over a larger geographic area. (Chapter 4)

4. During the fall (September - December) white-tailed deer visit one or few bait piles. If this is true, it will mean that infected deer come into contact with a limited number of other deer over bait piles. If it is not true, it will mean that infected deer can potentially come into contact with a larger number of other deer. (Chapter 4)

5. There is F2F contact between white-tailed deer at bait piles. If there is little F2F contact it will suggest that fall baiting is probably a minor avenue for transmission of bovine tuberculosis. If a great deal of F2F contact is observed, it will indicate that fall baiting is a potential avenue for transmission of bovine tuberculosis. (Chapter 2)

6. Under the 5-gallon baiting restrictions, the number of F2F contacts is greater than that observed with no restrictions. If this is true, then the value of the baiting restriction should be reevaluated. If it is not true, it will mean that restricting baiting to 5-gallons does not result in increased F2F contacts. (Chapter 2)

7. The use of some mechanical feeders (spin-cast or broadcast feeders) could allow feeding or baiting of deer while eliminating contacts. If few-to-no contacts between deer are made using these means of feeding, they might represent possible areas warranting further investigation. (Chapter 2)

8. During winter feeding there are higher numbers of F2F contacts made between deer over 5-gallon bucket piles (average areas: 2' in diameter x 5" deep) in comparison to the contacts made over other ways of feeding deer (e.g., round hay bales, spread hay, spread corn, beet piles, carrot piles, potato piles and even larger corn piles). If this is true, then the volume limitations and the methods of application should be reevaluated because of their potential to further spread bovine tuberculosis. If it is not true, it will mean that restricting the feeding volumes to 5-gallons and the method of application do not result in increased F2F contacts and they do not enhance the further spread of bovine tuberculosis. (Chapter 2)

9. During winter feeding there are higher numbers of F2F contacts made between deer over lines of corn (average areas: 8" wide x 25' long x 3/4" deep) spread from 5-

gallon buckets in comparison to the contacts made over other practices of feeding deer (round hay bales, spread hay, spread corn, beet piles, carrot piles, potato piles and even larger corn piles). If this is true, then the volume limitations and the methods of application should be reevaluated because of their potential to further spread bovine tuberculosis. If it is not true, it will mean that restricting the feeding volumes to 5-gallons and the methods of application do not result in increased F2F contacts and they do not enhance the further spread of bovine tuberculosis. (Chapter 2)

10. When winter feeding is dramatically decreased or stopped, white-tailed deer expand their range over that which they used when winter feeding was occurring. If this occurs, then halting winter feeding in the infected area will result in movement of deer out of the area and into an increased geographic area that can become infected. If deer do not expand their range when winter feeding is stopped, then halting winter feeding may be a viable strategy for controlling *M. bovis*. (Chapter 3)

11. The final objective of the project is to make recommendations for managing the bovine TB outbreak in white-tailed deer in Michigan. (Chapter 5)

STUDY AREA

Fieldwork began in December, 1996. At that time, study site selection, trap site selection and installation of traps were the primary tasks of this research project. Deer were trapped and radio-collared the winters of 1996/1997, 1997/1998 and 1998/1999. Data were recorded on deer feeding behavior at winter feeding (the winters of 1996/1997 and 1997/1998) and fall baiting (the falls of 1997 and 1998) stations. Radio-collared deer were monitored from the time the first radio-collar was attached until December 02, 1999 when this project was concluded.

Site Selection

The study area included the core area and the four counties (Alcona, Alpena, Montmorency and Oscoda) that include the core area (Figure 2). The goal was to find multiple suitable study sites. The sites had to include properties that would represent relative white-tailed deer habitats, deer densities, and fall baiting and winter feeding practices in this part of Michigan.

The DMU 452 has a number of larger privately owned properties and many of these are of hundreds or thousands of acres. The DMU 452 was known to have a high deer density, with some properties having much higher densities than others. Contrasting sizes of acreage and deer densities were common among neighboring properties. Even though the properties in the DMU 452 may be owned by a diversity of individuals or groups of individuals a large number of the properties are owned for the sole purpose of hunting (deer hunting included). On most properties in the DMU 452 supplemental feeding may account for the higher deer densities, which is probably independent of property size. Historically, much of the habitat in the DMU 452 was very poor deer

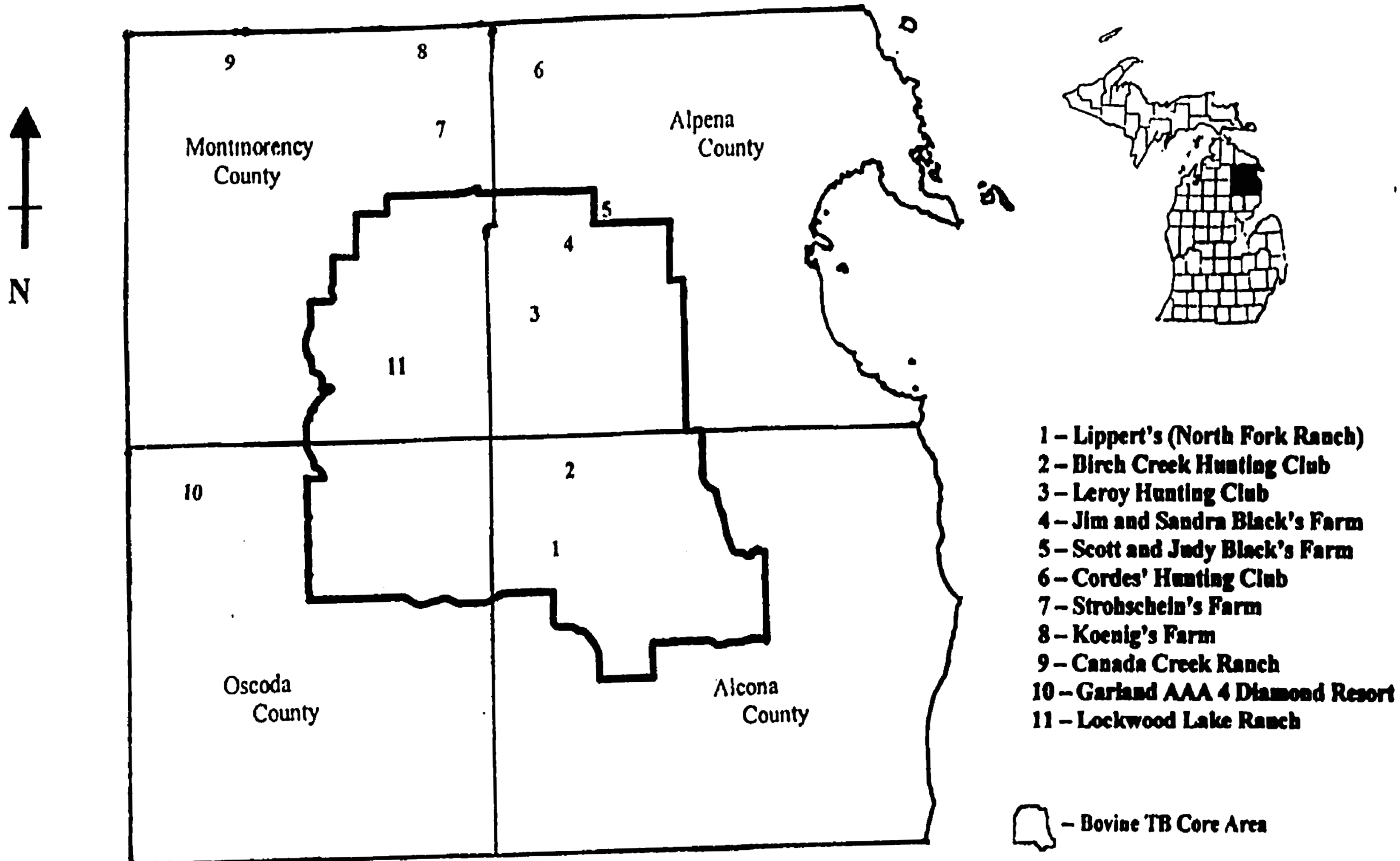


Figure 2. Study area map showing the study sites and the bovine TB core area.

habitat, but by using supplemental feed many of the habitat deficiencies could be overcome thus enabling properties with poor habitat to attract, contain and maintain higher deer densities (Peyton 2000). It was important for the properties used as the study sites to be diverse in size, ownership, deer density and habitat in order to well represent the DMU 452.

Another concern was that the study sites needed to replicate typical fall baiting and winter feeding practices of the DMU 452. The variables to be considered were: the food types used as fall baits and winter feeds, the volumes used at fall baiting and winter feeding stations, the frequency of applications of the fall baits and winter feeds, and the time periods in which the baits and feeds were used. Due to various limitations (e.g. money, time, personnel, equipment) there was a limit to how many sites could be used. Since there were restraints in the number of study sites we could select it was necessary to avoid choosing multiple research sites that were extremes and not representing the common variables of DMU 452 properties.

In addition, the preference was to work on sites where we would be allowed to continue our research throughout the entire project. Attempting to represent the appropriate habitats, deer density, and fall baiting and winter feeding practices was difficult, but finding willing property owners further complicated this task. Most of the property owners that were asked were willing and very cooperative with my research. The study sites selected for this research project appeared to represent the DMU 452 well.

Study Sites

Study sites selected prior to the ban of winter feeding

In the winters of 1996/1997 and 1997/1998 six primary and two secondary study sites were used for trapping deer (radio-collaring deer) and conducting observations. Four primary sites, on which both trapping and observations were conducted, and one secondary site, on which only observations were conducted, were located in the Core Area (Figure 2). Two primary sites and one secondary site were located outside the core area but still within the four counties of Alcona, Alpena, Montmorency, and Oscoda.

Lippert's Property (North Fork Ranch)

The Lippert's property was owned by Mr. Lawrence and Mrs. Dorthy Lippert. Late in the winter of 1998/1999 the Lippert's sold their property to Mr. and Mrs. Richard Mohammad (Figure 2). At that time I had already completed the work that needed to be conducted on the property so no attempt was made to acquire permission for property access from the Mohammad's. I did however, continue to monitor the Lippert radio-collared deer from the roads outside the property.

The Lippert's property (now known as North Fork Ranch) is located in Alcona County on HWY 65 approximately 3.2 km north of Curran, Michigan. It is in Mitchell Township, compartment T27N, range 5E and section 2. It consists of approximately 3,952 ha of hills, hardwoods and cedar swamps. The Lippert's used this property primarily as a retreat or vacation home. The property was and is currently managed by Mr. Jim Duetsch the property caretaker. Hunting was not a priority on this property even though deer were heavily baited in the falls and heavily fed throughout the winters. The

Lippert's mostly enjoyed the aesthetics of having wildlife on their property. In addition to a large population of deer, wild turkeys (*Meleagris gallopavo*), black bear (*Ursus americanus*), bald eagles (*Haliaeetus leucocephalus*) and other wildlife were common on this property.

There were approximately 11 well-established fields (each larger than 12.5 ha) that were used for food plots which were routinely planted for wildlife, especially deer. These fields were planted in either rye or clover. No deer were harvested with permission from the property owner in the fall of 1996. In the falls of 1997 and 1998 individuals did harvest with permission a number of deer from the property. During the fall of 1999 no deer were legally harvested from this property.

There were approximately five manually-applied feeding stations operated by the caretaker throughout the winter of 1996/1997 and approximately eight manual-feeding stations in operation the winter of 1997/1998. Hay, corn, sugar beets and carrots were used as feed at these stations. There were also mechanical feeders at the feeding stations but they were inoperable throughout the first winter. During the 1997/1998 winter there was an operating mechanical feeder at two different feeding stations (one a 100 pound and the other a 500 pound capacity) which spread corn three times daily (approximate times were 8:00 AM, noon, and 4:00 PM); each application was less than 60 seconds in duration. Each fall and winter the baiting and feeding stations functioned in the same locations as they did the preceding years. The primary difference between Lippert's fall baiting and winter feeding was the application. The volume of bait applications were significantly smaller in the early fall than in the late fall and winter. Of the study sites, this one supplied much more feed than the other sites and also had more deer. Even so this site was similar to a number of properties of the DMU 452.

Deer were trapped and radio-collared on this property during the winters of 1996/1997, 1997/1998 and a few days in late December of 1998. The radio-collared deer were monitored from the first winter 1996/1997 until December 1999. Winter feeding observation periods were conducted in both the 1996/1997 and 1997/1998 winters. A tranquilizing gun and darts were used during the falls of 1997 and 1998 in an attempt to increase the sample size of bucks. Observations were conducted at bait stations in the falls of 1997 and 1998. Observations were conducted on this property at feeding stations that were equipped with mechanical (spin-cast or broadcast) feeders. Observations were completed at stations where corn was spread by a granular fertilizer spreader and over corn applied by five gallon bucket in systematic lines and piles.

Leroy Hunting Club

The Leroy Hunting Club is north on HWY 65 from the Lippert's. It is in Alpena County and has as its western border Fletcher's Pond. It is in Green Township, compartment T30N, range 5E and section 28 (Figure 2). The Club is made up of approximately 30 members who hunt rabbit (*Sylvilagus floridanus*) , wild turkey, grouse (*Bonasa umbellus*), bobcat (*Felis rufus*), coyote (*Canis latrans*), black bear and white-tailed deer. Of the 3,952 ha, approximately one third is swamp adjacent to Fletcher's Pond. The majority of the remaining property is high ground consisting primarily of hardwoods. In the northeastern corner of the property there are two natural gas-wells that are in operation. A majority of the vegetation on the west side and in the middle of property was destroyed by a tornado a few years ago. The aftermath of this event is apparent, even though multiple growing seasons have passed.

On Leroy Hunting Club there was one active feeding station the first winter. The second winter a second feeding station was added. The club members would have abandoned winter feeding altogether if we had not requested that they continue. These applications needed to continue so we could collect accurate and reliable information. The original (old) feeding station had a mechanical (broadcast or spin-cast) feeder functioning both years as well as an area underneath the spin-cast feeder where the club members would pile bait and feeds manually. The spin-cast feeder would spread corn on schedule three times (approximately 8:00 AM, noon, and 5:00 PM) daily all winter; each application was less than 60 seconds in duration. The original and new feeding stations each also had a pile of hay, potatoes and sugar beets almost all winter.

On this property during the winter of 1996/1997, deer were trapped and radio-collared, observation periods were conducted at winter feeding stations and radio-collared deer movement was recorded. During the second winter the club members requested that trapping not be continued on their property. The members of the Leroy Hunting Club had a poor fall (1997) of hunting deer and some blamed the disturbances of this research project for the harvest out-come. Some members claimed that just about every deer that was seen during the hunting season was radio-collared. The end result was that trapping was discontinued on the Leroy Hunting Club after the first winter. The members of the Leroy Hunting Club did allow the observations of deer activity at feeding stations to continue and the monitoring of radio-collared deer within the club boundaries as the need emerged. The cooperating property owners were asked not to shoot any of the radio-collared deer and Leroy Hunting Club was the only place no collared deer were lost during the first hunting season. After three years of hunting seasons not one of the radio-collared deer was harvested on their property.

On this property deer were trapped, radio-collared and movements monitored from the winter of 1996/1997 until December 1999. Winter feeding observations were completed for both 1996/1997 and 1997/1998 winters, along with observations of deer feeding under a mechanical (broadcast or spin-cast) feeder and corn supplied by five gallon buckets in piles. The club members requested that no observations be conducted during the falls because of the use of the property for hunting by its club members.

Scott and Judy Black's Farm

The Black's Farm is north on HWY 65 from the Leroy Hunting Club and approximately one mile south of the HWY 32 and HWY 65 intersection (Figure 2). The property is owned by Scott and Judy Black and consists of 370 ha. It is in Alpena county, Green Township, compartment T31N, range 6E and section 31. The property has HWY 65 as the west border and Taylor Hawks Road as a border on the south. Adjacent to HWY 65 are large fields surrounding a 4.9 ha wet weather pond and as the property progresses eastward it changes from a narrow wooded area into a cedar swamp. There is one natural gas well on the property which is located in the field area within close proximity of HWY 65. The well area and access road are planted in grass which is suitable forage. The Black's farming operation is mostly for hay and beef production. On the property the Black's hunt deer and waterfowl.

This site was added the second winter as a study site primarily on which to radio-collar deer to make-up for the inability to trap and radio-collar deer on the Leroy Hunting

Club. It was not a practice of the property owners to winter feed deer, but with their permission we established feeding stations. The initiation of winter feeding here was to aid our trapping and radio-collaring tasks. Once the feeding stations were designated, observations at these stations were conducted. These stations were established to replicate others within this area of Michigan. After a number of unsuccessful trap nights to radio-collar deer it was decided that our time could be better spent on the other sites. Midway through the second winter (1997/1998), the first winter of working on this property, we decided to terminate our work here.

Lockwood Lake Ranch

Lockwood Lake Ranch is located in Montmorency County east of HWY 33 and west of Fletcher's Pond. It is in Rust Township, compartment T29N, range 4E and section 7 (Figure 2). The property is owned by the Mr. Henry Joy family and is heavily hunted by family and friends. The property is maintained by Mr. Lewis Crawford who, among other things is very active in keeping the property in a structured tree harvesting program. Mr. Joy and Mr. Crawford's objectives are to cut the timber in a manner that will benefit the wildlife; primarily the deer. The property was previously a horse ranch. No livestock are being raised on the property at the present time and the fields have been left barren. The property gets its name from the large lake (approximately 383 ha in size) found on the property. The lake is surrounded by 4,693 ha of mostly hardwood hills and some cedar swamps. The property is also occupied by 20 natural gas wells that are in operation. Roads and small fields were cleared in order to construct these gas wells. The road sides of these net-working gas wells and gas well fields were planted with suitable foraging grass.

On this property deer were trapped and radio-collared both winters (1996/1997 and 1997/1998), the collared deer were located from the first winter until December 1999, winter feeding observations were completed both winters, darting and radio-collaring of bucks was attempted in the fall of 1997, observations were conducted of fall baiting stations during the falls of 1997 and 1998 and observations were conducted over corn supplied in five gallon amounts (both corn lines and piles). There were three active feeding stations the first winter, one of which was also used the second winter. The first winter feeding stations were mostly round hay bales and corn (spread manually, from 5 gallon buckets). The landowners planned to abandon winter feeding because of the state's request and because of the substantial costs. However, I requested from the landowners that winter feeding continue through the winter of 1997/1998 in an attempt to increase the likelihood of successfully trapping and radio-collaring deer as well as to benefit the winter feeding research. During the second winter, besides the original feeding station, four new feeding stations were added. None of the stations had hay and all but the original station had a large pile of potatoes with an occasional bucket of corn spread over the potatoes. These new stations were designed in a manner that would replicate other stations in this area of Michigan. The original station (from the first winter) was maintained only by manually spread buckets of corn.

The fall baiting piles were more numerous (roughly 10 continuously used) and in more locations than the winter feeding stations. Most of the fall baiting stations were simply applications of shelled-corn by bucket. There were a few fall baiting stations that had small piles of sugar beets.

Strohschein's Farm

The Strohshein Farm (site five) is located north of Hillman on Morrow road, west of HWY 451 and it is also in Montmorency County. It is in Montmorency Township, compartment T32N, range 4E and section 27 (Figure 2). Mr. and Mrs. Arthur Strohschein are the property owners. The farm is approximately 395 ha consisting of mostly fields and some woods. The wooded area consists mostly of spruce (*Picea mariana* and *Picea glauca*) and pine (*Pinus strobus* and *Pinus resinosa*). There is some swamp on the farm and it occupies approximately 15 percent of the property. The farm is primarily a beef-cattle operation and is hunted (for deer) heavily by family and friends annually.

On this property, deer were trapped both winters (1996/1997 and 1997/1998), the radio-collared deer were monitored from the first winter until December 1999 and winter feeding observations were conducted both winters. One feeding station (manually applied) was active both winters and it was located close to the center of the property. The feeding station included square bales of hay and spread corn (by bucket). No fall baiting observations were conducted here because of hunting activity.

The first winter, after looking for additional trap locations on the farm, it was decided to attempt to place a trap on Kant Make It Klub. The club is on the southwestern border of the Strohschein farm. Permission was granted and a trap was placed. The trap site was so close to the Strohschein farm it was referred to as the Strohschein trap 3. The second winter all traps were placed on the farm.

After the ban on fall baiting and winter feeding the Strohschein's planted winter food plots (winter wheat and standing corn) as a means to supply something for the deer.

Lanes throughout their wooded property were planted with wheat as well.

Koenig's Farm

The Koenig's Farm was one of the five sites used the first winter (1996/1997) but it was evacuated mid-way through the trapping season because of poor trapping success (Figure 2). A large unharvested field of corn was the suspected reason for the poor trapping success. During the second winter this farm was not used. The Tom Koenig family are the owners of the property. This farm is located in the northern most portion of Montmorency County. It is in Montmorency Township, compartment T32N, range 4E and section 9. It consists of 395 ha of mostly fields and some woods. The wooded area is mostly spruce and pine. There is some swamp area on the property too. The farm was a small dairy operation of less than 30 cows. There were no feeding stations on this farm, however the Koenigs claim the deer would come up to the barn and feed from stacked round bales. Annually, some deer hunting is done on the farm by family members.

Cordes' Hunting Club

Some winter observations were conducted, only the first winter (1996/1997), on the Cordes' Hunting Club but it is not considered a primary study site because no trapping was done there (Figure 2). This Hunting Club is located north of Hillman in the northwestern portion of Alpena County. The reason it was used as an observation site was because it had two active winter feeding stations. Both feeding stations were supplied with beets, potatoes and hay. One feeding station was lighted at night making night observations possible. This property had been used by Sitar (1996) on another deer research project as a study site.

Birch Creek Hunting Club

In the early part of the second winter the Birch Creek Hunting Club was the site selected as an additional site where deer feeding activity under mechanical feeders (broadcast or spin-casting corn feeders) could be observed. This was another site that was not considered a primary study site because no trapping was done on the property (Figure 2). Birch Creek Hunting Club is north 3 miles on HWY 65 from the Lippert property and is also in Alcona county. There were over 5 feeding stations throughout the property that had mechanical feeders. The feeders were re-filled only twice during the fall and winter seasons because they had the capability of holding multiple tons (approximately 6 to 10 tons) of feed. The feeders would spread feed twice a day (approximately 7:00 AM and 5:00 PM) for time periods of 15 to 30 seconds each time. All mechanical feeders were also accompanied by hayracks. These hayracks were wood framed structures which supply square bales of hay to the deer.

Study sites selected after the ban of winter feeding

In 1998 the Michigan Department of Agriculture placed a ban on winter feeding of deer in the DMU 452 (Table 1). This ban went into effect the winter of 1998/1999 and was to be observed in DMU 452 only. One of the objectives of this study was to determine if deer behavior changed after fall baiting and winter feeding was halted. It was suspected that trapping in the winter months and using bait as the lure could be interfering and altering "natural" deer behavior at our study sites. It was on this assumption that we chose to abandon the practice of trapping on the old study sites (Leroy Hunting Club, Lippert's, Lockwood Lake Ranch and Stroschein's Farm) the winter of 1998/1999. Even though trapping was discontinued on the old sites, monitoring of the radio-collared deer was continued on these sites.

In the winter of 1998/1999 four new trapping sites were used. Again, an attempt was made to best represent the many variables of this area. The MDNR had discovered bovine TB in deer more to the west of the core area so their area of interest expanded simultaneously. In choosing our four new study sites we felt that it was necessary to expand in a westward direction while at the same time representing the core area. We chose 2 new sites (Canada Creek Ranch and Garland AAA 4 Diamond Resort) further to the west and 2 sites (Birch Creek Hunting Club and Jim Black's Farm) still within the core area.

Canada Creek Ranch

In northwestern Montmorency County west of HWY 33, east of Otsego County, and south of Presque Isle County is the Canada Creek Ranch (Figure 2). It is in Montmorency Township, compartment T32N, range 1E and is included in many sections. The property is owned by 1,550 members and is heavily hunted by members and their families and friends. The property consists of 34,580 ha, 30,875 ha of which are undeveloped. There is one major creek (Canada Creek) which flows through the east portion and approximately 7 lakes on the property.

The developed area is on the east side of Canada Creek and it includes 3,705 ha. This area is found in the northeastern portion of the Canada Creek property. The residential area includes many houses and cabins, which either are year-round dwellings, weekend get-a-ways or hunting/fishing camps. There are 600 houses or cabins, many rental cabins, a hotel (20 room), a camp ground and restaurant within the development.

Of the undeveloped property; approximately 10% is swamp, 20% is grassland or fields, and 70% is forested. They plant 98.9 to 148.2 ha of the open fields in rye, wheat, clover and/or legumes for summer food plots for wildlife. The forest includes a diversity of species consisting of approximately 20% aspen (*Populus tremuloides*, and *Populus grandidentata*), 20% oak (*Quercus alba, Quercus macrocarpa* and *Quercus rubra*), 20% northern hardwoods (*Acer saccharum, Betula alleghaniensis, Fagus grandifolia* and *Tsuga canadensis*), 20% conifers (e.g. *Larix laricina, Abies balsamea* and *Thuja occidentalis*) and 20% a mix of other species. The ranch owners are active in harvesting timber from their property, but they do so in a manner to benefit wildlife. The well-being of the fish, wildlife and their habitats are of utmost importance to the ranch members.

Work was conducted only in a specific area of the ranch property just to the east of the northwestern corner. This area was in a cedar (*Thuja occidentalis)* swamp which was determined to be ideal habitat in which to trap deer. This area was also ideal because it was far enough away from the designated residential area that during the trapping season (winter months) it was fairly quiet and secluded. To the north of the swamp was the Mackinaw State Forest and Cheboygan County. Deer were trapped and radio-collared in an area between 305.0 and 610.1 ha in size. Within the Canada Creek Ranch property deer were trapped, radio-collared and monitored.

Garland AAA Four Diamond Resort Complex

Garland AAA Four Diamond Resort Complex was the other site on which deer were trapped in the western area of the DMU 452 (Figure 2). The property owner is Mr. Ron Otto. The property director of development is Mr. David Stebbins. The property is in northwestern Oscoda County five miles south of Lewistown on county road 489. It is in Greenwood Township, compartment T28N, range 1E and is included in many sections. It is bisected vertically by county road 489 and has Williams road distinguishing it's northeastern border. The property consists of approximately 8,645 ha. All access roads to the property have locked gates except the main entrance to the resort and a few front residential roads. The property is a AAA four diamond resort complex, which includes 4 elite golf courses (72 holes), a restaurant, a hotel (120 rooms), 12 elaborate houses, 90 villas or cottages, a 5,000 foot paved, lighted privately owned public airport and 160 lots that are for sale. Some of the dwellings are year-round homes while others are vacation or weekend get-a-ways. There is a white-tailed deer, boar *(Sus scrofa)*, and elk (*Cervus elaphus*) enclosure in a large portion (2,717 ha) of the property east of county road 489. This enclosure is called Garland Safari in which guided hunts are sold.

West of county road 489, behind the golf courses and houses is a large area of the property that is undeveloped. This area is baited and hunted each fall by deer hunters. Deer were trapped and radio-collared in the undeveloped area as well as on the property just south of their enclosure which is just north of the southeastern border. It is in this southeastern area that the property adjoins state property. This property was a preferred site because they practiced fall baiting and winter feeding. This site provided a good representation of other properties similar to it in the DMU 452. There are many golf courses in the DMU 452, and there are many enclosures of relative size similar to the enclosure on Garland in the DMU 452. Deer were trapped, radio-collared and monitored on the Garland Resort property.

Birch Creek Hunting Club

Deer were trapped, radio-collared and monitored on the Birch Creek Hunting Club property. Previous work had been conducted on this property and through that experience it was decided that this site was appropriate as one of the new sites (Figure 2). This site was considered because it is located well within the bovine TB core area. Birch Creek Hunting Club is north 3 miles on HWY 65 from the Lippert property and also in Alcona county. It is in the Mitchell Township, compartment T28N, range 5E and section 13. It is east of HWY 65 on Bugg Road approximately 2 miles. The property is 1,580 ha of mostly hills and upland hardwoods. There is a creek which runs through the property from the west side to the east side and along the creek cedar swamps can be found. The forested area is mostly made-up of oaks, maples, pines, cedars, spruces, and aspen. The forested areas are managed to benefit the wildlife in this area.

The property is owned by 10 members who manage the property for the sole purpose of hunting (especially deer hunting). Mr. Larry Ruhstorfer is the club president. There are four houses on the property and all are somewhat centrally located. Included in the houses are two cabins, a large clubhouse, and one residential site (house). There are two lakes that are located in close proximity to the houses; one is 3.7 ha and the other is 6.18 ha. There are approximately 148.0 ha of fields throughout the property which are regularly planted as wildlife food plots. They are planted with oats, wheat, buckwheat, sunflower, soybean, alfalfa, or corn. The club members have created and planted more fields since the fall baiting and winter feeding bans in order to supply something for the deer.

This property, cabins, and clubhouse are used by the members as weekend get-always or as a vacation site throughout the year except during the hunting season. During the hunting season it is used fairly often by all the members as a hunting camp. It is hunted heavily for deer by the members, their families and friends. This property has had a large number of deer residing on the property especially throughout the winter months. Other game animals that are regularly and successfully hunted on the club property include turkey, grouse, bear, coyote, and raccoon.

On this property in years past, members fed deer heavily through the winter months. The majority of the feed applications were through the use of mechanical spin-casting feeders (spreading shelled corn) and hay racks. These mechanical feeders were at each one of the club's feeding stations that were scattered throughout the property. The feeders were equipped with very large grain bins (multiple ton capacity) which required very limited attention. The hay racks were large structures that were able to hold multiple square bales of hay and these were frequently refurbished.

Jim and Sandra Black's Farm

Jim and Sandra Black's farm was the fourth new site that was chosen as a new study site (Figure 2). This site was chosen because it was within the bovine TB core area. This farm is not to be confused with Jim's brother and sister-in-law's (Scott and Judy Black) farm. The farm is in Alpena County, 1.0 miles east of Fletcher Pond, approximately 0.5 miles south of the intersection of Taylor Hawks Road and HWY 65. It has as it's east boundary HWY 65. This farm is located in the Green Township, compartment T35N, range 5E and section 6. The owners farm row-crops on this farm. The row-crops which are planted here include: beans, corn, wheat and oats. Seven hundred and forty-one ha of the property are farmed and the remainder of the property is 185.3 ha of forested area and 61.8 ha of swamp. The farmed area is mostly on the east side of the property adjacent to HWY 65. The forested area is mostly located in the northwestern portion and it includes a mixture of tree species from oaks to cedar. The swamp is mostly included in a south area just west of the middle of the property. There is a 4.9 ha pond which is located between the farmed property and the forested area. There are two natural gas wells are on the property and they are regularly checked by gas-well attendants. The property is heavily hunted for deer by both family and friends.

Deer were trapped and radio-collared in the forested and swamp areas of this property. All of our work was conducted on the west side of the farm. This farm was a choice site for some deer throughout the winter months because of thermal cover due to the topography of the farm as well as the trees. During the spring months the fields of this property are covered (we have observed multiple times well over 100 deer in one field) with deer foraging on fresh or new grasses. Deer were trapped, radio-collared and monitored on the Black's Farm.

GENERAL METHODS

Trapping

Marking deer with radio-collars and ear-tags was fundamental to the success of each objective of this study. The information presented in all of the following chapters hinged on either monitoring radio-collared deer or identifying deer marked with radio-collars or ear-tags. Deer were trapped at eight sites in the camp-club region of Michigan's northern lower peninsula (Alcona, Alpena, Montmorency and Oscoda counties) during the winters of 1996/1997, 1997/1998 and 1998/1999. Each of these areas were sites where fall baiting and winter feeding of deer had been common at least during the previous two to three years. Similar trapping procedures were followed from year to year.

Clover traps (Clover 1954, 1956; Nelson and Mech 1992, Beringer et al. 1996) were used for trapping because of their convenience, ease in placement and operation, and ability to restrain a captured deer while at the same time protecting the trappers from the captured animal. Box traps (Van Deelen 1995, Mooty et al. 1987) were also used to capture deer during these seasons. Box traps were not as mobile but they seemed to be more successful in capturing deer. Some of the benefits box traps had over clover traps were that box traps required less maintenance, protected the deer from predation or being frightened, offered more thermal cover and were not tripped as easily by other animals. During the first trapping season more emphasis was placed on the use of clover traps because of their availability. However, in the second and third seasons the access to either type trap was equal and our preference was for box traps.

Traps were baited up to four days prior to setting them or until deer sign was evident. The preferred clover trap sites were in thick cover within close proximity to a winter feeding station and along heavily traveled pathways. The preferred box trap sites were similar to those of clover traps, but were not limited to sites with good thermal cover. The box traps could also be placed on or adjacent to a winter feeding station in areas with no thermal cover. Shelled corn was the primary bait, but bait was adjusted to match the winter feed being used at each trap site. On the occasions when it appeared that deer were reluctant to enter the traps, the trap's bait was then enhanced with sliced apples and molasses.

Once the traps were set they were left for a maximum of 24 hours without being checked (Beringer et al. 1996). To insure the safety of captured animals we attempted to check each trap well before an animal could have spent 24 hours in captivity.

Traps were not set when the temperature was forecasted to be below -12.2 °C or when the wind chills were below -17.8 °C for fear of trap mortalities. In cases of unfavorable weather the traps were tied open and heavily baited so visiting deer could become comfortable with entering the traps, but would not be detained. The clover traps were more often tied open because of unfavorable weather than the box traps.

When restraining the captured deer we blindfolded them and attempted to handle them as efficiently as possible (Beringer et al. 1996), being sensitive to noise and duration of stress. The captured animals were restrained for only a matter of minutes; long enough to determine sex and age, ear-tag them and fit them with a radio-collar. The age of the captive deer was determined by evaluating the progressive wear and replacement of molars on the lower jaw (Severinghaus 1949, Sauer 1984).

Trapping the first winter began December 31, 1996 and was concluded March 28,

1997. Fourteen clover traps and two box traps were used. Throughout the trapping season the number of traps at each site changed as necessary. The goal of having at least fifteen collared deer per trapping site was accomplished at two sites but we were not able to maintain that number due to mortalities.

The second trapping season officially began January 7, 1998 and concluded March 28, 1998. Of the traps used, there were fourteen clover traps and eight box traps. Again, the traps were moved from site to site to optimize our success. Our initial goal was to have 15 radio collared deer at each primary study site. However, because of the unseasonably warm winter and subsequent variable trapping success, we modified our goal to merely ensuring that all available collars were used. The warmer weather complicated our trapping success, so wherever trapping was more successful a few more collars were placed.

The third trapping season began December 28, 1998 on the Lippert's property, but was temporarily halted December 31, 1998 because of trap site selection. It was at this time we abandoned the old trap sites (Leroy Hunting Club, Lippert's, Lockwood Lake Ranch and Strohschein's Farm) and received permission to trap deer on the new study sites. Trapping on the new sites was initiated on February 1, 1999 and concluded on April 4, 1999. Of the traps used there were fourteen clover traps and eight box traps. Again, the traps were moved from site to site in order to benefit our success. Again, our initial goal was to have 15 radio collared deer at each study site. These sites were not in the practice of using winter feed (winter feeding had been halted) so trapping was more difficult. The winter was again unseasonably warm adding difficulty to our trapping success so we modified our goal to a minimum of five radio-collared deer per study site.

Darting

Darting was used as a method to collar adult bucks. Within the months of September through November 1997 and 1998 we attempted to dart bucks because the traps (clover and box) were selective for deer other than mature bucks. We chose these months because we wanted the antlers to be on the bucks (for identification) and at this time the antlers should be beyond the velvet stage. We used, as recommended by Stephen Schmitt (MDNR, veterinarian, pers. comm.), a mixture of Rompun and Telazol (2 cc) as our tranquilizing drug. We used a 32 gauge Palmer dart rifle (in 1997 and 1998) and a Pneu-dart rifle model 194 (in 1998) with disposable 2 cc, wire-barbed darts equipped with radio-transmitters from the Pneu-dart company (Kilpatrick et al. 1997). Both rifles were operated with Pneu-dart 22 caliber charges; Medium #3 Green. The Pneu-dart rifle proved to be the rifle of choice because it was equipped with a 4 powered scope and the rifle gives the user the ability to adjust the velocity for each shot; assuring better shots with less injuries. Deer were darted at well-established fall bait piles from blinds and they were darted along roadsides and in fields from a truck. These techniques were conducted on two of our study sites (Lippert's and Lockwood Lake Ranch) each of which were greater than 500 ha. Both properties had roads that meandered throughout and bait piles scattered throughout the properties. We darted from the truck and from blinds at bait piles during the day and throughout the night. During the night hours we used a spotlight to enhance our visibility.

Upon contact with a deer, the tranquilizing agents were injected into the animal by a charge from inside the dart. After darting a deer we waited 6 to 10 minutes to ensure that the agents had sufficient time to work and to guarantee that a darted deer would not injure itself due to our approach. After the desired time passed we located the darted deer with a hand-held receiver and proceeded with aging, ear-tagging and radio-collaring the animal. Each darted deer was equipped with a white ear-tag (5 x 7 cm) labeled with a warning against consuming this animal before a given date. Dr. Schmitt (MDNR Wildlife vet.) stated that 5 days would be more than enough time for the immobilizing agents to be eliminated from the darted deer.

Marking

All captured deer were marked with two colored ear-tags (Fearing medium hog tags) and each capture year had an appropriate series number. For example, the first year of capturing deer we used 100 series ear-tags and in year 2, 200 series ear-tags. Distinct combinations of colors and ear-tag numbers allowed the identification of individual deer (Sitar 1996). For ease in identifying ear-tagged deer, each study site was given its own tag colors. Each of the radio-collars (LMRT – number 3, Lotek Engineering Inc., Newmarket Ontario or Model 505, Telonics Inc., Mesa, AZ) was equipped with motion-sensitive mortality sensors (4-hour sensors) and had a minimum battery life of three years. The same radio-collars were used for fawns except a strip of foam (approximately 3 x 5 x 40 cm) was added to the inside of the collar for a spacer to allow room for growth. All collars were painted blaze orange to make radio-collared deer more visible in natural settings. The radio-collars are originally either white or brown; neither color is optimal for detecting during a incidental observations. White is very difficult to identify in winter settings and brown is difficult to identify in most any setting. All collars were marked with an appropriate address and phone number to facilitate return of the collars. Metal dog-tags with the appropriate information were riveted to each collar the winters of 1997/1998 and 1998/1999. All individuals involved in handling deer wore appropriate gloves and face masks (3M 1860 Health Care Particulate Respirator Type N95) to minimize the possibility of contracting bovine tuberculosis. All practices used in trapping, handling, and marking were approved by the All-University Committee on Animal Use and Care (AUF# 12/96 - 178 - 00).

CHAPTER 2: BEHAVIORAL RESPONSES AT WINTER FEEDING AND FALL BAITING STATIONS.

Fall baiting and winter feeding of white-tailed deer has been common for many years in the states of the Great Lakes region (Lewis 1990). Large hunt clubs have fed deer for decades to maintain artificially high numbers (Peyton 2000). Doenier (1997) found supplemental feeding of deer had increased in north-central Minnesota in recent years. Many times throughout the years of my field work, property owners of the DMU 452 had expressed the importance of baiting in order to lure and keep deer on their property thus ensuring successful fall harvests. Also, many times it had been expressed that if you did not bait deer during the fall hunting seasons you would not see deer and those properties in close proximity that did bait would have "your deer". Winterstein et al. (1995) reported that the number of hunters that used bait increased from 29 % in 1984 to 41 % in 1991. Peyton (1994) found in a survey of Michigan deer hunters that their reasons for baiting deer included: deer hunters believed that if they baited they would see more deer and that the bait would draw deer from other hunters. After conversations in the DMU 452 with many hunting club members, many residential individuals and some feed store owners it was discovered that these beliefs, in most areas of the DMU 452, evolved into the belief that the more bait that is applied or supplied the better. In conversion it was also discovered that the number of bait and feed stations as well as the volume of the applications had increased since the early 1980's.

The practices of winter feeding evolved similarly in that some property owners believed that if they could keep deer on their property throughout the winter and then if they planted summer food plots this would guarantee that those deer would be there for the fall hunting seasons. Again, in time the volumes of winter feed increased on most properties and again the behavior became very competitive.

In addition, through conversion with individuals in the DMU 452 the following had been identified as some of the reasons why some individuals fed deer during the winter months: 1) to increase the likelihood of more deer surviving the winter or to support deer numbers that natural forage would not (Karns 1980, Lewis 1990), 2) to attempt to lure (Darrow 1993) and hold deer on their property, 3) because it was legal, 4) because the MDNR did not dissuade the practice and 5) for wildlife viewing (Hiller 1996).

Observations were conducted at fall baiting (falls of 1997 and 1998) and winter feeding (winters of 1996/1997 and 1997/1998) stations because the behaviors of deer at these stations were believed to have played a major role in the spread of bovine tuberculosis within the deer herd, and potentially to domestic livestock. Data are scarce on how deer behave at fall baiting and winter feeding stations (Lewis 1990).

In this chapter, I describe deer behavior at fall baiting and winter feeding stations in the 4 counties that include the core TB area. Comparisons are made between the 2 falls for which deer behavior was documented as well as between the 2 winters for which data were collected. Lastly, I evaluated specific baiting and feeding practices that have been applied in and around the core TB area.

METHODS

Winter Feeding

The winter feeding stations were observed from blinds, trucks and sometimes permanent buildings by using spotting scopes, binoculars and night-vision scopes. At each feeding station the number of deer present was recorded and if there were marked (radio-collared and/or ear-tagged) deer present it was noted as well. The feeding behavior of deer was observed and recorded at the Leroy Hunting Club, Lippert's, Lockwood Lake Ranch and the Stroschein's Farm the winters of 1996/1997 and 1997/1998. In addition less than 10 observation periods were conducting at the Cordes' Hunting Club the winter of 1996/1997. Observations were conducted at spin-cast feeder sites at the Birch Creek Hunting Club the winter of 1997/1998. Deer behavior was recorded during the falls of 1997 and 1998 at the Lippert's and the Lockwood Lake Ranch fall baiting stations.

The major intent during winter observations was to record the face-to-face (F2F) contacts. F2F contacts included both nose-to-nose (N2N) and within-3-feet (WN3) contacts. A N2N contact was when 2 or more deer heads were literally nose-to-nose. The standard N2N measurement was any contact 15 cm or less apart. WN3 contacts were when heads (noses) would come literally within a meter of each other and yet greater than 15 cm. Also, it was suspected that N2N contacts would increase the likelihood of disease transmission between deer (Petoskey 1980, Lewis 1990). N2N and WN3 contact data were recorded, but it was determined that distinguishing these two measurements was not as important as having one measurement of close contacts (F2F contacts) among deer at feeding and baiting stations.

After arrival at an observation station the observers allowed thirty minutes for the area to settle down. If deer began feeding at the feeding station before the thirty minute waiting period expired the 60 minute observation period began. If not, the observers waited the complete thirty minutes and then began the 60 minute observation period whether deer were there or not.

There were two observation data sheets used while observing the deer. The first data sheet (Appendix Figure 9) was used to record the behavior of unmarked deer at the baiting and feeding stations. On data sheet 1, stations were divided into two types: those with spread food and those with piled food. In general, spread foods were those that the horizontal distance covered was much greater than the vertical height of the food. In other words foods that were spread had some uniform depth in appearance. The piled foods were those that appeared to have a vertical height that was not uniform throughout the horizontal distance covered. Every five minutes within the hour-long observation period, a head count was taken and the number of WN3 contacts at that time was also recorded. N2N contacts were recorded every time they were observed throughout the observation period. At times during observations the concentration of deer was so great it was impossible to see everything. Therefore, the number of F2F contacts recorded may be lower than the actual contacts made.

Data sheet 2 (Appendix Figure 10) was used while observing marked deer that were at the stations during an observation period. These deer were observed continually throughout the sixty-minute time period. A marked deer included a deer with a radio-collar and ear-tags, a deer with a radio-collar only or a deer with an ear-tag only. It was also discovered that when multiple marked deer were at the feeding stations the data collection proved to be quite challenging.

Other information that was recorded during an observation period was the name of the study site and station being observed, the date, the times of the beginning and end of the observation period, the names or initials of the observers, weather conditions, the approximate temperature and the approximate wind. On data sheet 1 (Appendix Figure 9) next to spread feed and piled feed there was a blank provided to list the type or types of food available. All observers were expected to record on the data sheets a detailed description of the food supplied at the winter feeding or baiting stations. It was common practice for the observers to draw a description (in the right-hand margin of data sheet 1) of each observed station labeling food types and listings detailed dimensions. The results presented in this chapter are spread feed and piled feed combined.

Fall Baiting and Alternative Methods of Feeding

The fall baiting observations were conducted using the same method as the winter feeding observations. As an added interest we also studied some alternative ways of feeding. The practices we observed were the use of mechanical feeders such as spin-cast or broadcast feeders (corn was the feed used) that fed according to a timer and corn thrown by a granular fertilizing machine pulled behind a tractor. The spin-cast feeders were observed at multiple sites and the fertilizer spreader was only used at one site. We were able to conduct 40 observation periods studying deer activity under spin-cast feeders and 12 observation periods of deer activity in the area of corn spread by the fertilizing machine. The data collected were recorded in the same manner as for the winter feeding and fall baiting observation periods.

During the time that fall baiting and winter feeding bans were being considered (approximately late in 1997 or early 1998), the MDNR decided to impose a limit to fall baiting instead of a total elimination. In 1998, the MDNR limited fall baiting in the DMU 452 to 5-gallon amounts of bait at one site at a time. I decided to observe the deer activity at 5-gallon corn piles and lines in the winter of 1997/1998 in order to give the MDNR a better understanding of what they were initiating. I had observed these practices in the previous year (winter of 1996/1997 and fall of 1997) and suspected that these practices would cause an increased number of contacts. After some consideration it was decided to observe the practices of 5-gallon piles and lines because they were the two easier ways of applying bait/feed and they were the easiest to replicate as well. Sixty observation periods studying 5-gallon corn piles and 65 observation periods studying 5-gallon corn lines were completed. The replicated corn piles averaged approximately 61 cm in diameter and 12.7 cm deep. The replicated corn lines observed averaged approximately 20 cm wide by 8 m long and 2 cm at the deepest point. The data were collected and recorded in the exact manner as the fall baiting and winter feeding observation data so comparisons would be appropriate.

RESULTS

During the winters of 1996/1997 and 1997/1998 feeding stations were operated as normal, but the third winter (1998/1999) feeding was discontinued because winter feeding was banned by the MDA in the DMU 452 (effective January 1999). Figure 3 shows the activity of deer around winter feeding stations during the winters of 1996/1997 and 1997/1998. Overall as the concentration of deer increased so did the

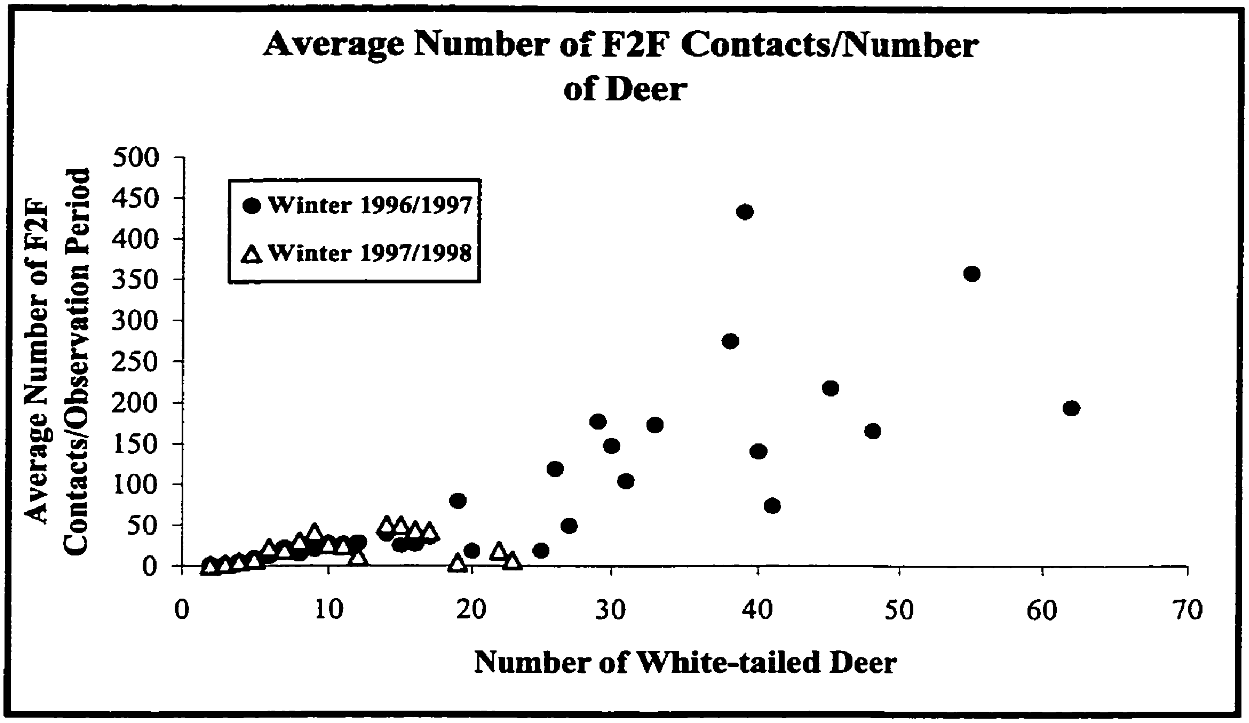


Figure 3. Average number of face-to-face (F2F) contacts per observation period for different numbers of deer during the winters of 1996/1997 and 1997/1998.

number of contacts. The first winter our observation periods began January 17, 1997 and ended April 14, 1997. During the winter of 1996/1997 there were 152 observation periods, 1,298 deer observed, 2,132 WN3 contacts and 2,142 N2N contacts were recorded. There was an average of 8.6 deer (n = 152, range = 0 to 62) with an average of 28.1 F2F (n = 152, range = 0 to 238) contacts per observation period (Table 2). The second winter our observation periods began January 10, 1998 and concluded April 3, 1998. During the 1997/1998 winter (Figure 3) we had 203 observation periods, observed 778 deer, recorded 707 WN3 contacts and 1,013 N2N contacts. There was an average of 3.8 deer (n = 203, range = 0 to 23) with an average of 8.5 F2F (n = 203, range = 0 to 61) contacts per observation period (Table 2). Even though not as many deer were observed during the winter of 1997/1998 the numbers of F2F contacts

Table 2. Methods of baiting or feeding, average number of deer observed per period and average number of face-to-face (F2F) contacts per observation period in northeastern lower Michigan.

METHOD OF BAITING/FEEDING	AVERAGE NUMBER OF DEER OBSERVED PER PERIOD	AVERAGE NUMBER OF F2F CONTACTS PER PERIOD
WINTER FEEDING-1996/1997 n = 152	8.6 (range = 0 - 62)	28.1 (range = 0 - 238)
FALL BAITING-1997 n = 215	2.2 (range = 0 - 18)	3.1 (range = 0 - 34)
WINTER FEEDING-1997/1998 n = 203	3.8 (range = 0 - 23)	8.5 (range = 0 - 61)
FALL BAITING-1998 n = 189	3.1 (range = 0 - 15)	12.3 (range = 0 - 100)
SPIN-CAST FEEDER-WINTER 1997/1998 n = 40	3.6 (range = 0 - 31)	3.1 (range = 0 - 28)
FERTILIZER SPREADER - WINTER 1997/1998 n = 12	37.0 (range = 0 - 92)	2.6 (range = 0 - 6)
5 GALLON BUCKET-LINES - WINTER 1997/1998 n = 65	6.9 (range = 0 - 24)	26.6 (range = 0 - 164)
5 GALLON BUCKET - PILES - WINTER 1997/1998 n = 60	4.3 (range = 0 - 35)	43.3 (range = 0 - 318)

replicated those F2F contacts of the winter of 1996/1997 in relation to the number of deer observed.

The winter feed types and volumes that were observed at the winter feeding stations during the winters of 1996/1997 and 1997/1998 were constant among the study sites. The volume of an individual feed pile observed ranged from a 5-gallon bucket of shelled corn spread daily (in relatively the same location and same time daily) to a pile of sugar-beets (more than 5 tons in volume) complimented with an occasional square bale of hay and/or shelled corn spread over it. The types of feeds used at the study sites were shelled corn, ears of corn, various types and volumes of hay (square and round bales), potatoes, carrots and sugar-beets.

Two fall seasons of fall baiting data were collected. The first fall observation period began September 9, 1997 and ended December 18, 1997. Figure 4 shows the activity of deer around fall baiting stations in 1997 and 1998. During the fall of 1997 we had 215 observation periods, observed 447 deer, recorded 289 WN3 contacts and 370 N2N contacts (Figure 4). There was an average of 2.2 deer (n = 215, range = 0 to 18) with an average of 3.1 F2F (n = 215, range = 0 to 34) contacts per observation period (Table 2). The second fall observation periods began September 16, 1998 and ended December 31, 1998. During the fall of 1998 we had 189 observation periods, observed 566 deer, recorded 1,076 WN3 contacts and 1,255 N2N contacts (Figure 4). There was an average of 3.1 deer (n = 189, range = 0 to 15) with an average of 12.3 F2F (n = 189, range = 0 to 100) contacts per observation period (Table 2). There were an increased number of F2F contacts per number of deer at fall baiting stations in 1998 as compared to the fall of 1997.

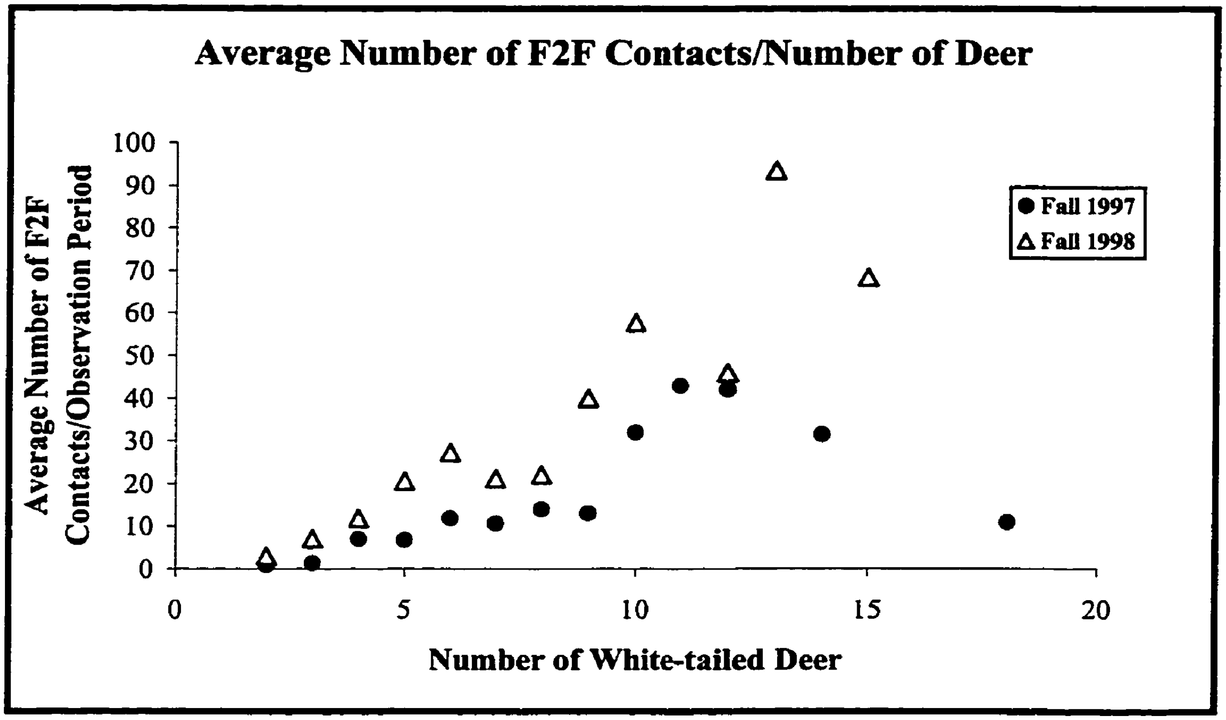


Figure 4. Average number of face-to-face (F2F) contacts per observation period for different numbers of deer during the falls of 1997 and 1998.

During the winter of 1997/1998, 40 observation periods were conducted at winter feeding stations maintained by broadcast or spin-cast feeders; 290 deer, 70 WN3 contacts and 55 N2N contacts were recorded (Figure 5). There was an average of 3.6 deer (n = 40, range = 0 to 31) with an average of 3.1 F2F (n = 40, range = 0 to 28) contacts per observation period (Table 2). After conducting 12 observation periods during the winter of 1997/1998 at feeding stations that were refurbished by a fertilizer spread, 438 deer, 20 WN3 contacts and 11 N2N contacts were recorded (Figure 5). There was an average of 37.0 deer (n = 12, range = 0 to 92) with an average of 2.6 F2F (n = 12, range = 0 to 6) contacts per observation period (Table 2). Except for one case (with approximately 19 deer) more F2F contacts were observed (per number of deer) at spin-cast feeders than were recorded while observing at a fertilizer feeding station (Figure 5). Many more deer

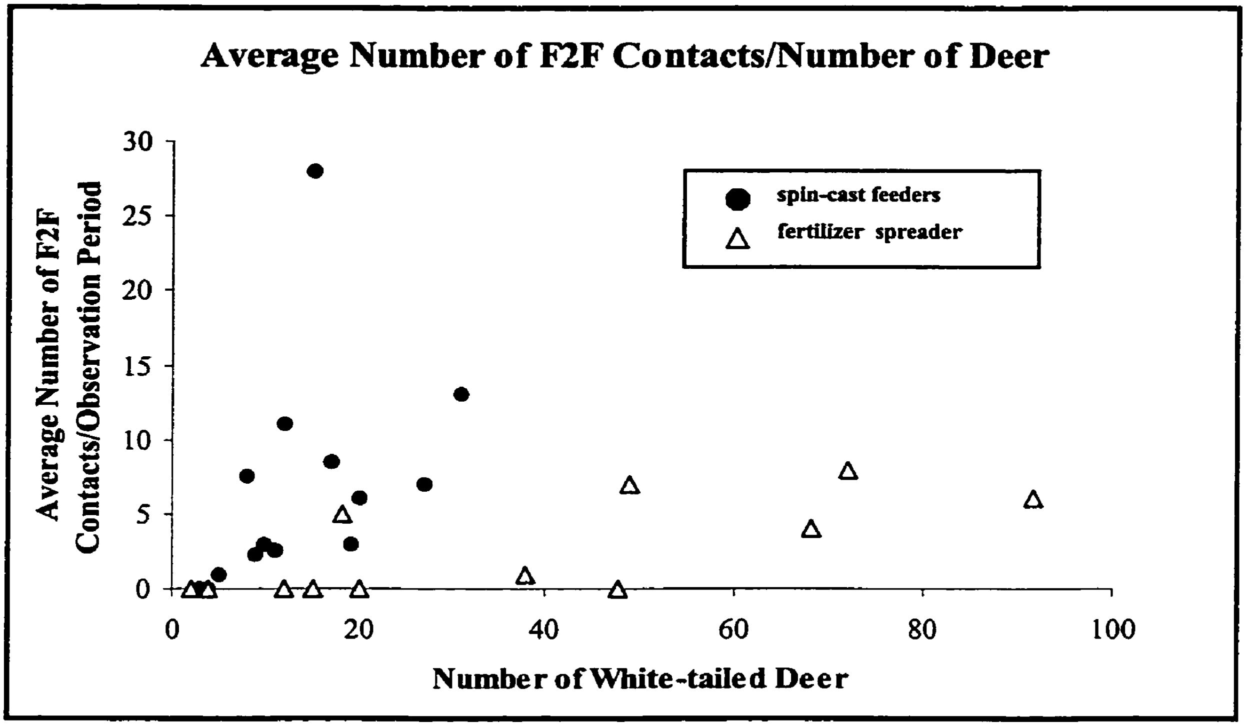


Figure 5. Average number of face-to-face (F2F) contacts per observation period for different numbers of deer during the winter of 1997/1998 using spin-cast feeders and a fertilizer spreader.

were observed feeding at fertilizer stations than at the spin-cast feeder stations and yet fewer F2F contacts occurred. Fewer contacts occurred at both of the alternative methods of feeding than any of the other methods or seasons observed (Table 2). Additionally, approximately 100 deer made less than 6 F2F contacts at a fertilizer feeding station (Figure 5).

After conducting 65 observation periods at winter feeding stations that were supplied with only 5-gallons of corn spread in a line 449 deer, 664 WN3 contacts and 1,066 N2N contacts were recorded (Figure 6). There was an average of 6.9 deer (n = 65, range = 0 to 24) with an average of 26.6 F2F (n = 65, range = 0 to 164) contacts per observation period (Table 2). There were 256 deer, 1,585 WN3 contacts and 1,015 N2N contacts recorded after conducting 60 observation periods at winter feeding stations that

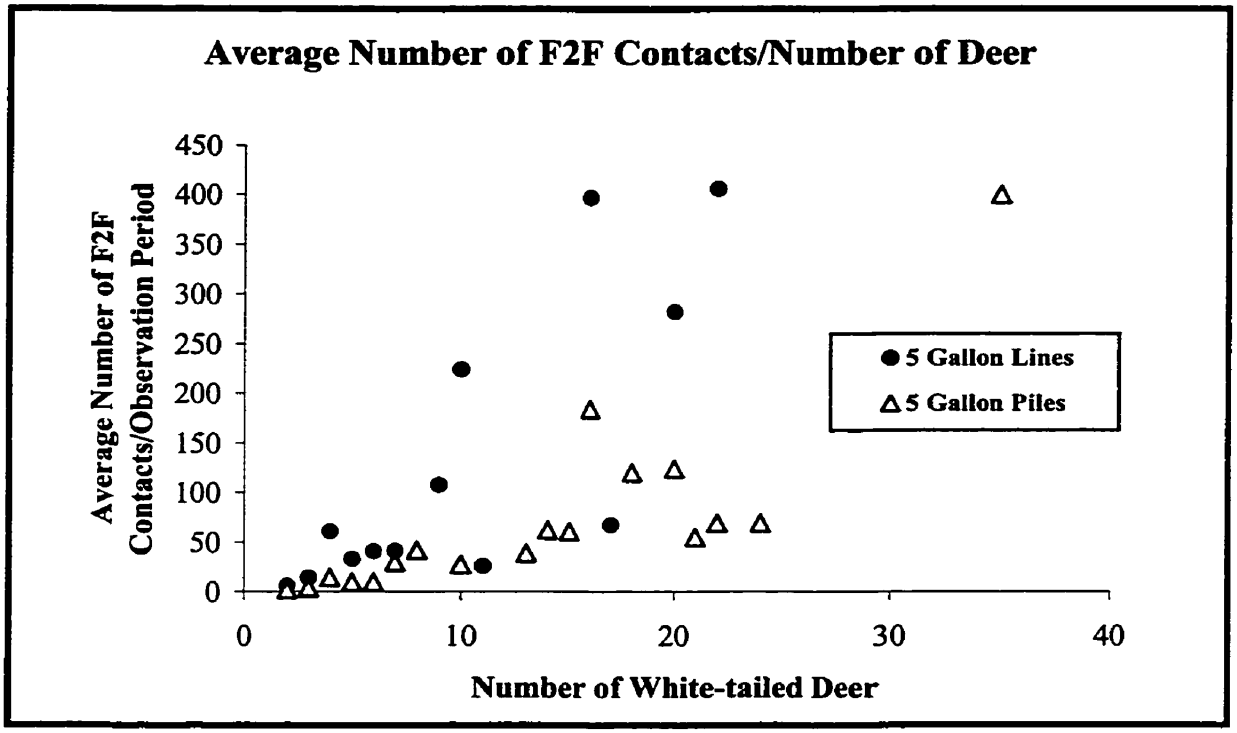


Figure 6. Average number of face-to-face (F2F) contacts per observation period for different numbers of deer during the winter of 1997/1998 at 5 gallon lines and 5 gallon piles.

were supplied only with 5-gallon buckets of shelled corn placed in piles (Figure 6). An average of 4.3 deer (n = 60, range = 0 to 35) and 43.3 F2F (n = 43.3, range = 0 to 318) contacts were observed per observation period (Table 2). In situations where there were fewer than 11 deer at 5-gallon line feeding stations, there were an increased number of contacts when compared to 5-gallon corn piles (Figure 6). When there were between 12 and 16 deer it is not clear which method resulted in the most F2F contacts per number of deer. When there were greater than 17 deer, lines of corn generated more F2F contacts than did piles of corn.

Figure 7 best illustrates the differences between the two seasons and the different methods used during the winter seasons. During fall baiting observations of 1997, the spin-cast feeder observations and the fertilizer spreader observations showed that more

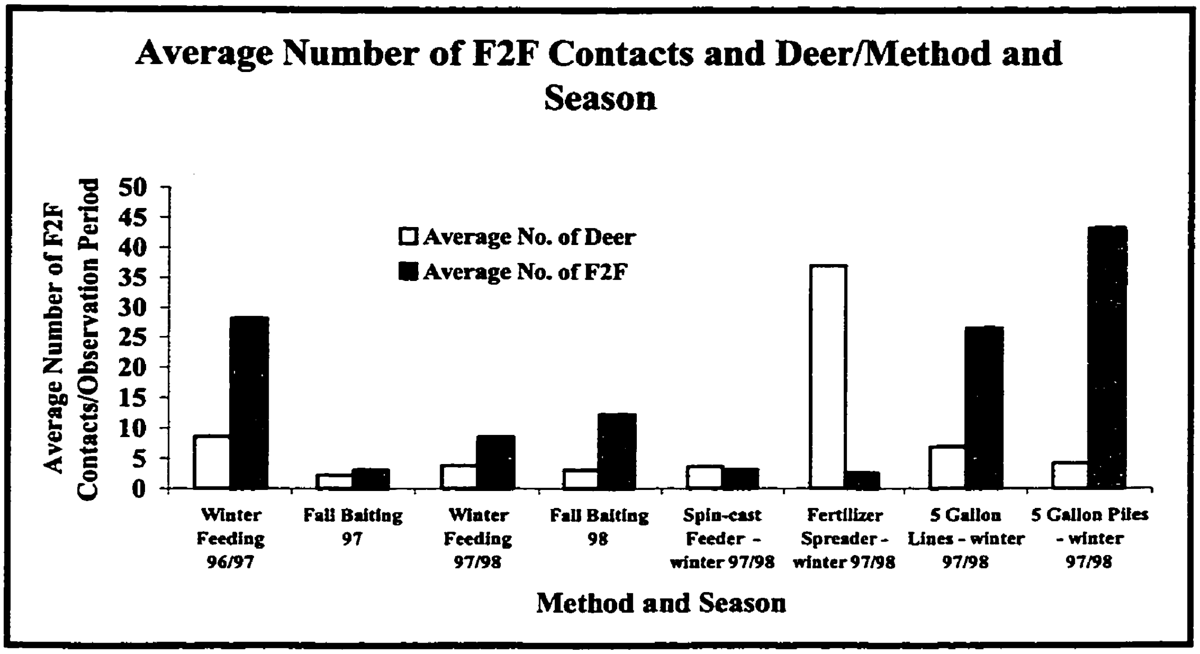


Figure 7. Average number of face-to-face (F2F) contacts and deer per observation period at different methods of feeding and baiting.

deer were observed, but there were fewer contacts. The fertilizer spreader averaged far fewer F2F contacts than did any other method. The methods that caused the most F2F contacts per observation period and per number of deer were the winter feeding of 1996/1997, the fall baiting of 1998, the 5-gallon bucket lines and the 5-gallon bucket piles.

DISCUSSION

It was obvious that deer did feed at winter feeding and fall baiting stations. It was not my objective to determine why deer feed at these stations. After conducting two winters (1996/1997 and 1997/1998) of observations and documenting deer behavior at winter feeding stations it was evident that there were face-to-face (F2F) contacts that occurred. There were a large number of F2F contacts recorded while observing deer feeding at winter feeding stations. Winter feeding, therefore, provides an avenue for transmission of bovine TB.

After conducting two falls (1997 and 1998) of observation periods documenting deer behavior at fall baiting stations it was evident that there were face-to-face (F2F) contacts that occurred. There were a large number of F2F contacts recorded while observing deer feeding at fall baiting stations. This suggests that fall baiting provides an avenue for transmission of bovine TB.

Upon completion of experimental observation periods of deer feeding behavior during the winter of 1997/1998 and the fall 1998 (5-gallon restrictions in place) at stations where shelled corn was applied in 5-gallon amounts it was determined that more face-to-face contacts occurred than did during non-restricted baiting periods. Due to the increased F2F contacts observed at stations with these limited amounts it was clear that the idea of restricted baiting should be reconsidered and abandoned.

The use of some mechanical feeders (spin-cast or broadcast feeders) for fall baiting and winter feeding applications did not eliminate F2F contacts between deer while they were feeding. Use of these methods of application did decrease, with one method drastically so, the number of F2F contacts between deer, but no method eliminated F2F contacts.

At feeding stations where shelled corn was applied in 5-gallon piles it was discerned that more F2F contacts per number of deer occurred using this method of application than any other method examined during this research project. At feeding stations where shelled corn was applied in 5-gallon lines it was discovered that high numbers of F2F contacts did occur between deer. Not as many F2F contacts per number of deer occurred using this method of application as did using the 5-gallon piles.

Winter Feeding Behavior

During the winter of 1996/1997 more deer fed at winter stations and made more F2F contacts than in the following winter of 1997/1998. Many assumptions were made about what could have or played a role in making these distinctions between these two winters of feeding. For example, the second winter was more mild (less snow fall and higher temperatures) and this may have caused less of a yarding affect (Semeyn 1963, Verme and Ozoga 1971). Winter Severity Index for the winter for 1996/1997 was 77.9 and the winter of 1997/1998 was 45.3 respectively (Steve Cadwick, MDNR, pers. commun.). There may have been an increase in hunter harvest that affected the number of deer being present at winter feeding stations (Lewis 1990). One variable, methods of feeding, was relatively stable during both of the winter seasons. The necessary historical data do not exist to determine if either of these winters fall within what would be considered "normal" for deer behavior at winter feeding and fall baiting stations. However, identifying an overall trend of what "normal" deer behavior at winter feeding and fall baiting stations was not relevant to my objective. My objectives included simply answering the questions do F2F contacts occur at fall baiting stations and do F2F contacts occur at winter feeding stations.

Fall Baiting Behavior

More deer were observed feeding during the winter feeding than during the fall baiting seasons. I believe this was due to more natural food having been available during the fall season (Ozoga, 1982), the possibility that deer were still moving (not settled in their winter range) and the likelihood that hunting deterred deer from presenting themselves at fall baiting stations during daylight hours (Darrow 1993, Lewis 1990).

My interpretation of the activity when two to four or more deer were present at baiting stations was that the baited areas were typically big enough to keep two deer from having many contacts, but having four or more deer will drastically increase the number of contacts due to the limited area. Furthermore, deer behavior at fall baiting stations followed the simple model of more deer feeding at a station resulted in more close contacts made.

Deer behavior at fall baiting stations was unlike that at winter feeding stations which typically were stations with large volumes of feed spread over a larger area and with a increased number of deer feeding at the stations as well. In most cases fewer deer fed at fall baiting stations which resulted in fewer contacts, but a problem was that the bait at most fall baiting stations was provided in a limited area. In contrast to the deer behavior at fall bait during 1998 I assumed that the deer behavior at fall bait during 1997 was more typical to what deer behavior was actually like because unlike in the fall of 1997 there was a baiting restriction during the fall of 1998. During the fall of 1997 and in normal fall baiting conditions (during falls of no baiting restrictions) the numbers of deer presenting themselves at baiting stations were minimal enough not to cause extreme numbers of contacts.

In the fall of 1998 after a 5-gallon baiting restriction, the number of contacts drastically increased to the point of reflecting the number of contacts I observed at winter feeding stations. This restriction impacted the size of the fall baiting area (smaller volumes decreased the area) even more. After the restrictions, the few deer that did frequent the baiting stations now had a much greater chance of making F2F contacts. Not only was this a problem, but it was discovered that more bucks were observed feeding at the 1998 fall baiting stations than at the 1997 baiting stations. This led me to believe that the restrictions of small volumes of bait caused those deer (most likely adult males) that typically avoided bait stations during the daylight hours to present themselves. At fall baiting stations of more normal bait applications, deer that were more cautious could wait until after dark to feed on the bait because not all of the bait was consumed (Darrow 1993 and Montgomery 1963). Most of the volumes of bait that were observed while under the 5-gallon restriction were consumed well before nightfall. In other words these new restrictions caused a very rapid change in deer behavior. If the nocturnal feeders were going to take advantage of the fall bait they had to present themselves during the daylight hours. These deer that changed their behavior added to the numbers feeding at these fall baiting stations causing an increased number of F2F contacts.

The fall baiting behavior data were collected at two study sites within the DMU 452. During the fall of 1998 an insufficient number of deer were observed at the Lockwood Lake Ranch site to yield any meaningful data. The data recorded at the Lippert's property were the only usable data collected during the fall of 1998. At the Lippert's property adult bucks were almost twice as likely to be observed during the daylight hours in the fall of 1998 as they were in the fall of 1997. This held true both before and after the firearm hunting season (November 15) began. The average number of deer feeding at baiting stations did not differ between the falls of 1997 and 1998. However, the average number of F2F contacts per observation period was nearly 4 times higher in 1998 than it was in 1997. The only change in factors between these two falls was the volume of bait allowed. In 1997, there was no limit on the amount of bait that could be used. Whereas, in 1998 there was a 5-gallon bait restriction law in place.

It was apparent that the MDNR was concerned with the possible spread of bovine TB due to close contacts at winter feeding and fall baiting stations. I understood their goal to eradicate bovine TB in the DMU 452 included decreasing the numbers of close deer contacts and that this would be accomplished by eliminating winter feeding and fall baiting and decreasing the overall deer density of that area. After having experience observing deer behavior at baiting and feeding stations I disagreed with the management strategy of allowing 5 gallons of bait for the fall of 1998. After having experienced the fall of 1998 I was somewhat surprised at some things that occurred. The smaller volumes of bait used in the fall of 1998 did drastically increase the number of F2F contacts that were committed; which in turn could have potentially increased the spread of bovine TB, but those smaller volumes forced deer that would not normally feed at those baiting stations to show themselves (i.e., bucks).

In conversation with local hunters I discovered that they were experiencing similar circumstances. According to the MDNR (Stephen Schmitt, MDNR veterinarian, pers. comm.), of the positive cases of bovine TB the percentages were higher in the adult males (bucks). Since these smaller volumes of bait encouraged the appearance of more adult males there was an increased potential of them being harvested thus the increased potential of decreasing the numbers of infected deer as well.

Alternative Methods

Many properties within the DMU 452 had been using some sort of mechanical feeders and many used spin-cast feeders. Henke (1997), found that many property owners in southern Texas chose to use mechanical feeders to feed deer. Therefore I felt these methods needed documentation because they had been practiced in the past for many years. First, one of the basic objectives was to identify deer behavior at fall baiting and winter feeding stations and if deer feeding at these types of stations (those equipped with spin-cast feeders) were not observed the objectives would not have been completely met. Second, I had understood that the fall following these experiments (1998) the MDNR was considering a 5-gallon restriction in the volume of fall bait. The fall baiting restriction of the 5-gallon amount was a restriction of volume only; no guide-lines were made as to applications of the 5-gallon volume. Deer behavior data that were collected through the fall of 1997 supported the suspicion that the 5-gallon restriction was not a wise decision if the goal was to decrease F2F contacts.

After conducting observations at stations that were supplied with feed by alternative ways of feeding (spin-cast feeders and fertilizer spreader) it was discovered that fewer contacts were made than when the original feeding and baiting methods were used. These data supported the idea that there were methods of bait and feed application that were much better than simply manually applying 5-gallon amounts. In retrospect, the MDNR could have encouraged alternative feeding methods that would cause fewer F2F contacts and that were more likely to decrease the chances of bovine TB transmission.

Spin-cast feeders typically caused fewer contacts among deer than did other methods due to the increased area in which the feed was spread. However, after conducting our investigations of spin-cast feeders it was discovered that in some instances the number of F2F contacts was higher than expected (even though overall the contacts were lower than most methods). One reason that may have caused some spin-cast feeder's contacts to be higher than expected was the fact that some feeders were mounted on ground stands. Spin-cast feeders drop some feed directly below the feeder, but a feeder that is mounted on a ground stand causes a bit more feed to accumulate below the feeder. The one extreme point shown on Figure 5 (almost 30 F2F contacts) is an example of the activity due to the interference of ground stand legs.

Obviously, hanging spin-cast feeders were preferred over ground supported spin-cast feeders as a way to supply food. Another major advantage to the spin-cast feeders' was that the feed does not stay on the ground long. At all the places observed, the deer and turkey (if present at site) were conditioned to the sound and timing of the spin-cast feeders (Henke 1997). They seemed to know when these feeders were going to feed and recognized the sound of the feeders when operating. Sometimes the animals would be on the station waiting for the feeder to start and within a few minutes the feed would be consumed.

Little is known about the energetic trade-off for deer feeding at spin-cast feeders. How much energy can a deer get from a handful of corn kernels it finds around the spin-cast feeder? If deer expend more energy searching for and getting the corn than they get from the corn, one solution would be to increase the amount of corn available (Delgiudice 1990). The data from this research project could only be applied to the set of conditions that were actually tested. If the density of feeders, the number of times the feeders spread feed and/or the duration of time the feeder spreads feed were increased the data of this research project could not be used for predictions. It is, however almost certain that if any of the parameters that were observed were increased the number of F2F contacts would increase.

When comparing the data in Table 5 and Figure 5 the outcome of the fertilizer spreader was very impressive. The major advantage to this method was the area in which the feed was spread. Corn was spread thinly over multiple acres and it was almost impossible for deer to make contacts. This practice was not a method used by feeders or baiters in the area, but the intent was again to document that if supplemental feeding was permitted that there were methods which would decrease, but not eliminate, the numbers of F2F contacts. This method of spreading shelled corn with a fertilizer spreader did appear to cause a decrease in the numbers of F2F contacts, but the number of observation periods of this method were limited. Only 12 observation periods were documented at these stations and these observation periods were conducted during a matter of a few days.

Before considering the utilization of mechanical feeders for a management strategy many factors must be considered. For example, if the number of F2F contacts were a serious issue then how many F2F contacts would be acceptable? The complicating factors would include what combination of conditions would ensure that the limit of F2F contacts was not exceeded, what would be the allowed density of feeders per area, how many times a day would they be allowed to spread feed, what would be the acceptable volume of corn per acre or area and what would be the length of time they would spread feeds? The effect of weather conditions, snow depth and deer density on deer behavior at feeding stations supplied with feed from mechanical feeders is uncertain. The factor of most concern would have to be monitoring the use of the mechanical feeders to guarantee compliance.

It was my understanding that the present objective of the wildlife managers of DMU 452 was to eliminate bovine TB from the deer population. Since this was the objective, anything that would facilitate F2F contacts would not be acceptable.

5-Gallon Lines And Piles

The major disadvantages of these two methods were that the feed was supplied in a limited area and the number of possible contacts between deer was increased. Having experience with sites and individuals who had practiced feeding or baiting deer with 5-gallon amounts of corn I observed that most did not put much effort into spreading the corn. During the fall, most would pile the bait in one pile to ensure that the deer that would feed on their bait pile was in a hunter's shooting lane. During the winter months most property owners or caretakers would spread the shelled corn in lines. Therefore, these methods were what we replicated during our observations.

If two deer were feeding at a 5-gallon pile of corn they were going to come into contact with each other. The practice of 5-gallon piles caused many more F2F contacts per number of deer than did the method of the 5-gallon bucket lines. Furthermore, while observing these methods much more aggressive activity (fighting) was observed than with the other ways of supplying bait and feed; I assume this was due to encroachment upon an individual's space (Lewis, 1990). Eventually the piles were spread out to some degree due to these fights but it was not enough to decrease the numbers of F2F contacts.

After the scattering of the 5-gallon bucket piles deer would be layered from the center of the pile out to the outer circumference of the area. This event would cause many F2F contacts yet many contacts in this situation were not F2F contacts because some deer were eating from around the hind feet of others. Many of the layered deer (i.e., those away from the center of the pile) were in close contact with many other deer, but not within the F2F zone. These contacts, even though they are not within the criteria to make them a F2F contact, were of major concern because if any of these layered deer were infected with bovine TB they could leave it at the station (body fluids) for other deer to contract. Something else to consider was that deer at these stations were always moving. Deer that might be layered throughout the scattered 5-gallon pile were moving to the center as well as out to the outer areas; always fighting for a better spot. This layered situation was not as common with 5-gallon lines.

With these methods, especially the piles of corn, food was left on the ground for an extended period of time allowing many deer (multiple groups) to feed over long periods of time. The time I have referred to here as an extended period of time is short when compared to typical winter feeding practices, but when compared to the time it takes deer to consume all the shelled corn supplied by a spin-cast feeder it is an extended time.

The 5-gallon line was a method more like what would be found during winter feeding (when using this volume of shelled corn), but it too causes many more F2F contacts than typical fall baiting and other winter feeding practices. Deer that fed at these stations supplied with corn in lines would position themselves shoulder to shoulder down each side of the line. In this event deer were committing F2F contacts with those deer that were to the right and left of them as well as with multiple deer facing them from the other side of the line.

Additional Observations

Some of the study sites on which we conducted our work appeared to be over-browsed and we suspected that this was due to the abundance of deer that were supported by supplemental feeding (Karns 1980, Lewis 1990, Peyton 2000). Additionally, survival rates increase in areas which practice supplemental feeding (Hiller 1996, Lewis 1990, Nahlik 1974, Schmitt et al. 1997). Not only were more deer surviving, but those surviving were concentrated in limited areas due to the feeding stations.

Through controlled experiments, scientists with the United States Department of Agriculture have determined that *M. bovis* left on bait in frozen conditions can live 16 weeks (Diana Whipple, USDA veterinarian, pers. commun.). Whipple stated that these experiments were conducted with six different types of baits (hay, carrots, corn, apples, sugar beets and potatoes). It was suspected that since deer (both those that have and have not contracted bovine TB) had been attracted to the same limited space time after time to feed (the fall baiting or winter feeding stations) that it was likely that bovine TB may be present at a station even without positive deer still being present. This suspicion has not been proven to be true for any of the baiting and feeding stations in the DMU 452. It is, however, known that bovine TB has been contracted as an aerosol (Thoen and Bloom 1995). It was noticed at a number of winter feeding stations that piles of sugar beets, potatoes and carrots would freeze together throughout the winter season making a pile of loose feed into a pile of one unit of feed. At the times during which these feed piles were frozen, deer were observed using the heat from their mouths and nostrils to dislodge food. Once a piece of food was warmed enough to be removed, it would be consumed, but the deer would not move from the area at which it was working. Instead this process would continue, melting, removing and consuming at the same location on the pile until the deer stopped feeding. As a result, the frozen piles of feed at these feeding stations were dented with borrows made from deer noses. Throughout the winter multiple numbers of deer were observed working in and around the same areas on frozen feed piles. I suspect that each deer that feeds this way at a frozen feed pile leaves much of it's own saliva and nasal droppings in the feed pile at which it's working. In other words, bovine TB positive animals could have left the bacteria on winter feeding piles or in cavities of the piles and uninfected deer may have contracted the disease through either an aerosol or oral consumption. Situations like this may have resulted in areas or feeding stations that were highly contaminated with bovine TB.

After conducting multiple years and seasons of recording the feeding behavior of deer it was determined that at some locations the fall baiting and winter feeding stations remained at the same location day after day and some year after year. The sites of some fall baiting stations were later used as sites for winter feeding stations and this practice was carried out year after year.

MANAGEMENT IMPLICATIONS

At all baiting and feeding station observed during this research project in the DMU 452 F2F contacts increased as deer numbers increased. The area in which the volume of feed or bait was spread had a great bearing on the amount of F2F or close contacts that were made. I stress that the volume of feed or bait that was supplied was not as much a factor as how it was supplied and in most cases this meant that if you were trying to avoid excessive contacts it was best to liberally spread the bait and feeds.

It was discovered that the application of small volumes of feeds by simply piling or spreading them in lines was worse than other applications. Figure 5 shows that the number of F2F contacts at stations supplied with smaller volumes could easily surpass 100 with a minimal number of deer present. In most cases of feed application spreading was the method to use to avoid higher numbers of contacts rather than piling.

Managers that are managing deer populations in areas in which supplemental feeding is allowed must be concerned with and consider the potential for the spread of disease through close contacts by feeding deer. According to the experience obtained during this research project there is not a method of winter feeding or fall baiting (supplemental feeding) that can be practiced that will eliminate or cause no close contacts between deer. I suspect that all methods of supplemental feeding will cause close deer contacts. If managers are interested in eliminating close contacts I recommend abandoning supplemental feeding all together. If close contacts between deer are not a major concern and supplemental feeding is continued I still strongly suggest implementing methods which would decrease the chances of close contacts therefore decreasing the chances of spreading disease.

CHAPTER 3: MOVEMENT PATTERNS AND SEASONAL RANGES OF WHITE-TAILED DEER.

The movement patterns of free-ranging white-tailed deer have been of major interest since 1995 when the MDNR found bovine TB to be more than simply an isolated incident in northeastern Michigan. Wildlife managers in the DMU 452 were concerned about how far bovine TB could spread through a series of close (F2F) contacts over multiple seasons of movement. Furthermore, deer typically move or migrate as social units (Nelson and Mech 1981). Few data on the movement of free-ranging deer were available for the DMU 452. Sitar (1996) documented deer movement and ranges for a sample of deer in Presque Isle, northern Montmorency and northern Alpena counties, but little was recorded on how deer move in the TB core area. Of additional concern was the question, if supplemental feeding were banned in the TB core area would deer movement behavior change significantly? It is understood that factors such as available habitats (food, cover, etc) and deer densities or a combination of factors play a major part in deer movement (Sitar 1996).

Identification of deer movement patterns was necessary so that wildlife mangers could identify what role supplemental feeding played in influencing the movement behavior of free-ranging deer in the DMU 452. Some thought feeding bans might cause deer in the DMU 452 to travel more often or further, potentially spreading the disease into new areas. Behavioral changes resulting from the feeding bans could set-back the efforts to eliminate bovine TB from the deer population of the DMU 452. Evaluation of management solutions required a collection of information including those of deer migration or movement of deer in the DMU 452 (Nelson and Mech 1984).

In this chapter, I describe deer movement in terms of being non-migratory, migratory, dispersal or undetermined movements. The home ranges, seasonal ranges and direction of movement were determined for all the radio-collared deer in this project. Comparisons were made between age and sex, and among trap sites.

METHODS

Locations of radio-collared deer were estimated by triangulation of 3 bearings from known locations using hand-held receivers (both Lotek Inc. Ontario, Canada, model STR_1000 and Telonics Inc. Mesa, Arizona, model TS-1 Scanner/Programmer), with two element or three-element Yagi antennae (Labisky and Fritzem 1998, Van Deelen et al., 1998). Each radio-collared deer was located at least once per week from the time of collaring until the collar was thrown, the radio-collar malfunctioned, the deer's death or the termination of the project (Tierson et al., 1985). Locating began January 1997 and was concluded December 1999.

All bearings were taken from points that were recorded in the Universal Traverse Mercator (UTM) grid coordinate system (Vercauteren and Hygnstrom 1998). Each recorded UTM point and bearing was entered into LOCATE II (Pacer, Truro, Nova, Nova Scotia) and point locations were determined. LOCATE II requires an estimated error to be entered for each radio-triangulation before determining a point location. Pre-determined or appropriate estimated errors were calculated for all individuals who had recorded bearings for locations of radio-collared deer (Saltz 1994).

Shape-files were built in Arcview from the point locations that were defined in

LOCATE II. Using the point locations in Arcview, I determined the date at which the radio-collared deer initiated and concluded their seasonal migrations. A migration movement of a radio-collared deer started when a point location appeared well outside of the seasonal range and in the direction of the reciprocal seasonal range (Sitar 1996). Point locations identified between the determined seasonal ranges were excluded from the data used to identify range sizes. The same practice was used in determining the seasonal ranges of non-migratory deer. I used the time period identified as the time when migration was initiated to distinguish the seasonal ranges of the non-migratory radio-collared deer. The point locations that were recorded during the identified time of migration were not used in determining seasonal ranges for the non-migratory deer either. The Kruskal-Wallis *k*-sample test (Steel and Torrie, 1980) was used to determine if there were any significant differences between the spring and fall migration dates.

The time of year, distance, direction and if the movement was traditional were determined for each migration and compared among the differing sites and seasons. Traditional ranges for migratory radio-collared deer were determined from deer for which multiple years of data were recorded. Van Deelen (1998) defined ranges as being traditional if seasonal ranges overlapped from each year to the next for individual migratory deer. The distances between the seasonal ranges (winter and summer) for the dispersing, migratory and unknown classified radio-collared deer were calculated from the centers of the kernel estimated polygons (Figure 8).

Once the migration point locations were removed from the range data, UTM files were created to identify seasonal range sizes. These UTM files (the LOCATE II files of point locations) were converted into the Michigan Georef projection via a program called

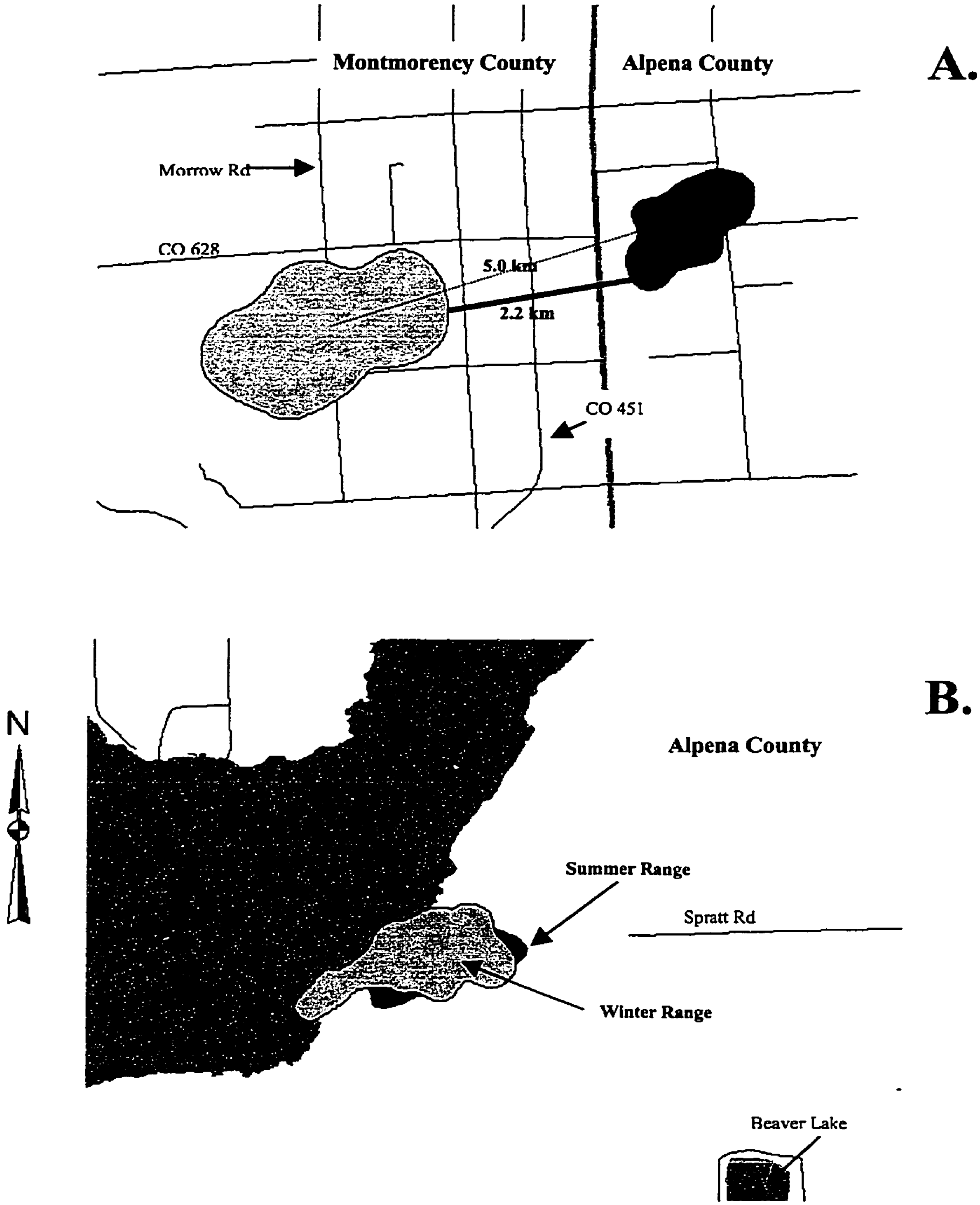


Figure 8. Part A is an example of a migratory deer (Strohschein's 1.888). Part B is an example of a non-migratory deer (Leroy 0.920).

Corcon. ArcView (ESRI) and Michigan Georef projection maps were then used to process these telemetry data onto relevant maps. Seasonal ranges were then identified by using ArcView's Spatial Analyst (version 1.1) and the home range extension tool. I used the adaptive kernel estimator with a least-squares cross-validation (LSCV) choice of *h* (the smoothing parameter) in determining the seasonal range estimates as used by Worton (1989), Seaman (1998), and Seaman (et al.1999). Lawson and Rodgers (1997) expressed that the kernel estimator was less biased by the chosen scale or grid density and would produce more consistent results. The polygons were built by using the confidence interval of 90% for all the seasonal range estimates as well. The Kruskal-Wallis *k*-sample test was used to determine if there were any significant differences between the sizes of winter and summer ranges of non-migratory and migratory deer before and after the feeding and baiting bans.

A minimum of 30 locations were used per radio-collared deer for seasonal range estimates. There were a few well justified exceptions. For example, in some cases only one location was collected per week during the summer months resulting in fewer than 30 locations being available to estimate summer ranges. However, Sitar (1996) found the fidelity to summer ranges to be at 92% for deer in northeastern Michigan. Van Deelen (1998) found that fidelity to summer ranges was stronger than those to winter ranges.

Deer movement was identified as being non-migratory or migratory by the method used by Sitar (1996). To be classified as migratory, the winter range did not overlap the summer range and there was at least 1 km between the ranges. Figure 8a illustrates how Strohshein's Farm radio-collared deer (identification number 1.888) was classified as migratory because she had a distance greater than 1 km (2.2 km) between her winter and summer ranges. In the event that the outer perimeters of the winter and summer ranges overlapped or were within 1 km of each other the deer movement was classified as non-migratory (Figure 8b). A deer was classified as a disperser if the deer left the winter range (trap site) and did not return. A deer was classified as ambiguous if the deer's movements were recorded as a combination of any of the following categories; non-migratory, migratory and/or dispersal. Lastly, a deer movement was classified as unknown if it could not be determined if the individual migrated or dispersed. For example, a radio-collared deer could not be classified as non-migratory, migratory or dispersal if it died (e.g. predator, road kill) or the radio-collar malfunctioned in the spring before traditional spring movements began.

When determining the winter and summer ranges, non-migratory, migratory, dispersing and unknown deer were considered. It was necessary to express the non-migratory range as not just a home range, but as seasonal (winter and summer) ranges. All ranges will be expressed as seasonal (winter and summer) ranges to determine the effect of fall baiting and winter feeding on deer movement.

The ambiguous classifications were divided into the individual categories which made-up the combination. For example, if an ambiguous classification was made up of the combination of a deer migrating one year and not migrating the next I placed the data from the first year with the migration data and the non-migratory data from the second year with the non-migratory data.

RESULTS

After 3 years of trapping deer, 163 individuals were radio-collared (Appendix Table 1). Of the radio-collared deer, 119 individuals were used in the seasonal range and movement estimates. There were a total of 13,537 locations (mean number of locations = 114, and range = 11 to 324) used in the seasonal range and seasonal estimates. In addition, 3 deer that were radio-collared by the MDNR in 1996 (1 adult female and 1 yearling male at Lippert's and 1 yearling female at Leroy's) were used in the seasonal range and movement estimates (343 locations). Forty-one radio-collared deer were not used in any estimates because each had fewer than 30 locations. A total of 273 locations were not used (mean = 6.7 locations, range = 1 to 25). During the course of this project 3 deer were discovered to each have a leg hung between the radio-collar and their own neck. The data for these three deer (303 locations) were excluded from all estimates due to their lack of "normal" mobility. While locating one of these 3 radio-collared deer 3.2 km from where she was trapped she was discovered to have had her leg hung. She would have probably been considered a migratory deer. The other 2 radio-collared deer would have probably been considered non-migratory because neither moved from the property on which they were trapped.

Most of the monitoring of the radio-collared deer took place between the hours of 6:00 AM and 10:00 PM. The times of each location were recorded appropriately, but further evaluation of time in relationship to locations will not be addressed in this dissertation.

Movement and Direction

Figures 9 and 10 illustrate the initiations of spring and fall movements. The mean last day on winter range was April 27 in 1997 (N=16), April 2 in 1998 (N=17) and March 24 in 1999 (N=24). The median last day for the 3 winter seasons was March 29. A significant difference ($x^2 = 10.8$, $P<0.01$) between the mean last day of winter range was determined after comparing the data of the 3 years using the Kruskal-Wallis *k*-sample test. The mean last day on summer range was October 29 in 1997 (N=10), November 2 in 1998 (N=7) and October 15 in 1999 (N=6). The median last day for the 3 summer seasons was October 28. No significant difference was determined among the mean last day of summer for the 3 years (Kruskal-Wallis *k*-sample test; $x^2 = 0.36$, $P>0.05$). The seasonal ranges were determined using March 29 and October 28 as the cut-off dates.

Figure 11 shows the mean migratory distances of the radio-collared deer per study site (old and new study sites). The mean migratory distance for the radio-collared deer from Leroy Hunting Club was 11.0 km in 1997 (n = 8, range = 4.9 to 20.6 km), 20.9 km in 1998 (n = 1) and 5.7 km in 1999 (n = 2, range = 4.6 to 6.8 km). The mean migratory distance for the radio-collared deer from Lippert's was 7.0 km in 1997 (n = 3, range = 5.1 to 8.2 km), 7.2 km in 1998 (n = 5, range = 5.7 to 9.2 km) and 6.6 km in 1999 (n = 4, range = 4.8 to 8.7 km). There was only one deer classified as migratory that was trapped at Lockwood Lake Ranch and its migratory distance was 4.6 km in 1997. There was only one deer classified as migratory that was trapped at the Strohschein's Farm and I collected 3 years of migratory data from her. She migrated 5.0 km in each of the 3 years (1997, 1998 and 1999).

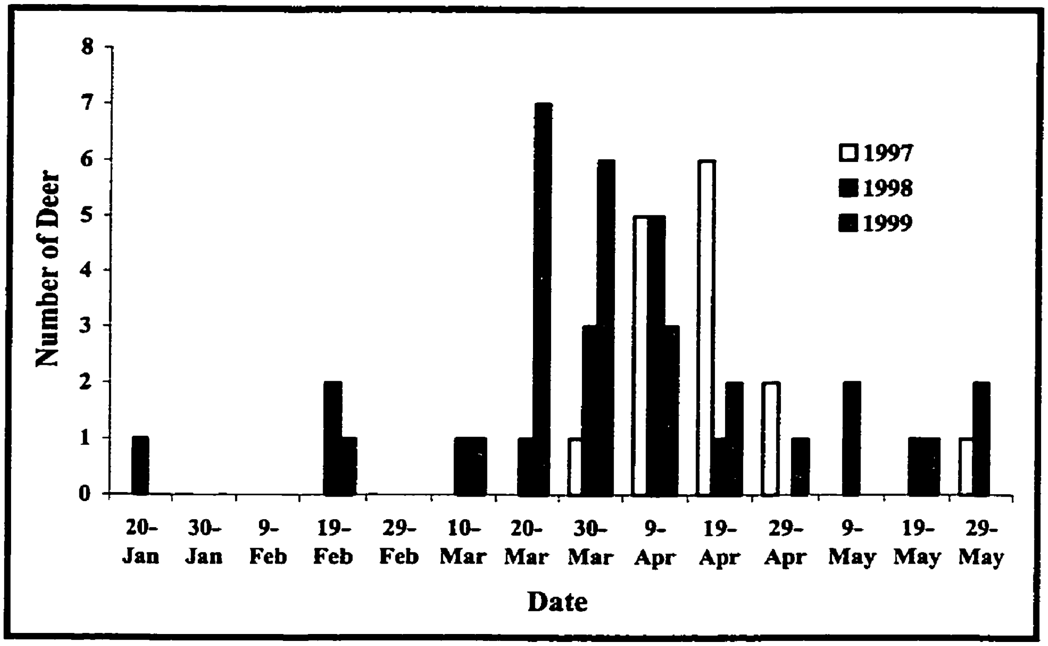


Figure 9. Initiation of spring movement for radio-collared deer in 1997, 1998 and 1999.

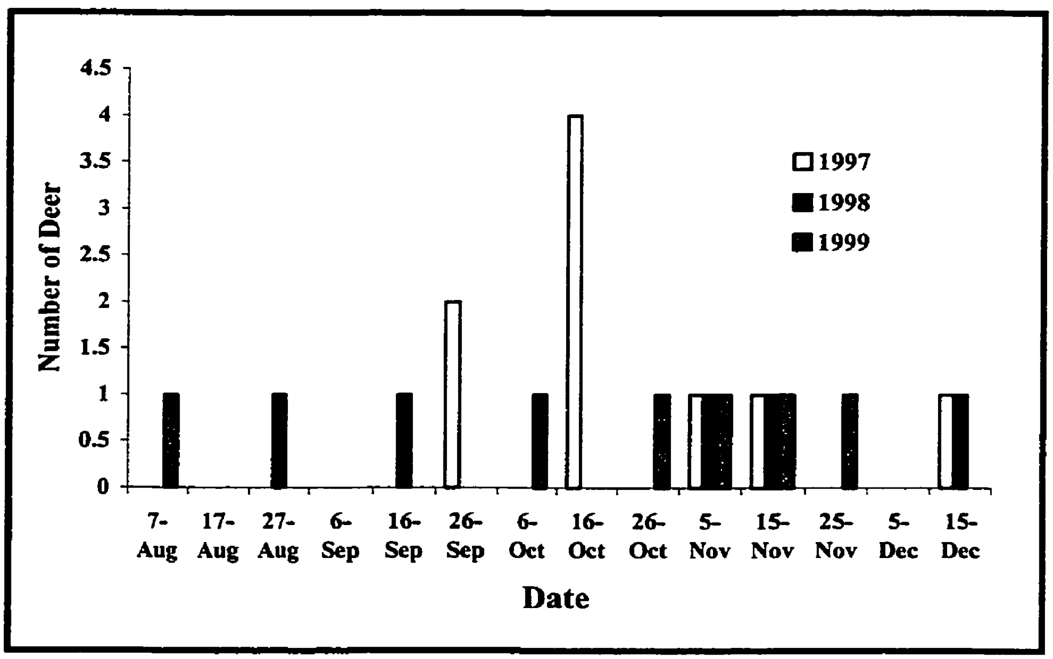


Figure 10. Initiation of fall movement for radio-collared deer 1997, 1998 and 1999.

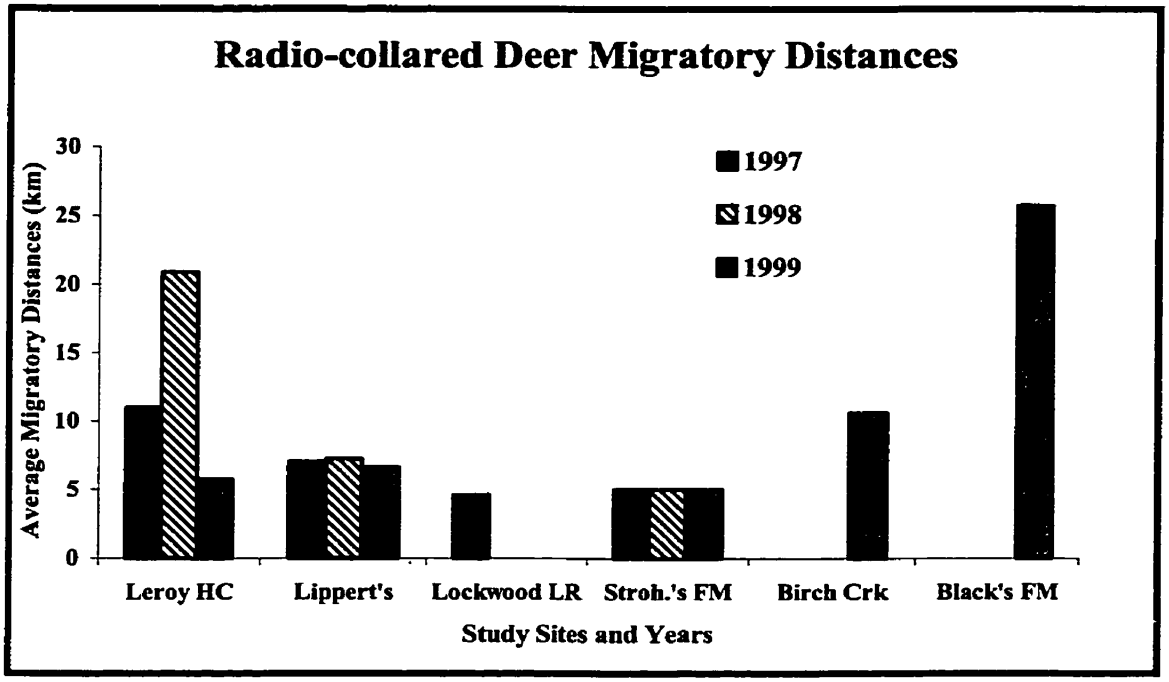


Figure 11. The mean distances traveled each year by migratory radio-collared deer from each study site.

Of the radio-collared deer at the new sites in the winter of 1998/1999 (Birch Creek Hunting Club, Black's Farm, Canada Hunting Club and Garland Resort) none were migratory that were collared at Canada Hunting Club and Garland Resort. At Birch Creek Hunting Club the mean migratory distance was 10.6 km in 1999 (n = 6, range 5.9 to 18.4 km). The mean migratory distance of the Black's Farm radio-collared deer was 25.7 km in 1999 (n = 3, range 24.7 to 26.3 km).

Migratory distances of females (Yearling and Adult)

Figure 12 shows the mean migratory distances of yearling and adult radio-collared female deer per study site. The mean distance for yearling females from the Leroy Hunting Club was 8.2 km in 1997 (n = 2, range = 6.5 to 9.8 km). On this property the only year that there were any migratory yearling females radio-collared was 1997.

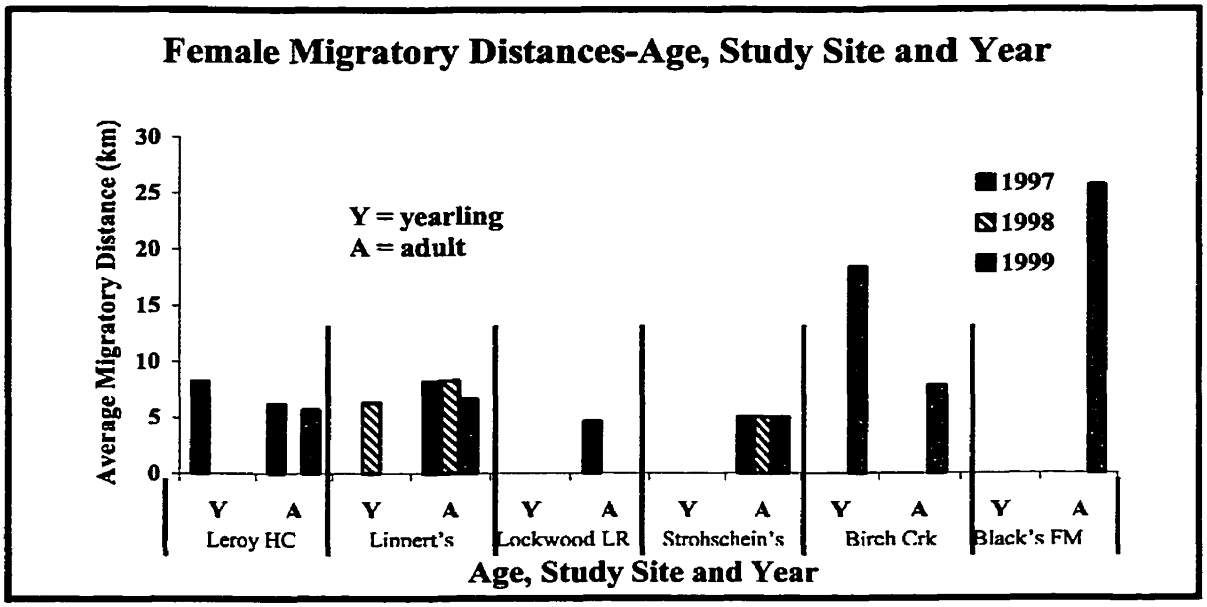


Figure 12. The mean distances traveled each year by migratory female radio-collared deer from each study site.

The distance for adults females from the Leroy Hunting Club was 6.2 km in 1997 (n = 3, range = 4.9 to 7.4 km) and 5.7 km in 1999 (n = 2, range = 4.6 to 6.8). During 1998 no females of the Leroy Hunting Club radio-collared population migrated.

The only year I had any migratory yearling females from Lippert's was in 1998 and their mean distance was 6.3 km in 1998 (n = 2, range = 5.7 to 6.9 km). The mean distance for adult females from Lippert's was 8.2 km in 1997 (n = 1), 8.3 km in 1998 (n = 2, range = 7.4 to 9.2 km) and 6.6 km in 1999 (n = 4, range = 4.8 to 8.7 km). There was only one migratory radio-collared deer from Lockwood Lake Ranch and it was an adult female. I only recorded one season of information from her and her migratory distance was 4.7 km in 1997. Only one radio-collared deer migrated from the Strohschein's Farm sample and I recorded information from her (an adult) all three years (1997, 1998 and 1999). She migrated 5.0 km each year.

The Birch Creek Hunting Club and Black's Farm were the only two sites of the new study sites that had female migratory radio-collared deer. From the Birch Creek Hunting Club, there was only one yearling that migrated and she migrated distance traveled was 18.4 km. The mean distance for migratory adult females from the Birch Creek Hunting Club was 7.8 km in 1999 (n = 3, range = 5.9 to 9.5 km). Of the Black's Farm female radio-collared deer no yearling females migrated. The mean distance traveled for adult females from the Black's Farm was 25.7 km in 1999 (n = 3, range = 26.0 to 26.3 km).

Migratory distances of males (Yearling and Adult)

Figure 13 shows the mean migratory distances of yearling and adult radio-collared male deer at each study site. The Leroy Hunting Club and Lippert's were the only ones of the old sites on which there were radio-collared migratory males. The mean migratory distance for yearling males from the Leroy Hunting Club was 17.3 km in 1997 (n = 2, range = 13.9 to 20.6 km). The only year there were any migratory yearling males radio-collared was 1997. In 1997 there was one migratory adult male from the Leroy Hunting Club population and he traveled a distance of 18.8 km. In 1998 there was one migratory adult male from the Leroy Hunting Club and he traveled a migratory distance of 20.9 km. In 1999 there were not any radio-collared males to monitor. The mean migratory distance for yearling males from Lippert's in 1998 was 6.4 km (n = 2, range = 5.1 to 7.6 km) and in 1999 the single migratory yearling male traveled a distance of 6.8 km. I monitored a male that was radio-collared by the MDNR as a yearling at Lippert's in 1996. This migratory buck was monitored while he traveled a total distance of 4.6 km.

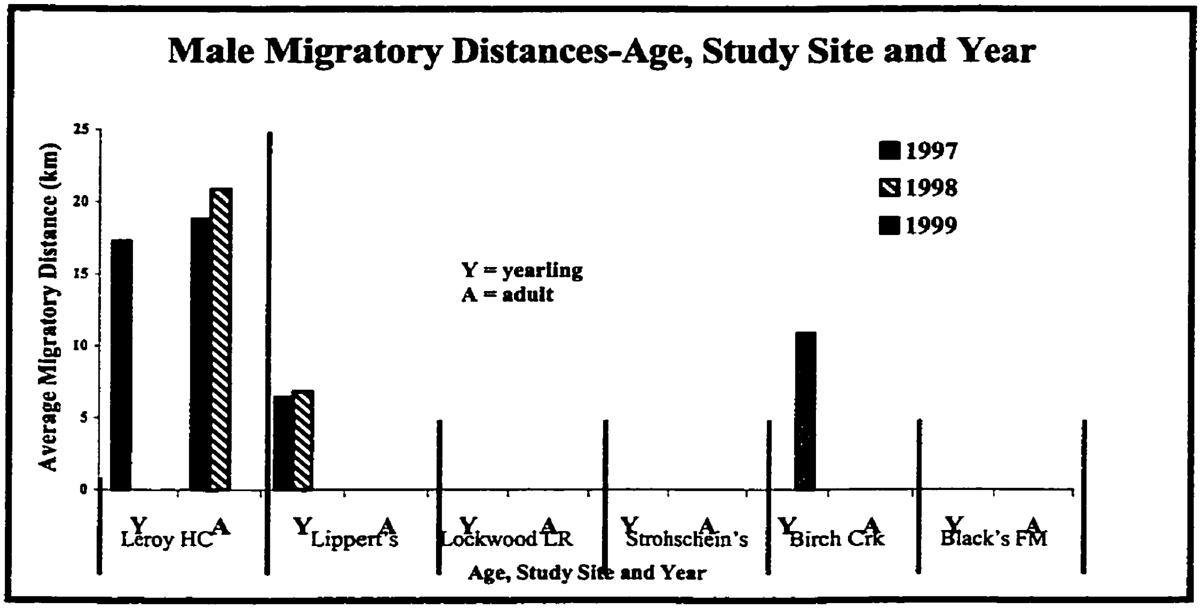


Figure 13. The mean distances traveled each year by migratory male radio-collared deer from each study site.

The Birch Creek Hunting Club was the only one of the new study sites that had migratory male radio-collared deer. Two yearling males migrated a mean distance of 10.9 km (n = 2, range = 6.2 to 15.5 km) in 1999.

Migratory Distances (by sex) Before and After the Feeding Ban

After combining all of the migratory radio-collared females before the winter feeding ban of 1998/1999 I found their mean migratory distance to be 6.7 km (n = 13, range = 4.6 to 9.8 km). The mean after the feeding ban (after 1998/1999) for the females from the old sites was 6.1 km (n = 7, range = 4.6 to 8.7 km) and for the females from the new sites was 17.0 km (n = 7, range = 5.9 to 26.3 km).

After combining all the migratory radio-collared males before the winter feeding ban of 1998/1999 I found their mean migratory distance was 13.4 km (n = 7, range = 5.1 to 20.6 km). The mean after the feeding ban (after 1998/1999) for the males from the old sites was not calculated due to the lack of samples and for the males from the new sites it was 10.9 km (n = 2, range = 6.2 to 15.5 km).

After combining all of the migratory radio-collared females and males before the winter feeding ban of 1998/1999 I found their mean migratory distance was 9.0 km (n = 20, range = 4.6 to 20.6 km). The mean after the feeding ban for the females and males from the old sites was 6.1 km (n = 7, range = 4.6 to 8.7 km) and from the new sites was 15.6 km (n = 9, range = 5.9 to 26.3 km). I determined the mean migratory distance for all females (combining females of old and new sites) after the feeding ban was 11.6 km (n = 14, range = 4.6 to 26.3 km). No migratory radio-collared males from the old sites were available so combining the data of the migrating males (old and new sites) was not necessary.

Other movements of radio-collared deer (Dispersal and Unknown)

There were a number of radio-collared deer that traveled significant distances and had movements which were categorized as dispersal or unknown movements (Figure 14). Many of these individuals died (e.g. predators, road-killed, hunter harvested) before they could complete their potential migration. During the winter of 1996/1997 an adult doe was radio-collared at the Koenig's Farm. She dispersed (a movement of 3.0 km) the following spring (1997) and did not return to the Koenig Farm. Her movement had been monitored for over 3 years and to date she remains in the area to which she dispersed. One radio-collared deer from the Leroy Hunting Club dispersed and one was categorized as unclassified or an unknown movement. The first, an adult female, dispersed in 1997 a distance of 9.7 km. The second, also an adult female, moved (10 km) in 1999 and was

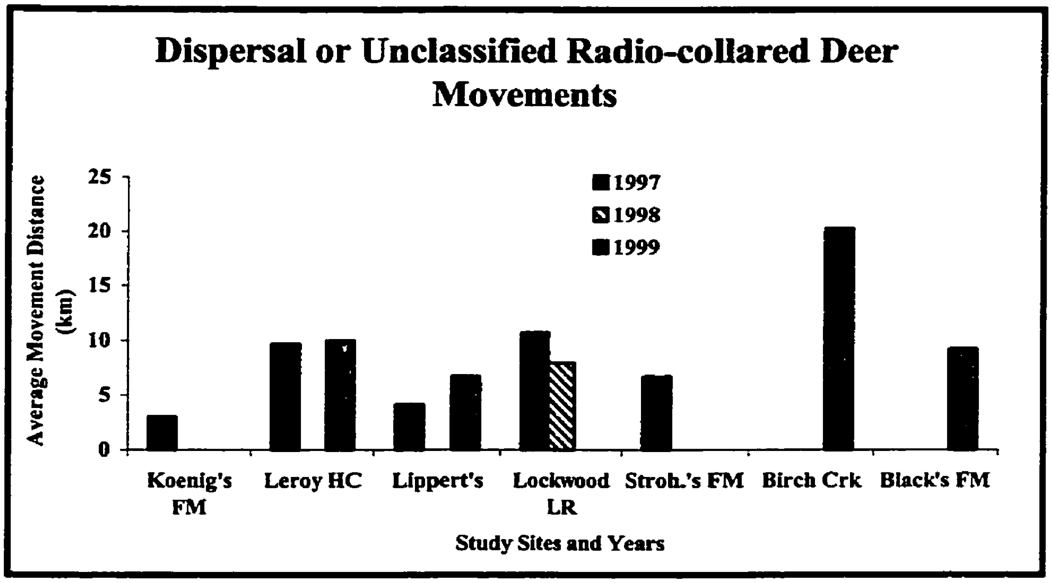


Figure 14. Radio-collared deer movements that were either dispersal movements or movements that were unknown due to premature death.

struck by a vehicle. She had previously migrated to and from the Leroy Hunting Club. I monitored a doe that was radio-collared by the MDNR in 1996 at the Leroy Hunting Club. She dispersed 19.3 km. She did not return to the hunting club and was found dead in November of 1997 (suspected vehicle fatality). One radio-collared deer from Lippert's fell into these categories in 1997. It was an adult female and she dispersed 4.1 km. In 1998, 6 radio-collared deer were classified in the unknown category and none could be classified as dispersers. The mean movement for these deer was 6.7 km (n = 6, range = 3.8 to 9.1 km). These 6 deer were made-up of 2 yearling females (4.4 and 3.8 km movements), 3 yearling males (7.3, 8.9 and 9.1 km movements) and 1 adult female (6.8 km movement). In 1997, a radio-collared adult male left the Lockwood Lake Ranch and traveled 10.7 km. He was found dead during the summer and was classified as an unknown movement. In 1998, two yearling males fell into these categories and their mean movement was 7.9 km. One of these yearling males traveled 5.4 km and was later classified in the unknown movement category due to being hunter harvested. The other yearling male dispersed 10.4 km in 1998 and remained there throughout 1999. A doe dispersed 6.7 km from the Strohschein's Farm in 1997 and stayed there until November of 1998 at which time she was hunter harvested.

The Black's Farm and Canada Creek Hunting Club were the only sites of the new sites that had radio-collared deer that fell into these categories. The deer from the Black's Farm mean movement was 20.3 km (n = 8, range = 7.6 to 31.9 km) and they were made up of only adults; 3 adult females (7.6, 20.8 and 31.9 km movements) and 5 adult males (11.0, 18.1, 21.5, 24.9 and 26.8 km movements). The majority of these unknown classified radio-collared deer were hunter harvested before they had a chance to complete what could have been a migratory movement. One radio-collared deer from Canada Creek Hunting Club fell into this category. It was an adult female which dispersed 9.2 km (in 1999) and has remained there ever since.

Direction of Migration, Dispersal and Unknown movements

Figures 15 and 16 show the direction of all the spring movements made by the radio-collared deer. Figure 15 shows the radio-collared deer movements from Canada Creek Hunting Club, Koenig's Farm, Leroy Hunting Club, Lockwood Lake Ranch and Strohschein's Farm. Figure 16 shows the radio-collared deer movements from Birch Creek Hunting Club, Black's Farm and Lippert's.

The sample sizes of radio-collared deer that moved at Canada Creek Hunting Club and Koenig's Farm were too small to draw any conclusions (Figure 15). The movement of the Canada Creek Hunting Club deer was south and the Koenig's

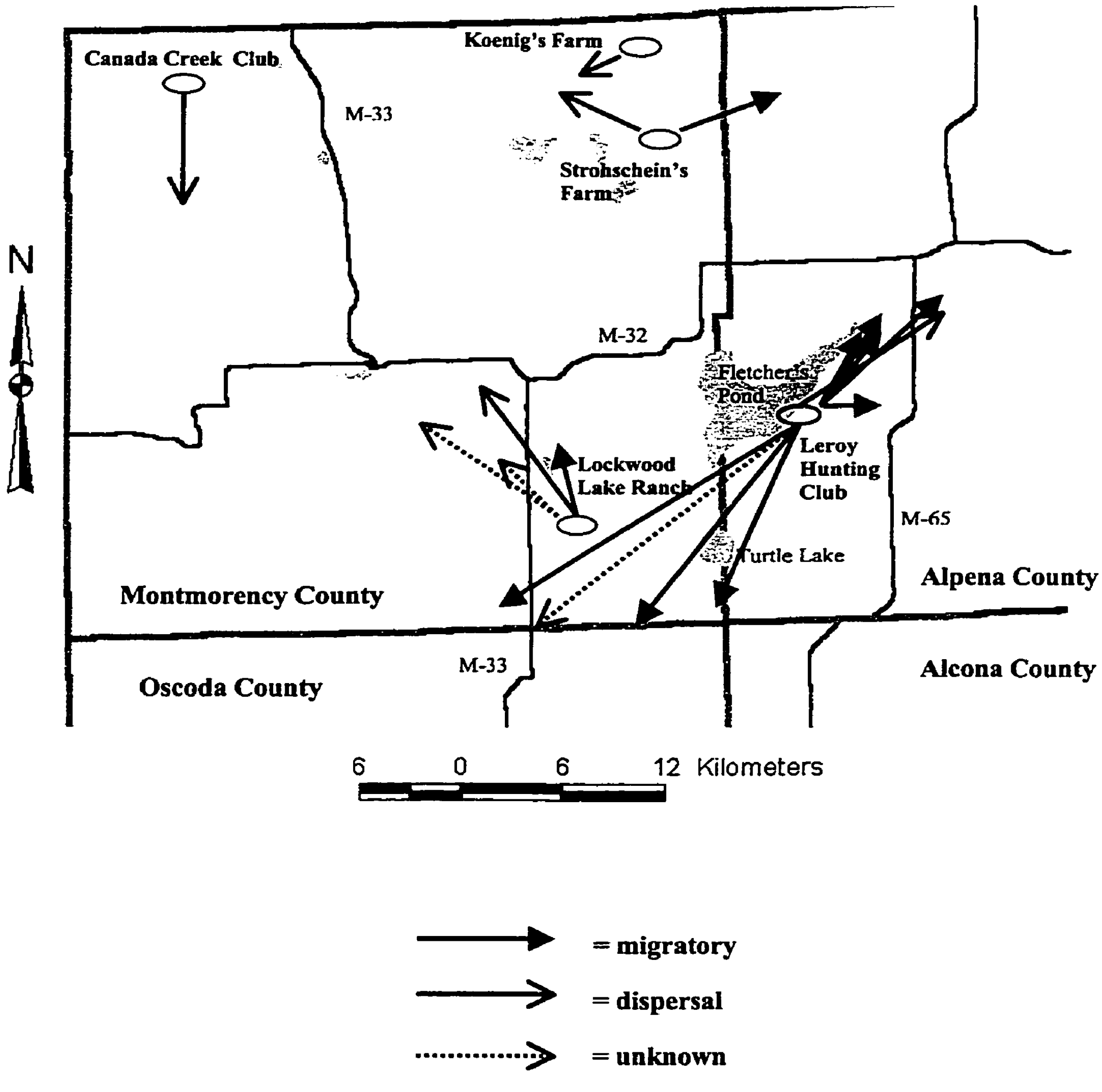


Figure 15. Distance and direction of spring movements from Canada Creek, Koenig's Farm, Lockwood Lake Ranch, Leroy Hunting Club and Strohschein's Farm.

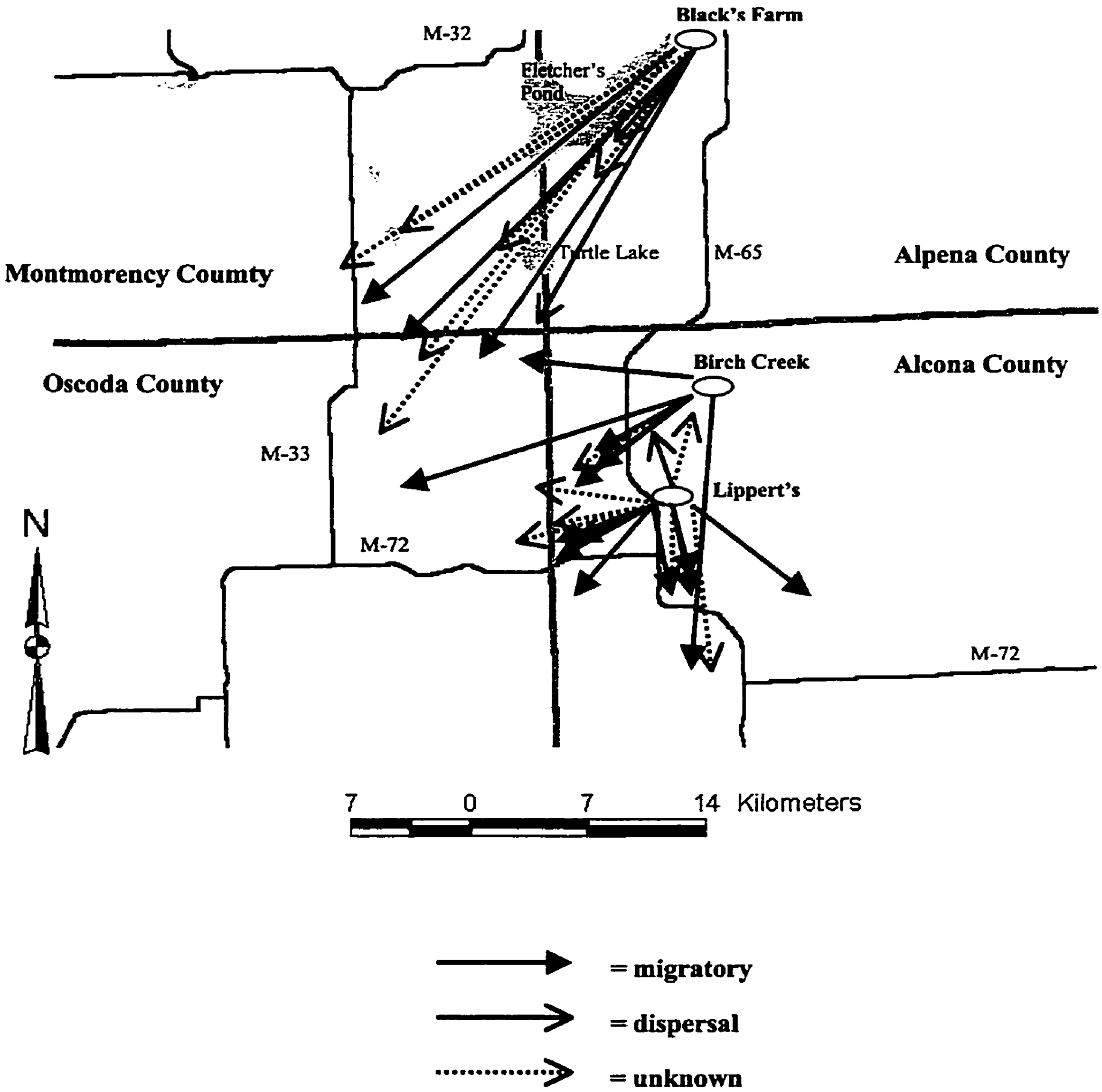


Figure 16. Distance and direction of spring movements from Black's Farm, Birch Creek Hunting Club and Lippert's.

Farm deer moved southwest. The Strohschein's Farm radio-collared deer moved northwest and northeast. The radio-collared deer that moved from the Lockwood Lake Ranch all moved north or northwest. The radio-collared deer that moved from the Leroy Hunting Club moved to the northeast along Fletcher's Pond (many passing through the Black's Farm), one to the east and the rest south or southwest. The radio-collared deer that moved from the Black's Farm moved southwest along Fletcher's Pond and many passed through (some stayed on) the Leroy Hunting Club property. The radio-collared deer that moved from the Birch Creek Hunting Club moved west, southwest and south (this deer probably passed through the Lippert's property). The radio-collared deer that moved from Lippert's moved north, west, southwest, south and to the southeast. The Lippert's radio-collared deer moved in every direction but east to northeast.

Seasonal Ranges – Old Study Sites

Table 3 lists the mean sizes of the seasonal ranges, the sample size involved in determining each seasonal range mean as well as the range of the areas. Also, the listings in Table 3 are seasonal ranges of the old sites prior to the winter feeding ban of 1998/1999. Table 4 lists the seasonal ranges, the sample size involved in determining each seasonal range mean as well as the range of areas after the winter feeding ban of 1998/1999. Also, Table 4 includes the seasonal ranges of the new sites.

Leroy Hunting Club

After comparing the mean seasonal ranges of the Leroy radio-collared deer I found that the non-migratory mean winter range during 1996/1997 was unusually large (Figure 17). Figure 17 shows that the mean ranges of all the other seasons fell well

Table 3. Mean seasonal ranges of the radio-collared deer from the old study sites before the feeding ban.

Study Sites	Categories	Winter 96/97	Summer 97	Winter 97/98	Summer 98
Leroy Hunting	Dispersal	53 ha, (1)[a]	23 ha, (1)	130 ha, (2) (22-237 ha)	45 ha, (3) (41-53 ha)
	Migratory	398 ha, (6) (76-708 ha)	188 ha, (6) (29-495 ha)	430 ha, (1)	159 ha, (1)
	Non-migratory	1,782 ha, (4) (135-3770 ha)	179 ha, (4) (41-325 ha)	162 ha, (7) (81-330 ha)	136 ha, (7) (63-284 ha)
	Unknown				
Lippert's	Dispersal	241 ha, (1)	62 ha, (1)	87 ha, (1)	65 ha, (1)
	Migratory	211 ha, (3) (100-281 ha)	1,325 ha, (3) (23-2855 ha)	654 ha, (4) (116-1958 ha)	85 ha, (4) (46-144 ha)
	Non-migratory	307 ha, (10) (24-931 ha)	217 ha, (10) (37-623 ha)	290 ha, (9) (55-1218 ha)	167 ha, (6) (95-240 ha)
	Unknown			334 ha, (7) (74-1122 ha)	141 ha, (6) (40-226 ha)
Lockwood Lake Ranch	Dispersal			520 ha, (1)	218 ha, (1)
	Migratory	446 ha, (1)	107 ha, (1)		
	Non-migratory	280 ha, (7) (49-581 ha)	245 ha, (7) (173-444 ha)	349 ha, (14) (119-766 ha)	348 ha, (14) (84-1217 ha)
	Unknown	181 ha, (1)	559 ha, (1)	174 ha, (1)	82 ha, (1)

Table 3. (cont'd)

Strohschein's Farm	Dispersal	274 ha, (1)	14 ha, (1)	61 ha, (1)	18 ha, (1)
	Migratory	416 ha, (1)	118 ha, (1)	121 ha, (1)	148 ha, (1)
	Non-migratory	166 ha, (9) (122-244 ha)	284 ha, (9) (197-533 ha)	192 ha, (14) (74-316 ha)	146 ha, (14) (41-657 ha)
	Unknown				

[a]Upper Value = mean, Value in ( ) = sample size, Lower Value = range of values
Blank = no deer in that category

Table 4. Mean seasonal ranges of the radio-collared deer from the old and new study sites after the feeding ban.

Study Sites	Categories	Winter 98/99	Summer 99
Leroy Hunting Club	Dispersal	56 ha, (2)[a] (36-75 ha)	62 ha, (1)
	Migratory	293 ha, (2) (218-367 ha)	66 ha, (2) (48-83 ha)
	Non-migratory	180 ha, (4) (34-372 ha)	178 ha, (3) (116-262 ha)
	Unknown		
Lippert's	Dispersal	232 ha, (1)	156 ha, (1)
	Migratory	262 ha, (6) (84-330 ha)	135 ha, (5) (105-195 ha)
	Non-migratory	294 ha, (8) (105-831 ha)	172 ha, (5) (75-301 ha)
	Unknown		
Lockwood Lake Ranch	Dispersal	1,469 ha, (1)	179 ha, (1)
	Migratory		
	Non-migratory	164, (3) (58-245 ha)	286, (3) (31-614 ha)
	Unknown		
Strohschein's Farm	Dispersal		
	Migratory	229 ha, (1)	156 ha, (1)
	Non-migratory	246 ha, (9) (47-432 ha)	114 ha, (8) (49-239 ha)
	Unknown		

Table 4. (cont'd)

Birch Creek Hunting Club	Dispersal		
	Migratory	208 ha, (6) (114-394 ha)	145 ha, (6) (44-384 ha)
	Non-migratory	349 ha, (5) (95-832 ha)	219 ha, (5) (91-430 ha)
	Unknown	227 ha, (1)	82 ha, (1)
Black's Farm	Dispersal	558 ha, (2) (250-865 ha)	737 ha, (2) (241-1232 ha)
	Migratory	1,014 ha, (3) (139-739 ha)	1,056 ha, (2) (400-1711 ha)
	Non-migratory	284 ha, (2) (144-212 ha)	107 ha, (2) (89-124 ha)
	Unknown	274 ha, (5) (126-510 ha)	747 ha, (4) (413-1433 ha)
Canada Creek Hunting Club	Dispersal	11 ha, (1)	322 ha, (1)
	Migratory		
	Non-migratory	100 ha, (3) (56-160 ha)	108 ha, (3) (68-136 ha)
	Unknown		
Garland Resort	Dispersal		
	Migratory		
	Non-migratory	297 ha, (3) (65-425 ha)	479 ha, (3) (352-585 ha)
	Unknown		

[a]Upper Value = mean, Value in ( ) = sample size, Lower Value = ranges of values

Blank = no deer in that category

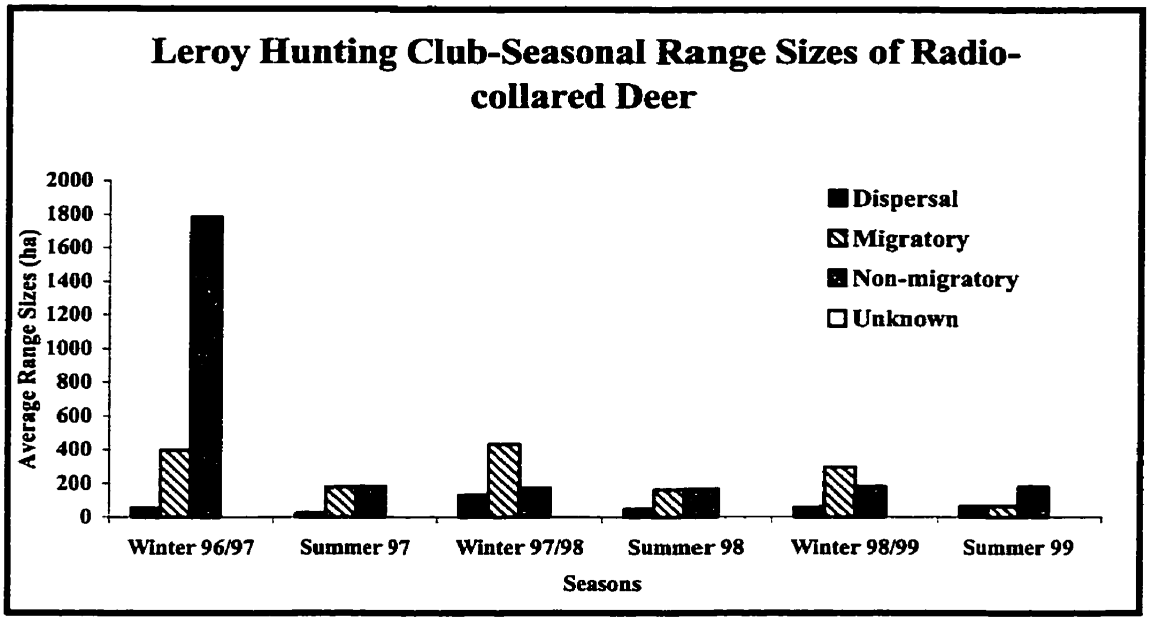


Figure 17. The seasonal ranges of Leroy Hunting Club's radio-collared deer. Those radio-collared deer of dispersal, migratory, non-migratory, or unknown movement behaviors.

below 600 ha, but the mean of the winter ranges of 1996/1997 for the non-migratory radio-collared deer was 1,782 ha (n = 4, range = 135 to 3,770 ha). The Leroy radio-collared deer that were classified as dispersers used fewer hectares during any of the seasons or any of the years. After excluding the mean winter range of 1996/1997 it appeared that the migratory deer used more area during the winters than the non-migratory deer. The migratory deer occupied fewer or up to the same number of hectares as those used by the non-migratory deer during the summer months. No radio-collared deer from the Leroy property were classified as unknown. The winter ranges of the dispersing deer were less than 200 ha. The average mean winter ranges of migratory deer were from just over 200 ha to 450 ha. The winter ranges of non-migratory deer ranged from a mean less than 200 ha to close to 1800 ha. The mean of the summer ranges of dispersal deer was less than 50 ha. The summer ranges of migratory deer ranged from a mean of approximately 50 ha to 200 ha.

Lippert's

After comparing the seasonal ranges of the Lippert's radio-collared deer, I found that the mean migratory summer (1997) and winter (1997/1998) ranges were unusually large in area (Figure 18). Both ranges were greater than 600 ha while all other ranges for seasons and years fell well below 400 ha. Radio-collared deer that dispersed appeared to have used fewer hectares overall than any of the other classifications. The mean range sizes used by the non-migratory deer were fairly constant throughout the years and seasons. The non-migratory ranges ranged from a mean of 307 ha (n = 10, range = 24 to 931 ha) for the winter of 1996/1997 to 172 ha (n = 5, range = 75 to 301 ha) for the summer of 1999.

Lockwood Lake Ranch

Only one radio-collared deer migrated from Lockwood Lake Ranch and her range sizes were: winter range, 446 ha and the summer range, 107 ha (Figure 19). The non-migratory radio-collared deer ranges were fairly constant and they ranged from 280 ha (n = 7, range = 49 to 581 ha) for the winter of 1996/1997 to 286 ha (n = 3, range = 31 to 614 ha) for the summer of 1999 (Tables 3 and 4). Only one radio-collared deer dispersed from the Lockwood Lake Ranch and his seasonal ranges varied from 1,469 (winter 1998/1999) to 179 ha (summer 1999). Only 1 radio-collared deer was categorized in the unknown classification at the Lockwood Lake Ranch. It's range sizes were 82 ha for the winter of 1996/1997 and 559 ha for the summer of 1997.

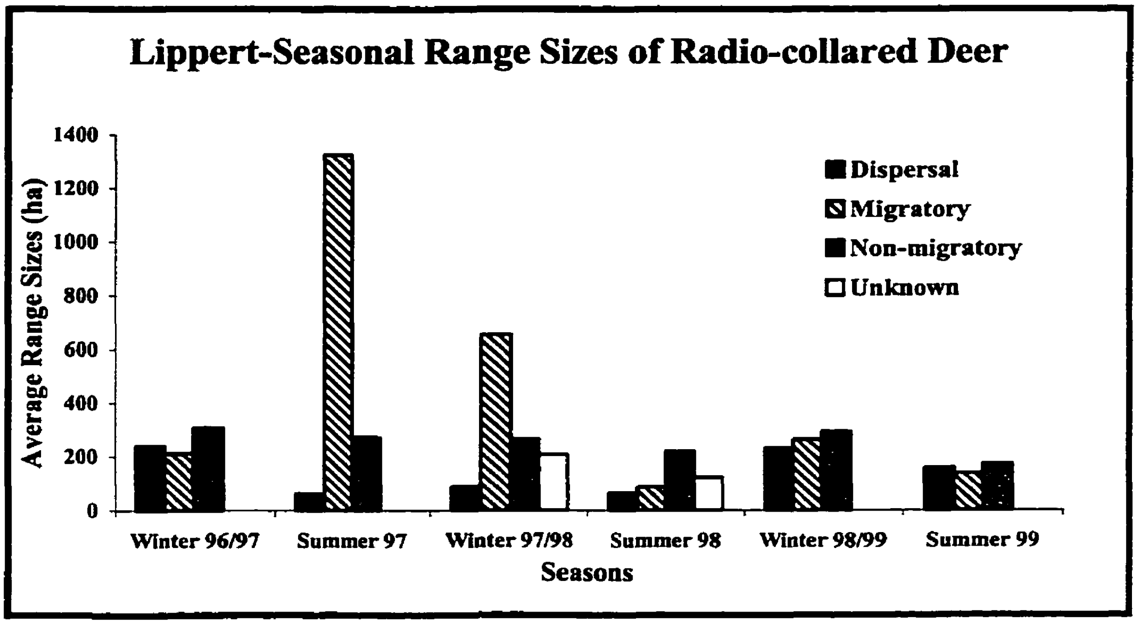


Figure 18. The seasonal ranges of Lippert's radio-collared deer. Those radio-collared deer of dispersal, migratory, non-migratory, or unknown movement behaviors.

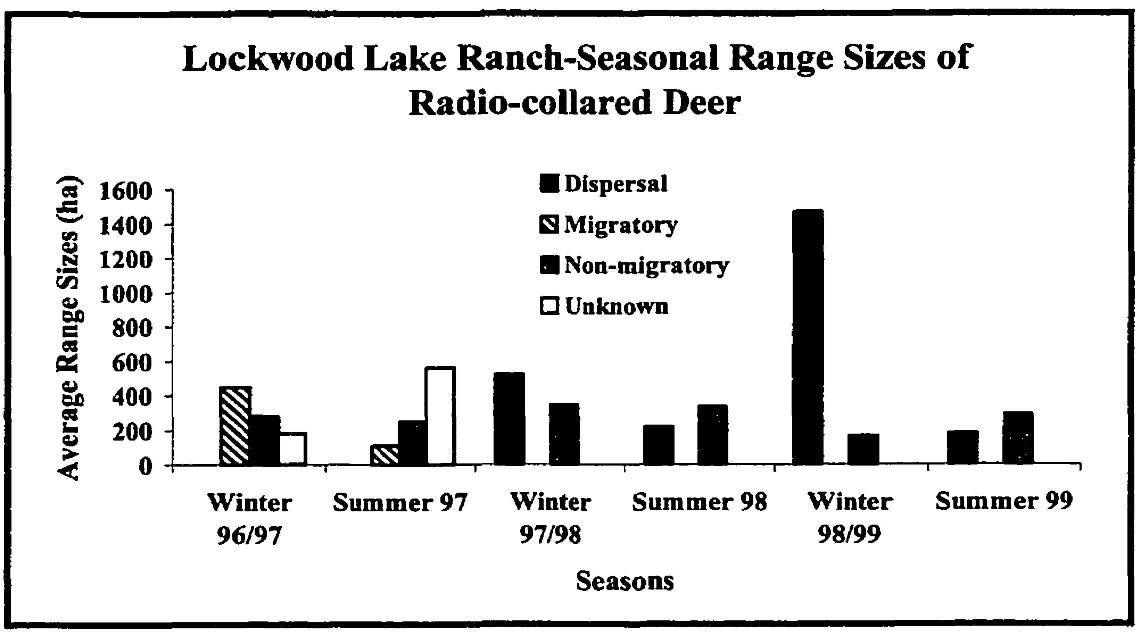


Figure 19. The seasonal ranges of Lockwood Lake Ranch radio-collared deer. Those radio-collared deer of dispersal, migratory, non-migratory, or unknown movement behaviors.

Strohschein's Farm

The dispersal columns in Figure 20 (Table 3 and 4) illustrate the range sizes of only one radio-collared deer from the Strohschein's Farm and her range sizes were 274 (winter 1996/1997), 14 (summer 1997), 61 (winter 1997/1998) and 18 ha (summer 1998). Only one radio-collared deer migrated from the Strohschein's Farm and her range sizes were 416 (winter 1996/1997), 118 (summer 1997), 121 (winter 1997/1998), 148 (summer 1998), 229 (winter 1998/1999) and 156 ha (summer 1999). The Strohschein's Farm non-migratory deer ranges were fairly constant and they ranged from 166 ha (n = 9, range = 122 to 244 ha) to their largest range 284 ha (n = 9, range = 197 to 533 ha) the winter of 1996/1997. Of the radio-collared deer used in the range estimates of the Strohschein's Farm deer, none were classified as an unknown movement.

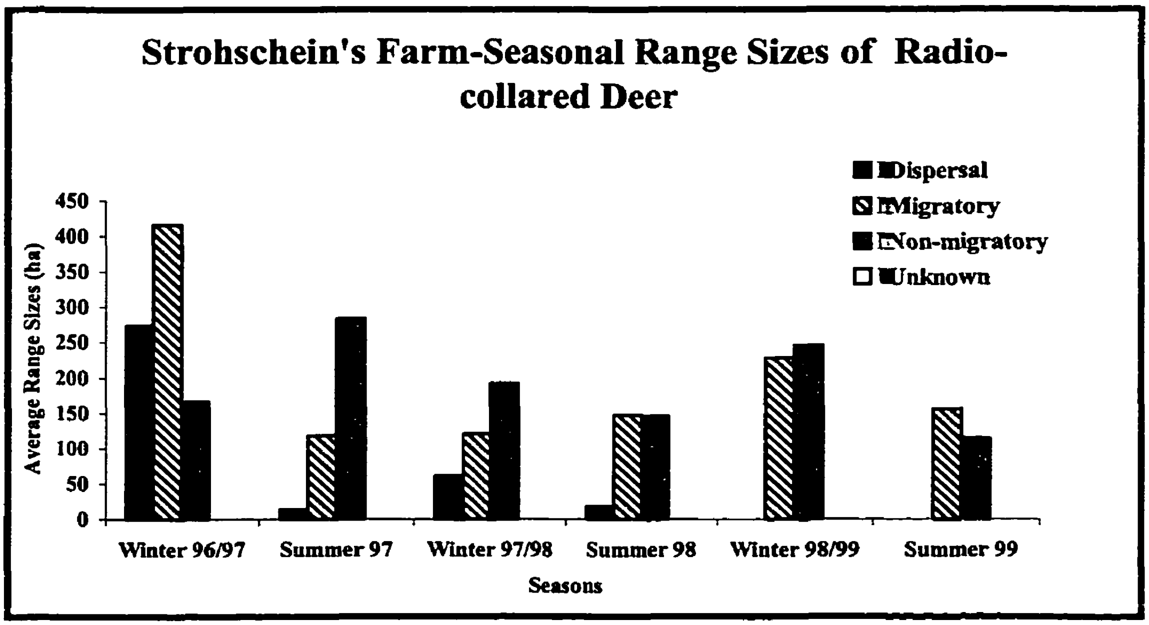


Figure 20. The seasonal ranges of Strohschein's Farm radio–collared deer. Those radio-collared deer of dispersal, migratory, non-migratory, or unknown movement behaviors.

Seasonal Ranges - New Trap (Study) Sites

The sample sizes from the Birch Creek Hunting Club and Black's Farm were much larger than those at the Canada Creek Hunting Club and Garland Resort (Table 4). None of the Birch Creek Radio-collared deer dispersed (Figure 21). The mean range sizes for the Birch Creek Hunting Club migratory deer were 208 ha (n = 6, Range = 114 to 394 ha) for the winter (1998/1999) and 145 ha (n = 6, range = 44 to 384 ha) for the summer (1999) range. The mean range sizes for the Birch Creek Hunting Club non-migratory deer were 349 ha (n = 5, range = 95 to 832 ha) for the winter (1998/1999) and 219 ha (n = 5, range = 91 to 430 ha) for the summer (1999) range. One deer was classified in the unknown movement category and it's range sizes were 277 ha for the

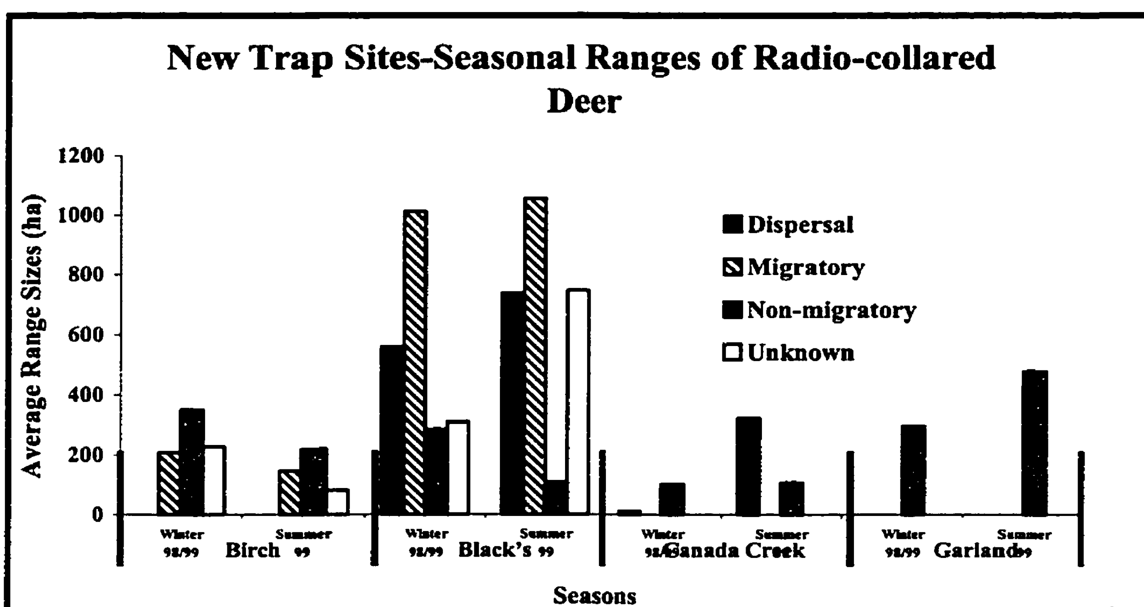


Figure 21. The seasonal ranges of the radio-collared deer from the new trap (study) sites. Those radio-collared deer of dispersal, migratory, non-migratory, or unknown movement behaviors.

winter (1998/1999) and 82 ha for the summer (1999). All Birch Creek Hunting Club radio-collared deer mean ranges were less than 400 ha.

The mean range sizes for the Black's Farm dispersal deer were 558 ha (n = 2, range = 250 to 865 ha) for the winter (1998/1999) and 737 ha (n = 2, range = 241 to 1,232 ha) for the summer (1999) range. The mean range sizes for the Black's Farm migratory deer were 1,014 ha (n = 3, range = 139 to 739 ha) for the winter (1998/1999) and 1,056 ha (n = 2, range = 400 to 1,711 ha) for the summer (1999) range. The mean range sizes for the Black's Farm non-migratory deer were 284 ha (n = 2, range = 144 to 212 ha) for the winter (1998/1999) and 107 ha (n = 2, range = 89 to 124 ha) for the summer (1999) range. Finally, the mean range sizes for the Black's Farm radio-collared deer that fell into the unknown category were 274 ha (n = 5, range = 126 to 510 ha) for the winter (1998/1999) and 747 ha (n = 4, range = 413 to 1,433 ha) for the summer (1999) range. The dispersal, migratory and unknown movement radio-collared deer from the Black's Farm all were found to have used larger areas than any of the other new study sites. The non-migratory deer from the Black's Farm were more consistent with the non-migratory deer from the other sites using less than 400 ha.

There was one radio-collared deer that dispersed from Canada Creek Hunting Club and her ranges were 11 ha the winter of 1998/1999 and 322 ha the summer of 1999. No radio-collared deer migrated and none were classified as unknown movements from the Canada Creek Hunting Club. The mean range sizes for the Canada Creek Hunting Club non-migratory deer were 100 ha (n = 3, range = 56 to 160 ha) for the winter (1998/1999) and 108 ha (n = 3, range = 68 to 136 ha) for the summer (1999) range.

No radio-collared deer dispersed or migrated and none were classified as unknown movements from the Garland Resort. The mean range sizes for the Garland Resort non-migratory deer were 297 ha (n = 3, range = 65 to 425 ha) for the winter (1998/1999) and 479 ha (n = 3, range = 352 to 585 ha) for the summer (1999) range.

Seasonal Ranges – Old and New Sites – Before and After Feeding Ban

After comparing mean seasonal ranges of the old study sites (females and males combined) both before and after the winter feeding ban of 1998/1999 along with the new study sites (females and males combined) after the winter feeding ban some interesting results were discovered (Figure 22). The mean ranges used by the dispersal deer were much smaller before the winter feeding ban than those after the winter feeding ban. Before the feeding ban the mean ranges were 140 ha (n = 7) for the winter of 1996/1997 and 59 ha (n = 9) for the summer 1997 (Table 5). After the feeding ban the dispersal

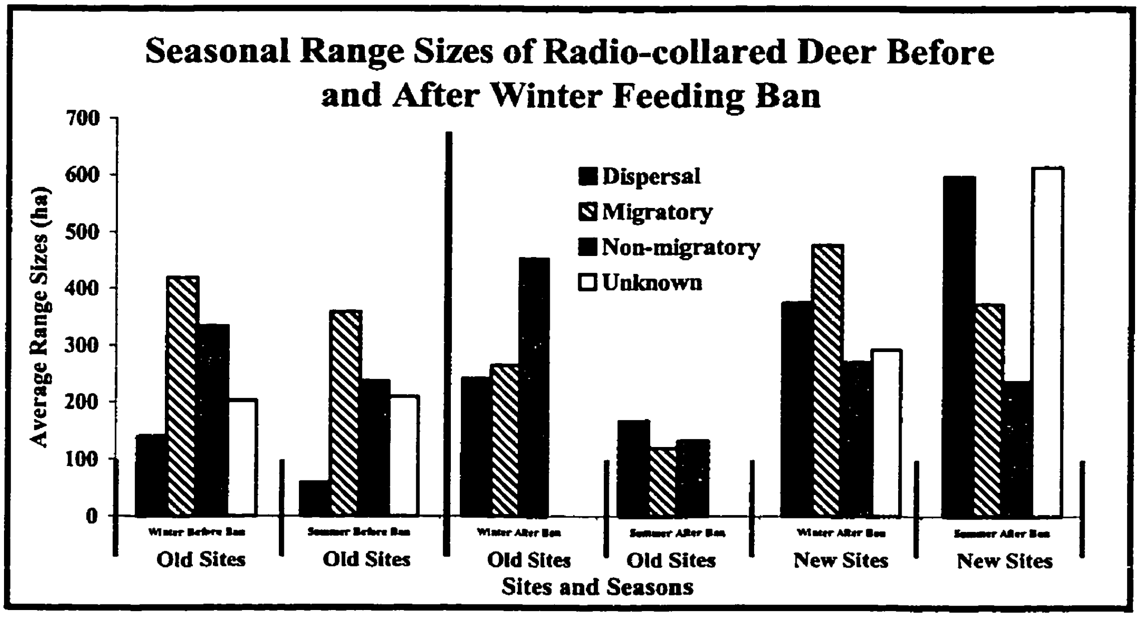


Figure 22. Seasonal ranges of radio-collared deer from old and new sites before and after the winter feeding ban of 1998/1999.

Table 5. Mean seasonal ranges of the radio-collared deer from the old and new study sites before and after the winter feeding ban (1998/1999).

	OLD SITES *Before Feed Ban*		**OLD SITES** *After Feed Ban*		**NEW SITES** *After Feed Ban*	
Categories	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**
Dispersal	140 ha,(7)[a]	59 ha,(9)	453 ha,(4)	132 ha,(3)	376 ha,(3)	598 ha,(3)
Migratory	420 ha,(17)	358 ha,(16)	265 ha,(9)	120 ha,(8)	477 ha,(9)	373 ha,(8)
Non-migratory	334 ha,(76)	236 ha,(72)	241 ha,(24)	167 ha,(19)	270 ha,(13)	236 ha,(13)
Unknown	202 ha,(5)	209 ha,(5)			293 ha,(5)	614 ha,(5)

[a]Value = mean, Value in ( ) = sample size
Blank = no deer in that category

ranges were 453 ha (n = 4) the winters of 1997/1998 and 1998/1999 (old sites), 132 ha (n = 3) the summer of 1998, 376 ha (n = 3) the winter of 1998/1999, and 598 ha (n = 3) the summer of 1999. The mean migratory ranges were larger for the radio-collared deer of the old study sites before the feeding ban than those after the feeding ban. Before the ban the migratory means were 420 ha (n = 17) the winter of 1996/1997 and 358 ha (n = 16) the summer of 1997. After the feeding ban the migratory mean ranges were 265 ha (n = 9) the winters of 1997/1998 and 1998/1999 (old sites), 120 ha (n = 8) the summer of 1998, 477 ha (n = 9) the winter of 1998/1999, and 373 ha (n = 8) the summer of 1999. Overall the mean non-migratory ranges were fairly constant before and after the winter feeding ban of 1998/1999. The non-migratory ranges were 334 ha (n = 76) the winter of 1996/1997, 236 ha (n = 72) the summer of 1997, 241 ha (n = 24) the winters of 1997/1998 and 1998/1999 (old sites), 167 ha (n = 19) the summer of 1998, 270 ha (n = 13) the winter of 1998/1999 and 236 ha (n = 13) the summer of 1999. The mean ranges of the radio-collared deer that were classified in the unknown category were somewhat smaller before the winter feeding ban than after the winter feeding ban. The mean ranges before the feeding ban for the deer of the unknown category were 202 ha (n = 5) the winter of 1996/1997 and 209 ha (n = 5) the summer of 1997. No deer from the old sites were classified in the unknown category after the feeding ban. After the winter feeding ban, the radio-collared deer from the new sites that were classified as unknown movements had mean ranges of 293 ha (n = 5) the winter of 1998/1999 and 614 ha (n = 5) the summer of 1999.

I used the Kruskal-Wallis test to determine if there were any significant differences in the ranges of the radio-collared deer from the old study sites before and after the winter feeding ban. I determined that there was no significant difference (x^2 = 0.5, P>0.05) between the winter range sizes of non-migratory deer before and after the winter feeding ban. There was a significant difference (x^2 = 5.1, P<0.05) between the sizes of non-migratory summer ranges from before and after the winter feeding ban. There was no significant difference between the winter (x^2 = 1.5, P>0.05) or summer (x^2 = 1.0, P>0.05) ranges (before and after the winter feeding ban) of the migratory radio-collared deer.

Mean Ranges by Sex and Age – Old Study Sites

Leroy Hunting Club

Comparisons were made after all data were categorized as either female or male yearling, female or male adult and winter or summer seasons (Figure 23). All sexes were represented in at least one category at the Leroy Hunting Club with the exception of adult males. Adult males were radio-collared at the Leroy Hunting Club, but only movements

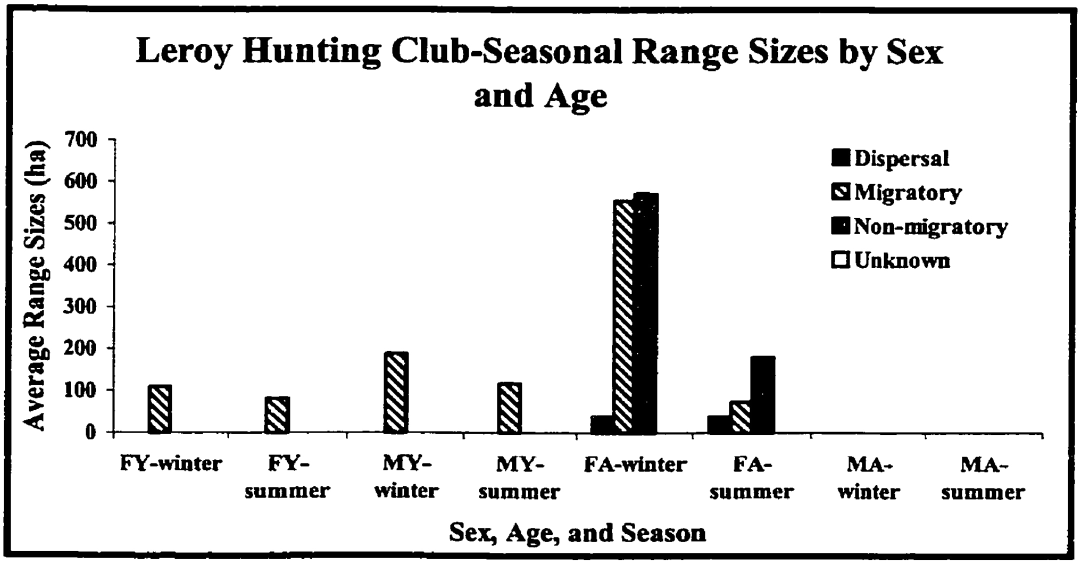


Figure 23. Mean seasonal ranges by sex and age of radio-collared deer from the Leroy Hunting Club.

determined. Not enough locations were recorded to determine seasonal ranges for the Leroy adult males. Only mean migratory ranges were determined for the yearling females and males of the Leroy Hunting Club. The female yearling mean migratory seasonal ranges were 109 ha, (n = 2, range = 76 to 142 ha) for the winters and 82 ha (n = 2, range = 29 to 135 ha) for the summer ranges. The male yearling migratory ranges were 187 ha (n = 1) for the winters and 117 ha (n = 1) for the summers. Only one adult female dispersed from the Leroy Hunting Club and her mean ranges were 38 ha for the winters and the summers. The adult female's mean migratory ranges were 556 ha (n = 4, range = 237 to 708 ha) for the winter and 74 ha (n = 3, range = 38 to 123 ha) for the summers. The non-migratory ranges for adult females were 572 ha (n = 16, range = 34 to 3,770 ha) for the winters and 180 ha (n = 16, range = 23 to 495 ha) for the summers.

Lippert's

All sexes and ages from the Lippert's radio-collared deer population were represented in at least one category (Figure 24). Adult females were the only deer to disperse. Their mean ranges were 187 ha (n = 3, range = 87 to 241 ha) for the winters and 94 ha (n = 3, range = 62 to 156 ha) for the summers. The yearling females, males and adult females all had migratory deer. The mean seasonal ranges for the migratory yearling females were 211 ha (n = 3, range = 116 to 267 ha) for the winters and 1,020 ha (n = 3, range = 61 to 2,855 ha) for the summers. The mean seasonal ranges for the migratory yearling males were 158 ha (n = 3, range = 92 to 281 ha) for the winters and 438 ha (n = 3, range = 23 to 1,097 ha) for the summers. The mean seasonal ranges for the migratory adult females were 794 ha (n = 3, range = 94 to 1,958 ha) for the winters and 118 ha (n = 3, range = 88 to 151 ha) for the summers. The mean seasonal ranges for

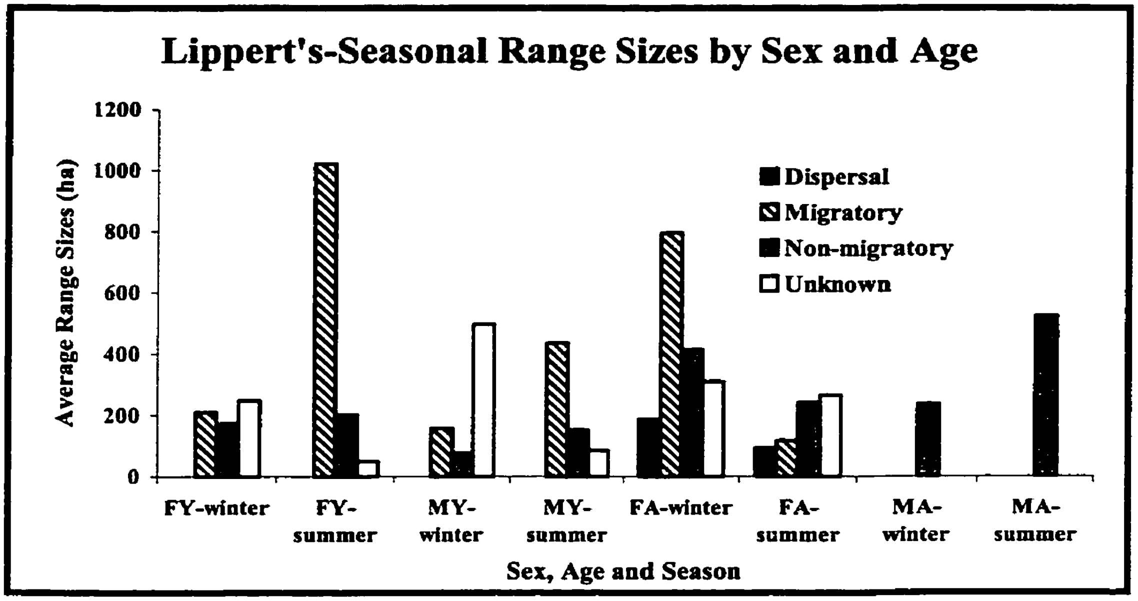


Figure 24. Mean seasonal ranges by sex and age of radio-collared deer from Lippert's.

the non-migratory yearling females were 172 ha (n = 5, range = 98 to 317 ha) for the winters and 203 ha (n = 5, range = 37 to 439 ha) for the summers. The mean seasonal ranges for the non-migratory yearling males were 74 ha (n = 3, range = 24 to 131) for the winters and 152 ha (n = 3, range = 95 to 240 ha) for the summers. The mean seasonal ranges for the non-migratory adult females were 415 ha (n = 15, range = 55 to 1,218 ha) for the winters and 243 ha (n = 11, range = 75 to 623 ha) for the summers. The seasonal ranges for the non-migratory adult males were 237 ha (n = 1) for the winters and 524 ha (n = 1) for the summers. The seasonal ranges for the yearling female radio-collared deer from Lippert's that was categorized in the unknown movement classification were 249 ha (n = 1) for the winters and 48 ha (n = 1) for the summers. The unknown yearling male seasonal ranges were 496 ha (n = 3, range = 92 to 1,122 ha) for the winters and 85 ha (n = 2, range = 40 to 130 ha) for the summers. Only one adult female was classified in the unknown category and she had seasonal ranges of 312 ha for the winters and 267 ha for the summers.

Lockwood Lake Ranch

All sexes and ages from the Lockwood radio-collared deer population were represented in at least one category (Figure 25). The yearling females that were radio-collared at Lockwood Lake Ranch were all non-migratory. Their mean seasonal ranges were 358 ha (n = 5, range = 119 to 743 ha) for the winters and 353 (n = 4, range = 87 to 815 ha) for the summers. The yearling male's movements were either dispersal, non-migratory or unknown. Only one yearling male represented each of the dispersal and unknown categories. The winter range for the yearling male that dispersed was 520 ha and the summer range was 218 ha. The winter range for the yearling male whose movements were unknown was 174 ha and his summer range was 82 ha. I was able to determine his

winter and summer ranges before his fall movement, however, I was unable to identify if he migrated or dispersed because he was hunter harvested. The mean winter range for the non-migratory yearling males was 417 ha (n = 8, range = 82 to 1,217 ha). No data were recorded for their summer ranges. The adult females were only migratory or non-migratory deer. The seasonal ranges for the migratory adult female was 446 ha (n = 1) for the winters and 107 (n = 1) for the summers. The mean seasonal ranges for the non-migratory adult females were 147 ha (n = 7, Range = 129 to 174 ha) for the winters and 199 ha (n = 8, range = 84 to 461 ha) for the summers. There was only one adult male that was radio-collared at Lockwood Lake Ranch and his movement was classified as unknown. His seasonal ranges were 181 ha for the winter range and 559 ha for the summer range.

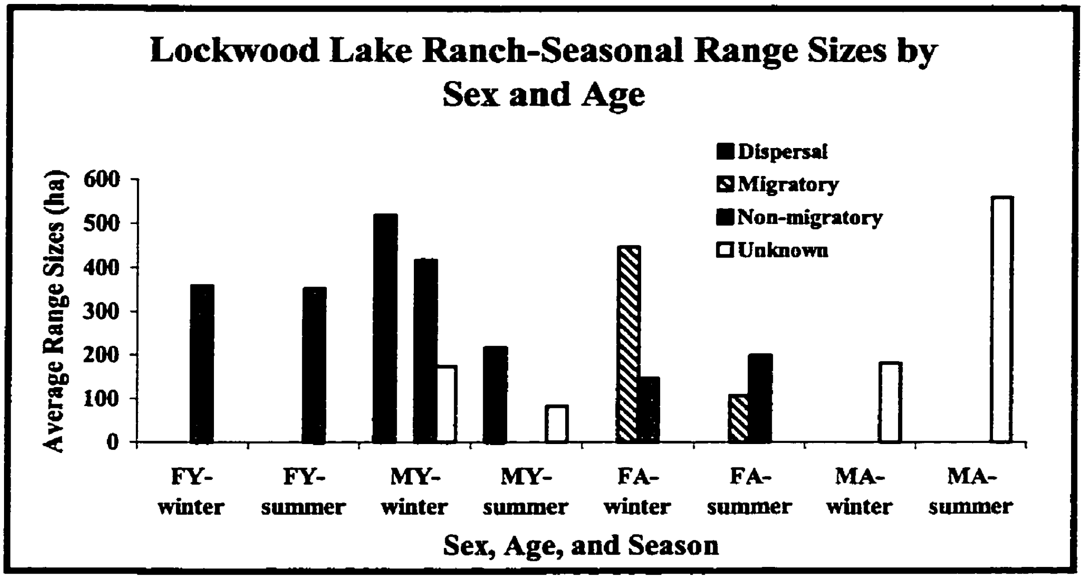


Figure 25. Mean seasonal ranges by sex and age of radio-collared deer from Lockwood Lake Ranch.

Strohschein's Farm

The Strohschein's Farm radio-collared yearling females and males were non-migratory only (Figure 26). The yearling females mean non-migratory ranges were 138 ha (n= 6, range = 76 to 244 ha) for the winter and 261 ha (n = 6, range 47 to 533 ha) for the summer. The yearling males mean non-migratory ranges were 176 ha (n = 8, range = 121 to 272 ha) for the winter and 170 ha (n = 8, range = 39 to 436 ha) for the summer. The adult females were classified as either dispersers, migratory or non-migratory. Only one adult female dispersed and only one adult female migrated. The doe that dispersed had a mean winter range of 168 ha and a mean summer range of 16 ha. The doe that migrated had a mean winter range of 255 ha and a mean summer range of 141 ha. The non-migratory adult female mean seasonal ranges were 191 ha (n = 7, range = 74 to 291 ha) for the winter and 241 ha (n = 7, range = 41 to 657 ha) for the summer. No seasonal

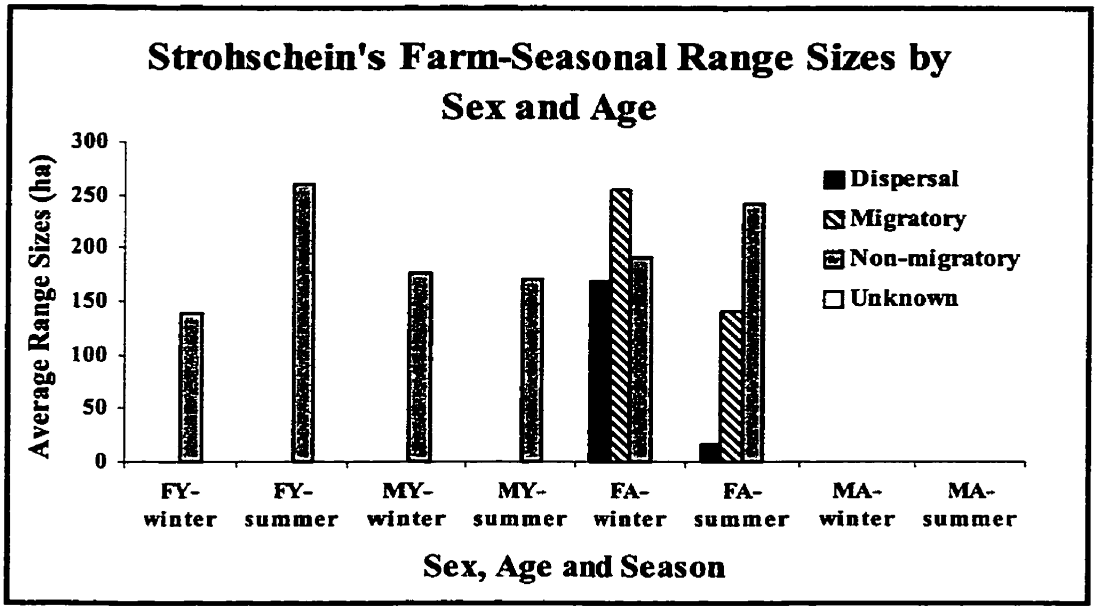


Figure 26. Mean seasonal ranges by sex and age of radio-collared deer from Strohschein's Farm.

ranges were determined for Strohschein's Farm adult males due to the lack of data.

Mean Ranges by Sex and Age – New Study Sites

Birch Creek Hunting Club

All sexes and ages were represented from the Birch Hunting Club radio-collared deer population with the exception of the adult males (Figure 27). No adult males were radio-collared while trapping at the Birch Creek Hunting Club. The movements of the yearling females and males that were radio-collared were classified as either migratory or non-migratory. Only one yearling female was migratory and only one was non-migratory. The seasonal ranges of the migratory yearling female were 394 ha (n = 1) for the winter and 44 ha (n = 1) for the summer. The seasonal ranges of the non-migratory yearling female were 832 ha (n = 1) for the winter and 197 ha (n = 1) for the summer. Two yearling males were migratory and their mean seasonal ranges were 201 ha (n = 2,

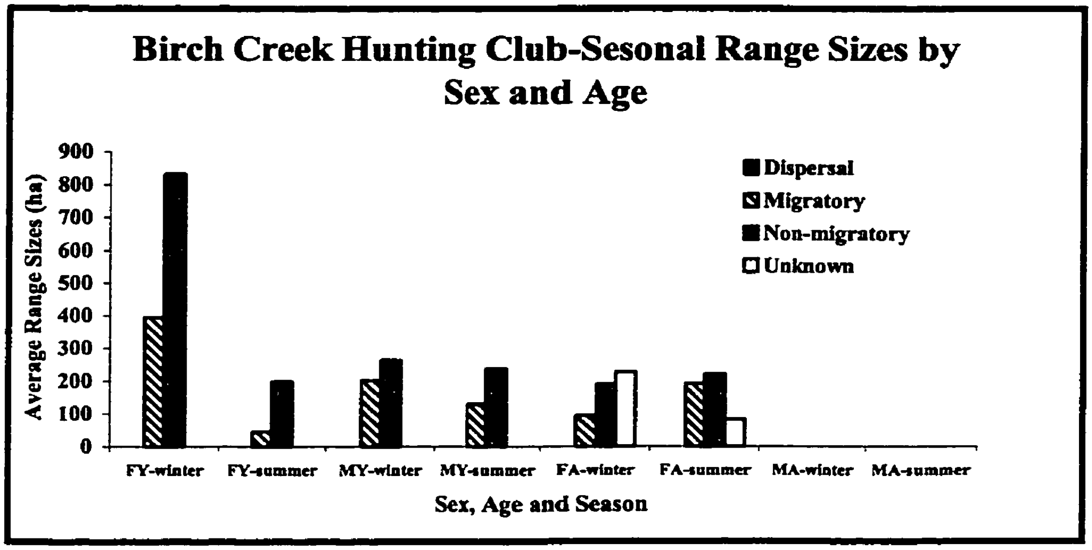


Figure 27. Mean seasonal ranges by sex and age of radio-collared deer from the Birch Creek Hunting Club.

range = 135 to 266 ha) for the winter and 128 ha (n = 2, range = 86 to 169 ha) for the summer. Only one male yearling was non-migratory and his ranges were 264 ha (n = 1) for the winter and 236 ha (n = 1) for the summer. The adult females mean migratory ranges were 152 ha (n = 3, range = 114 to 177) for the winter and 191 ha (n = 3, range = 73 to 384 ha) for the summer. The adult females mean non-migratory ranges were 189 ha (n = 3, range = 95 to 296 ha) for the winter and 221 ha (n = 3, range = 91 to 430 ha) for the summer. One adult female was classified as unknown and her range sizes were 227 ha (n = 1) for the winter and 82 ha (n = 1) for the summer.

Black's Farm

No movement patterns could be determined regarding the yearling female radio-collared deer at the Black's Farm (Figure 28). One yearling male was determined to be non-migratory and his range sizes were 144 ha (n = 1) for the winter and 124 ha (n = 1)

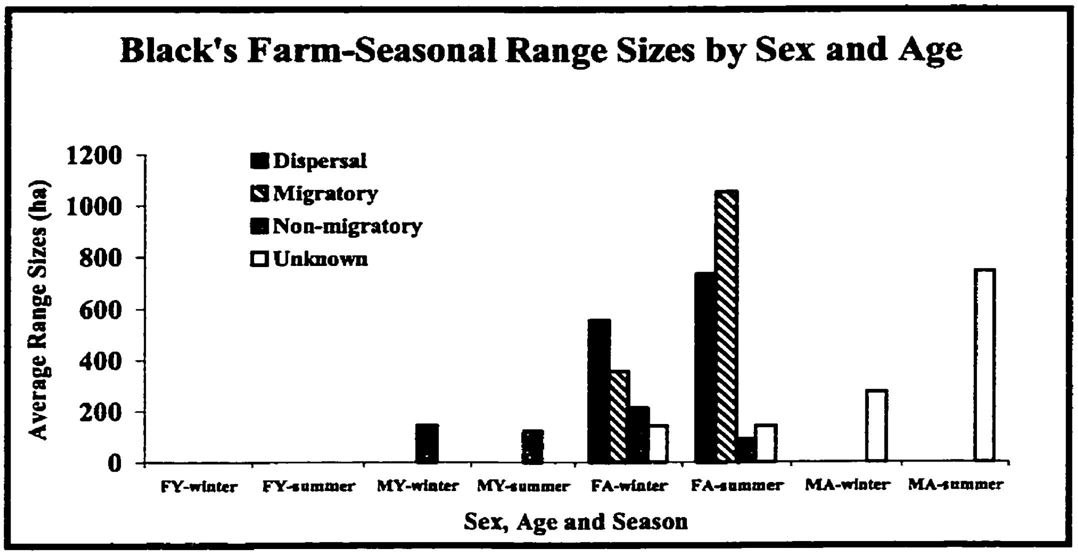


Figure 28. Mean seasonal ranges by sex and age of radio-collared deer from the Black's Farm.

250 to 865 ha) for the winter and 737 ha (n = 2, range = 241 to 1,232 ha) for the summer. The migratory adult female ranges were 356 ha (n = 3, range = 139 to 739 ha) for the winter and 1,056 ha (n = 2, range = 400 to 1,711 ha) for the summer. Only one adult female was classified as non-migratory and only one as unknown. The non-migratory adult females ranges were 212 ha (n = 1) for the winter and 89 ha (n = 1) for the summer. The adult female that was classified as unknown had seasonal ranges of 142 ha (n = 1) in both the winter and summer seasons. All adult males were classified in the unknown category and their mean seasonal ranges were 274 ha (n = 5, range = 126 to 510 ha) for the winter and 747 ha (n = 4, range = 413 to 1,433 ha) for the summer.

Canada Creek Hunting Club

There was only one yearling female and one yearling male that were classified from Canada Creek Hunting Club and both were non-migratory (Figure 29). The female's seasonal ranges were 56 ha (n = 1) for the winter and 68 ha (n = 1) for the

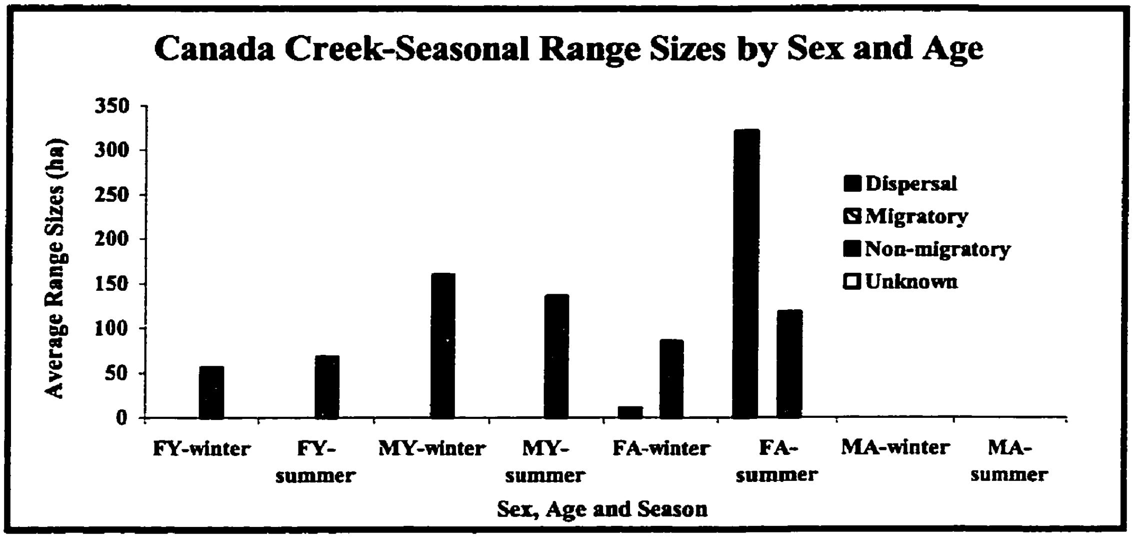


Figure 29. Mean seasonal ranges by sex and age of radio-collared deer from the Canada Creek Hunting Club.

summer. The male's seasonal ranges were 160 ha (n = 1) for the winter and 136 ha (n = 1) for the summer. Two adult females were classified; one dispersed and the other was non-migratory. The seasonal range sizes of the female that dispersed were 11 ha (n = 1) for the winter and 322 ha (n = 1) for the summer. The seasonal range sizes of the female that was non-migratory were 86 ha (n = 1) for the winter and 118 ha (n = 1) for the summer. No adult males were radio-collared at the Canada Creek Hunting Club.

Garland Resort

No data were collected on yearling females, yearling males or adult males at the Garland Resort (Figure 30). All adult females were classified as non-migratory and their mean seasonal ranges were 297 ha (n =3, Range = 65 to 425 ha) for the winter and 479 ha (n = 3, range = 352 to 585 ha) for the summer.

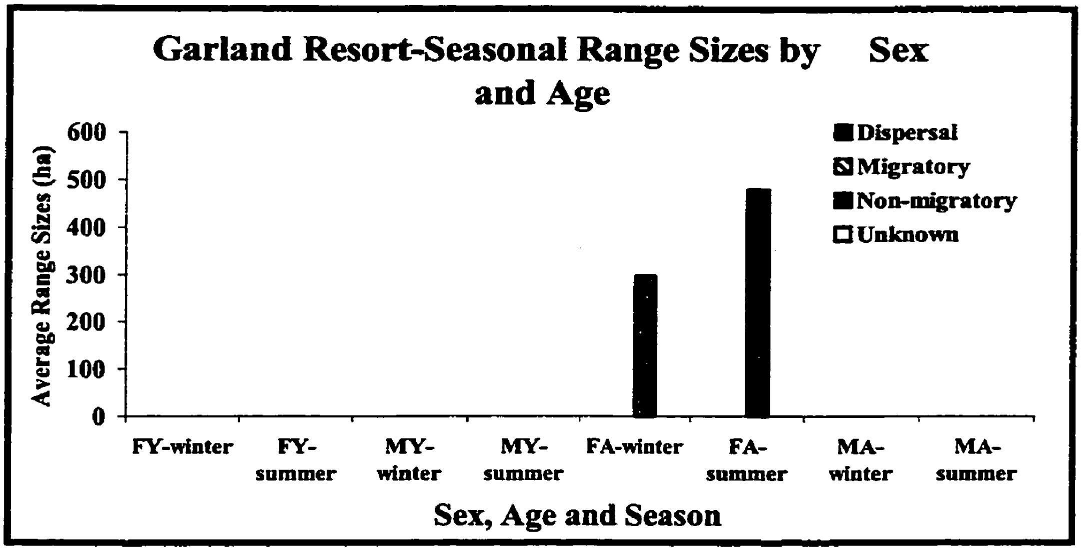


Figure 30. Mean seasonal ranges by sex and age of radio-collared deer from the Garland Resort.

DISCUSSION

April 1 and October 28 were determined to be the last days on winter and summer ranges, respectively, for the deer monitored during this project. The determined last day on winter range for the radio-collared deer of this study was similar to those found in other northern Michigan studies, but the determined last day on summer range was slightly earlier in the fall than those of other studies. Van Deelen (1995) found the last day of winter and summer seasons for Upper Peninsula deer to be April 4 and December 15, respectively. Sitar (1996) determined the last day of the winter season to be April 8 in 1994 and March 27 in 1995. The last day of the summer season was November 29 in 1994 and November 19 in 1995 for migratory deer in what is now the northern part of the DMU 452. I suspect that the last day of the summer season was earlier in the DMU 452 because of changes in activities on the properties which were studied. Most of the study sites had very little activity throughout the summer months. If there was activity or human use of the property it was predictable, but in the late summer as many hunters prepared for archery season human activity increased immensely. For example, a property of over a thousand hectares would have basically no activity at all for months and then in late summer 5 to 15 individuals would begin using the property.

Since I did not calculate home range sizes, only seasonal range sizes, it was difficult to make comparisons to results of other studies. Seasonal ranges cannot simply be added together to determine home ranges because in many cases there was considerable overlap. Sitar (1996) found the mean home range sizes of non-migratory deer to be 424 ha in 1994 and 356 ha in 1995. After comparing Sitar's results to the seasonal ranges from Table 5, I discovered that my seasonal ranges were slightly smaller. Combining the winters and summers would generate more similar range sizes to Sitar's findings. Sitar calculated seasonal ranges for her migratory deer and after comparing her results with mine I found the seasonal ranges to be similar. The mean winter range sizes for Sitar's migratory deer were 202 ha in 1994 and 355 ha in 1995. The mean winter range sizes for this project were 420 ha in 1996/1997, 265 ha in 1997/1998 and 477 ha in 1998/1999. The mean summer range sizes for Sitar's migratory deer were 337 ha in 1994 and 329 ha in 1995. The mean summer range sizes for this project were 358 ha in 1996/1997, 120 ha in 1997/1998 and 373 ha in 1998/1999. All of the mean seasonal ranges from Table 5 were below 500 ha in size with the exception of the new study site's summer range of the unknown categorized deer. All of the mean home ranges (non-migratory and migratory deer) of Sitar's study were below 500 ha in size.

Movement – Old Study Sites

After trapping, radio-collaring and monitoring deer from the old study sites for 3 years it is obvious that deer from the Lockwood Lake Ranch and Strohschien's Farm do not typically move (migrate or disperse). Only one deer migrated, one dispersed and two moved (they were classified in the unknown movement category) of over 20 radio-collared deer that were monitored from the Lockwood Lake Ranch. Only one deer migrated, one dispersed and none were classified as unknown movements of the over 30 radio-collared deer that were monitored from the Strohschein's Farm. Of the 13 deer that were radio-collared during the winter of 1996/1997 at the Leroy Hunting Club, 8 migrated, 1 dispersed and none were classified in the unknown category. Sixty-two percent of the radio-collared Leroy Hunting Club deer migrated and their mean migratory distance traveled was 11 km. Of the Lippert's radio-collared deer 9 migrated, 1 dispersed and 6 were classified as unknown of over 50 that were radio-collared. Eighteen percent of the radio-collared deer migrated to and from the Lippert's property and their mean migratory distance traveled was 6.9 km.

Few radio-collared deer moved (migrated or dispersed) from the Lockwood Lake Ranch because the forest on the property was managed in a timber rotation and there were high deer harvests during the fall hunting seasons. The timber harvest furnished deer with a diversity of structure throughout the property and a variety of browse (McCabe and McCabe 1984, Kammermeyer and Thackston 1995, Palik and Engstrom 1999). The deer on the Lockwood Lake Ranch were exposed to high hunting pressure, high successful fall harvests, decreased density during winter months, were fed during the winter months and benefited from timber harvesting. The Lockwood Lake Ranch deer had plenty of space, food and little competition during the winter and spring months giving them no reason to leave.

Confusion or abandonment of offspring after a dominant doe was harvested may have altered the traditional spring movements of local deer (Miller et al. 1995, Nixon et al. 1988, Ozoga et al. 1982 and Staines 1974). I am suggesting that once dominant does were harvested and adults were continually heavily harvested, movement may have stopped or changed due to the juveniles lack of traditional knowledge. I presume that these were some of the reasons why the radio-collared deer from the Lockwood Lake Ranch moved (migrate or disperse) very little. I suspect that those that did leave and return did so because it was a traditional movement (Nelson and Mech 1981, Tierson et al.1985). The ranch had a history of heavily feeding deer through the winter and there was appropriate wintering cover on the property.

Radio-collared deer from the Strohschein's Farm moved very little and were faced with some similar impacts as the deer on Lockwood Lake Ranch, but there were some differences too. In the area of the Strohschein's Farm there had been a reputation of high hunting pressure and high fall harvest. In conversations with Art Strohschein and other local property owners I discovered that deer had been fed there for many years and it was known as the most reliable and largest feeding station in the immediate area. During the winter months deer that survived the fall harvest fed and resided in the swamp adjacent to the Strohschein's winter feeding station. I suspect that once spring arrived deer moved little because there was low competition and plenty of space and food. There were many small farms in the area which grew corn and hay so food was abundant. I suspect that most of the deer movements from the Strohschein's Farm were non-migratory movements and these movements were by deer most likely looking for more space (Thomas et al 1964, Byford 1970, Kammermeyer and Marchinton 1976). The wintering habitat of the Strohschein's Farm was sufficient for a higher concentration of deer when the deer were being fed through the winter months, but it was inadequate for that density during the summer months. To some extent the deer held in the close winter quarters of the Strohschein's Farm had heavily browsed their potential spring and summer forage (McShea et al. 1997, Trumbull et al. 1989 and Verme and Johnston 1986). Those deer that did leave and return did so because it was a traditional movement (Nelson and Mech 1981, Tierson et al.1985); the farm had traditionally heavily winter fed deer and there was appropriate cover for wintering habitat.

Movement was greater from the Leroy Hunting Club because they and the neighboring clubs had the reputation of not harvesting does. Since there was little to no doe harvest, the traditional movements of dominant does were passed from generation to generation (Miller et al. 1995, Nixon et al. 1988, Ozoga et al. 1982 and Staines 1974). Deer moved from the Leroy Hunting Club because once spring arrived these deer were in an area where there was a higher deer density, no practice of timber harvesting and no farming (Thomas et al 1964, Byford 1970, Kammermeyer and Marchinton 1976). I suspect that they returned because it was a traditional movement (Nelson and Mech 1981, Tierson et al.1985), the club had traditionally winter fed deer and there was great cover on the club property for wintering habitat.

The radio-collared deer from the Lippert's property moved somewhat because dominant does could pass the tradition on (Miller et al. 1995, Nixon et al. 1988, Ozoga et al. 1982 and Staines 1974), there were high deer densities (limited space) and limited food. There were few if any deer harvested from the Lippert's property. If deer were harvested they were adult males so adult females survived to pass their traditional movements on to their offspring. The Lippert's had heavily fed deer for many years so many deer stayed on their property throughout the winter months. The deer that remained on the Lippert's property during the winter months browsed their potential spring and summer forage heavily (McShea et al. 1997, Trumbull et al. 1989 and Verme and Johnston 1986). Fields were planted for spring and summer food plots and there were many radio-collared deer that stayed the summer on the Lippert's property. Those radio-collared deer that moved from the Lippert's property moved because once spring arrived they were in an area where there was a higher deer density and no practice of timber harvesting (little to no new browse in the area). I suspect that they returned because it was a traditional movement (Nelson and Mech 1981, Tierson et al.1985). The Lippert's had traditionally heavily fed deer during the winter and there was wintering cover on the Lippert's property.

Seventeen percent of the radio-collared deer from all the old sites migrated and their mean migratory distance traveled was 8.4 km. After considering all these facts it must be understood that these percentages were slightly under-estimated due to premature deaths (e.g hunter harvested, road-kills). For example, there were 6 of the Lippert's radio-collared deer that were classified in the unknown category that were probably migratory deer. Twenty-two percent of all of the radio-collared deer from the old sites moved (migrated or dispersed). If I consider the unknown classified deer as deer that moved, twenty-seven percent of the radio-collared deer from the old study sites moved (migrated or dispersed).

Movement – New Study Sites

From the data collected from the limited sample sizes of the Canada Creek Hunting Club and Garland Resort radio-collared deer it was not clear what were the typical movement behaviors. Only one deer traveled from the Canada Creek property and she moved directly south. Not one radio-collared deer left the Garland Resort area. A majority of the radio-collared deer from the Birch Creek Hunting Club and the Black's Farm did make some sort of movement. Of the 13 deer radio-collared at the Birch Creek Hunting Club 6 migrated, none dispersed and 1 was classified as unknown. Forty-six percent of the deer radio-collared at the Birch Creek Hunting Club migrated and their mean distance moved was 10.6 km, but fifty-four percent moved if the unknown classified deer are added to the moved (were not classified as non-migratory) deer category. Of the 13 radio-collared deer at the Black's Farm, 3 migrated, 2 dispersed and 6 were classified as unknown. The mean movement distance for the Black's Farm migratory radio-collared deer was 25.7 km. Twenty-three percent of the Black's Farm radio-collared deer migrated, but a total of thirty-eight percent moved (migrated or dispersed). Eighty-five percent of the deer radio-collared at the Black's Farm moved if the unknown movement deer are included as having moved. If the unknown movement deer were excluded from the percent of deer that moved then the estimates would be somewhat misleading. The estimate would have been lower and would not represent the true activity of deer from the Black's Farm because there were 6 deer classified as unknown. Two were hunter harvested, 2 were censored (suspected hunter harvested), 1 was road-killed and 1 was killed by predators before being able to complete a migratory rotation. Twenty-seven percent of the radio-collared deer from the new sites migrated and their mean migratory distance traveled was 15.7 km. After considering all these facts it must be understood that these migratory percentages were slightly under-estimated due to pre-mature deaths (e.g hunter harvested, road-kills). When the unknown classified deer are added to the number that moved (migrated or dispersed) then sixty-three percent potentially moved.

After considering the movements (dispersal, migratory and unknown) from the old study sites before and after the winter feeding ban there appears to be no relative change. The radio-collared deer that were migratory or non-migratory before the winter feeding ban exhibited the same movement behavior after the ban. After considering the radio-collared deer of the new study sites one might assume that there has been an increase in deer movement within the DMU 452, but basing this assumption on one season of data from the new study sites would be unwarranted. I assume that the movements patterns that were identified from the new study sites, especially from Birch Creek Hunting Club and the Black's Farm, were fairly reflective of actual movement patterns of those sites year after year and before the feeding ban.

If multiple years of data were available of the movement patterns of the radio-collared deer from the Canada Creek Ranch I would suspect that the movements would show similar patterns to that of the Lockwood Lake Ranch because there too the property was heavily hunted and there was a timber harvesting rotation (Tierson et al. 1985). Since there was a higher harvest and good winter and summer habitat, I presume that overall the deer from the Canada Creek Ranch moved very little. If there were no timber harvesting rotation I would guess deer movement behavior would replicate that of the Leroy Hunting Club and the Lippert's property. I suspect that if some deer moved and returned it would be because of the wintering habitat and because of established traditional movement (Nelson and Mech 1981, Tierson et al.1985) to preferred wintering habitat.

Radio-collared deer from the Garland Resort showed no sign of movement. The lower hunting pressure and lower harvest due to the residential area gave the radio-collared deer an added security. In addition there was great wintering habitat and summer habitat especially with the many available resort greens of the golf courses.

The movement of the radio-collared deer from the Birch Creek Hunting Club was similar to that of the Leroy Hunting Club and the Lippert's property. The radio-collared deer from the Birch Creek Hunting Club moved because dominant does could pass the tradition on (Miller et al.1995, Ozoga et al. 1982 and Staines 1974), there were high deer densities (limited space) and limited food. There were few if any female deer harvested from this club's property. If deer were harvested they were most likely adult males. Adult females survived to pass their traditional movements on to their offspring. The Birch Creek Hunting Club had heavily fed deer for many years so many deer stayed on their property throughout the winter months. The deer that remained on the club property during the winter months heavily browsed their potential spring and summer forage (McShea et al. 1997, Trumbull et al. 1989 and Verme and Johnston 1986). While I worked there, a few fields were planted for food plots and there were many radio-collared deer that stayed the summer on the club property. I suspect that the radio-collared deer that moved from the Birch Creek Hunting Club property moved because once spring arrived they were in an area where there was a higher deer density, they were seeking traditional summer ranges and at that time there was no practice of timber harvesting (little to no new browse in the area). I suspect that they returned to the Birch Creek Hunting Club because it has swampy areas which are wintering habitat and because traditionally they had winter-fed deer.

The movement of the radio-collared deer from the Black's farm was and is somewhat of a mystery. The area was known to be heavily hunted during the fall hunting seasons and traditionally there was not a winter feeding program on the farm. Neither the farm nor the properties in the immediate area offered exceptional wintering habitat. Even so many deer resided through the winter in this area. The timber cutting on a property to the southwest helped to make this area a more suitable wintering habitat (Tierson et al. 1985). I do not know why most of the radio-collared deer from the Black's Farm moved or left once spring broke. It could simply be because they were leaving an area of high deer density (Nelson and Mech 1992) or seeking their traditional summer ranges. The fact that the area was heavily browsed in the winter months and that there may have been little space per deer could be their reasons for leaving. The deer were in an area where it seemed to be adequate spring and summer habitat. There were many hectares of farm crops planted annually in the area. I am not certain why so many deer left the farm area, but they did return in the fall. Again, I do not know why they chose to return in the fall either. In inspecting the property I would guess that the property provided good spring, summer and possibly fall habitat for deer, but not wintering habitat. The property was mostly flat open fields with a few hectares of forest. I assume that the wooded area would not be sufficient cover from the winter winds nor would it offer adequate browse to appeal to deer as a wintering habitat.

After considering all of the radio-collared deer from all of the study sites (old and new) it was found that nineteen percent of the radio-collared deer in the DMU 452 migrated. It was found that thirty-two percent of the radio-collared deer in the DMU 452 moved (were not classified as non-migratory). In addition I found that thirty-six percent of the radio-collared deer in the DMU 452 moved if the unknown classified deer were added to the moved category because they had the potential to move.

Directions of the Movements

After considering the spring movement of the migratory, dispersal and those radio-collared deer classified as unknown from all of the study sites, no direction seemed to be left un-traveled. It was evident at the sites for which there was a sufficient sample size (Black's Farm, Birch Creek Hunting Club, Leroy Hunting Club and Lippert's) that there were preferred directions of travel. The Leroy Hunting Club radio-collared deer moved south, southwest, northeast and east. I assume that the Leroy Hunting Club radio-collared deer did not move directly west, northwest or north due to Fletcher's Pond being in those directions. The only direction the Leroy Hunting Club radio-collared deer did not move that was barrier free was in a southeastern direction. The movement directions of preference for the Leroy radio-collared deer seemed to be south to southwest and northeast. These preferred directions (both southward and northward) for a given distance followed along the shoreline of Fletcher's Pond. I suspected that these moves were movements that were passed down as traditional movements (Miller et al. 1995, Nixon et al. 1988, Ozoga et al.1982 and Staines 1974). I assume that some dominant does in search of fresh browse (habitat that was not heavily browsed through the winter), more space (a lower deer density) and overall good fawning grounds found such areas down in the Turtle Lake Club property (to the southwest). Again, I assume that those deer that moved northeast did so because it was a traditional movement (Miller et al 1995, Nixon et al. 1988, Ozoga et al.1982 and Staines 1974). I suspect the dominant does that initially made this move found the farmland to be suitable spring and summer habitat (Thomas et al 1964, Byford 1970, Kammermeyer and Marchinton 1976).

The Lippert's radio-collared deer moved south, southwest, west, north and southeast. The only direction the Lippert's deer did not travel was in an eastern to northeastern direction. The preferred movement directions for the Lippert's radio-collared deer seemed to be south and west to southwest. I suspect these movements to be traditional movements made by does in search of good fawning habitat. The areas that they ended up in were chosen because they were not traditional wintering habitats (at least for high deer densities) and there had not been heavy winter feeding so the area was not over browsed.

The Birch Creek Hunting Club deer traveled south, southwest and west to northwest. It seemed that their preferred direction of travel was mostly southwest. The Black's Farm radio-collared deer that traveled moved either just south or south (along Fletcher's Pond) and then west. Again, I suspect these movements to be traditional movements made by dominant does in search of good fawning habitat. I suspect that the areas that they chose to end up in were chosen because they were not traditional wintering (Nelson and Mech 1981, Tierson et al.1985) habitats (at least for high deer densities) and there had not been heavy winter feeding so the area was not over browsed. They may also have found that deer density was lower, insuring them more space.

After considering all of the study sites, not one direction was left un-traveled, but few radio-collared deer moved to the southeast or to the east. Sitar (1996) found similar results in that she reported that the deer she had monitored migrated mostly in a northwestern to southwestern direction. Van Deelen (1995) determined that the deer he monitored moved in a northeasterly direction. Since some radio-collared deer from Lippert's, Lockwood Lake Ranch and Strohschein's Farm (study sites not located in close proximity to Fletcher's Pond) moved in west to northwestern directions, this leads me to believe that west to northwest movements or migrations are more common in the DMU 452 then what the radio-collared deer from Black's Farm and Leroy's indicated.

It is not evident that the radio-collared deer of the DMU 452 traveled from forested habitats during the winter months to farmland for the summer months or vice versa. No pattern such as this could be determined because some traveled from farmland to forested areas for the summers while others did the opposite. Sitar (1996) reported that the direction of most deer migrations in her study tended to be toward heavily forested areas in the spring and away from open farmland. No movement changes were identified in the radio-collared deer movement in the first year after the winter feeding ban. I suspect that all deer movement from my study sites were movements made by deer away from their preferred or traditional winter habitat because of one or both of the following reasons: a high deer density (complications of competition for food, space or other) and/or the winter habitat had been over browsed (Thomas et al 1964, Byford 1970, Kammermeyer and Marchinton 1976, Seagle and Liang 1997).

Seasonal Ranges By Study Site

The relative sizes of winter or summer ranges did not change (except for the non-migratory deer summer ranges) from before and after the winter feeding ban. After combining the ranges of the new study sites with those data of the old study sites (those after the feeding ban) one might be lead to believe there were changes in range sizes. Having only one year of data from the new sites only complicates and does not help in answering the question of whether deer ranges changed after the initiation of the winter feeding ban.

One winter without feeding may not be enough time for deer to notice that there has been a change and it may be too short of a time even if they noticed a change to actually act on that change and alter their behavior. Even though there was no significant difference found between the summer range sizes of the migratory deer there was a significant difference found between the summer range sizes of the non-migratory deer before and after the winter feeding ban. I suspect that the ban of winter feeding has little if anything to do with summer range sizes. These non-migratory deer used smaller summer ranges because there was less competition or a lower deer density due to the increased hunter harvest in the DMU 452.

After studying the ranges sizes of the study sites on Tables 3, 4 and 5 there are some range sizes that do not seem to fit into a trend. For example, the non-migratory deer at the Leroy Hunting Club during the winter of 1996/1997 used an extremely large range in comparison to the ranges of the winters that follow. It is difficult to determine why there are extremes of some seasonal ranges. The locations of the radio-collared deer (no matter what movement category) that were located for multiple years and throughout the duration of this research project became predictable. Anytime extremes were observed, I would suspect that there were major demographic changes (either deer additions, subtractions or both) in the deer herd thus impacting and possibly changing some range sizes of deer (Miller et al. 1995).

As mentioned above every precaution was taken to find suitable study sites. Even so, only a limited number of study sites could actually be worked due to time, money and other factors. Of the study sites used throughout the DMU 452, each site had qualities that could only be found at that site. These properties were independent. They occupied a geographical location that no other study site occupied. Factors such as human activity, land use, snowfall and others differed somewhat from site to site. Variables such as weather (i.e., length of winter, snow fall and temperatures), deer density and halting the traditional practices of winter feeding complicated attempts to identify range size trends. The answer to the question of why some of the range sizes were extreme and well outside of observed trends may simply be that three seasons of data does not give us enough information to determine or predict range size trends.

Seasonal Ranges By Sex and Age

After having investigated the ranges of the contrasting sexes and ages of deer at the different study sites, I have determined that, overall, each category used much larger winter ranges than summer ranges. Also, it was apparent that the sample size or data of the adult males were lacking. The sample sizes of the yearling females and males were better, but at some sites they too were lacking. The adult female category was very well represented at the old as well as the new sites.

MANAGEMENT IMPLICATIONS

It seems that the decisions that were made by the MDNR to decrease the deer density in the DMU 452 were wise because many deer in the DMU 452 are non-migratory and could sustain a disease such as bovine TB due to close association with other animals. At the same time there seems to be a large number of deer that do travel and if the deer density were to remain high then an increased number would likely be traveling and potentially spreading bovine TB by associating with those that do not migrate as well as others that do migrate. It is for these reasons I think it is unwise to place most of the emphasis or concern on deer that move (migrate or disperse). The emphasis should be on all deer in the DMU 452. Whether it moves (migrates or disperses) or not it has the potential to spread the disease.

From these data there does not seem to be a change in movement patterns or drastic changes in range sizes used by radio-collared deer before or after the winter feeding ban, but data needs to be collected for multiple seasons after the winter feeding ban to strengthen these findings. These data make an excellent start in determining trends of deer movement patterns and seasonal ranges sizes from the DMU 452, but some conclusions solely based on these data would be unwise.

I recommend that it would be in the best interest of wildlife managers to continue to encourage an increased deer harvest. I also suggest that they never consider reinstating supplemental feeding of deer in the DMU 452. I also recommend that they consider investigating all other feeding practices of wildlife within the DMU 452. These would include recreational or viewing stations of songbirds and feeding stations for the wild turkey. If the objective of wildlife managers of the DMU 452 is to eliminate bovine TB from the free-ranging deer population it would be unwise and negligent to allow these practices to continue as they have in the past. To some extent if these practices (feeding of turkeys and songbirds) are continued and the elimination of winter feeding stations of deer has not been halted, the artificial (not natural) close contacts of deer will continue thus continuing the spread of bovine TB.

The deer density in the DMU 452 had been maintained at an artificially high level for many years, but there has been an increase in hunter harvest and the plans are to continue an increased harvest until a desired number of deer per hectare is reached. I think it would be an ideal time to conduct habitat assessments or evaluations to determine how serious of an impact the high deer density has had on the habitat (Kammermeyer and Thackston 1995, Schmitz and Sinclair 1997, Frelich and Puettmann 1999) in the DMU 452. From this study I suspect that much of the deer movement was due to habitat that was over browsed. Managers need to have a good idea of how many deer the habitat can support. This will give them a better understanding of how much movement to expect from the deer that reside or would reside in the DMU 452.

CHAPTER 4: FEEDING BEHAVIOR OF MARKED DEER

Wildlife managers were interested in determining if deer in the DMU 452 would show fidelity to the same winter feeding or fall baiting station. They suspected that if a deer infected with bovine TB was faithful to one station then the likelihood of contracting TB would be increased for other deer that visited that particular station. This would lead one to believe that only a limited number of deer would be exposed to the disease as opposed to if the deer were not faithful to only one station, then numerous deer could be exposed to the disease.

In this chapter I describe the behavior of marked (ear-tagged and radio-collared) deer at winter feeding and fall baiting stations. Feeding behavior of these deer were determined for each study site, season and year. Fidelity to a station during each season or year was identified for each marked deer at each particular station. Also discussed is the feeding behavior as well as range use in association with a marked deer found to be bovine TB positive. Some detail is discussed on the movement behavior of bovine TB positive radio-collared deer (deer radio-collared during this study and a number from other studies) throughout the DMU 452 and their possible interactions with other radio-collared deer.

METHODS

Data on marked deer were collected during winter feeding and fall baiting observation periods. Once a marked deer began feeding at a station, an attempt was made to record every F2F contact that it committed until the observation period concluded. Using data sheet 2 (Appendix Figure 10), study site, station, date, times (beginning and end), weather, temperature, wind, identification number of marked deer (ear-tag and/or frequency number of collar), number of other feeding deer, number of F2F contacts and description of types of feed and methods of feed presentation were recorded. Identification numbers were determined by reading ear-tags with binoculars or using telemetry equipment to distinguish radio-collar frequencies. All documentation was recorded systematically from season to season as well as from year to year.

Fidelity to stations by season and year were determined by appropriate sorting of data. Once the data were sorted by season and study site, fidelity of marked deer to winter feeding or fall baiting stations was identified. Some radio telemetry point locations were used to better interpret marked deer movement and the extent of fidelity behavior.

Arcview was used in the same manner as described in Chapter 3 except instead of building range polygons with kernel estimators, range polygons were made using the minimum convex polygons. Winter feeding stations were plotted on maps using Arcview to better illustrate station association. Minimum convex polygons were used to illustrate winter ranges in relation to feeding stations and also to illustrate relationships of other radio-collared deer to a radio-collared deer that was determined by necropsy to be bovine TB positive.

All marked deer that were recovered as a mortality were taken to the MDNR's Rose Lake Wildlife Research Station and Michigan State University (MSU) College of Veterinary Medicine, Animal Health Diagnostic Laboratory where full necropsies were conducted. If an animal was suspected to be bovine TB positive by the MDNR and MSU, further investigation was carried-out by the Michigan Department of Community Health and the United States Department of Agriculture to substantiate a final diagnosis.

RESULTS

Winter 1996/1997 Feeding Behavior of Marked Deer

Leroy Hunting Club

At Leroy Hunting Club, 7 different marked deer (6 radio-collared and 1 ear-tagged) were observed feeding at the winter feeding station during the winter of 1996/1997 (Table 6). One ear-tagged deer (ear-tag - Yellow 10) was observed once at the winter feeding station, committed 13 face-to-face (F2F) contacts during a time period of 50 minutes and a total of 10 deer were present (Figure 31). Of the radio-collared deer, three adult females were observed feeding multiple times at the Leroy feeding station. These 3 adult females (identification numbers 150.611, 150.920 and 151.612) were discovered to be non-migratory does which had a mean winter range of 2,276 ha (n = 3, range = 135 to 3,770 ha) and summer range of 188 ha (n = 3, range = 41 to 325 ha). These 3 deer made a total of 7 appearances and committed 38 F2F contacts (n = 7, range = 0 to 13 contacts). The F2F contacts were committed during a total time of 4.3 hours (n =7, range = 1 to 60 minutes) with a total of 29 deer present (n = 7, range = 2 to 11 deer).

The other radio-collared deer observed were 1 female and 2 males which were later determined to be migratory deer. These 3 deer made a total of 3 appearances and committed 9 F2F contacts (n = 3, range = 0 to 5 contacts). The F2F contacts were committed during a total time of 1.2 hours (n =3, range = 12 to 50 minutes) with a total of 18 deer present (n = 3, range = 4 to 18 deer). Multiple seasons of movement data were recorded on all of these radio-collared deer that were observed at the Leroy Hunting Club feeding station except for the adult male (151.725) which was hunter harvested the first fall (the fall of 1998). The migratory female (151.421) moved east a distance of 4.7 km

Table 6. Radio-collared and ear-tagged deer observed feeding at winter feeding or fall baiting stations.

WINTER 1996/1997

Study Sites	Deer ID	Appearances	Sex, Age	Station
Leroy Hunting Club	150.611	3[a]	FA[b]	House[c]
	150.920	3	FA	House
	151.421	1	FA	House
	151.612	2	FA	House
	151.472	1	MY	House
	151.725	1	MA	House
	Yellow 10	1	?	House
Lippert's	150.572	1	FA	Joshua's
	"	1	"	Shawn's
	150.622	3	FA	Doug's
	150.642	3	FA	Shawn's
	150.912	1	FA	Joshua's
	151.184	1	FA	Shawn's
	151.541	3	FY	Shawn's
	150.390	1	MY	Shawn's
	150.992	1	MY	Doug's
	"	2	"	Shawn's
	151.033	4	MY	Shawn's
Lockwood Lake Ranch	151.531	3	FY	House
	151.915	2	MY	2 nd Barns
Strohschein's Farm	150.901	1	FY	Feed Area
	150.952	1	FY	Feed Area
	151.571	1	FY	Feed Area
	151.888	6	FA	Feed Area
	151.985	4	FY	Feed Area
	150.442	4	MY	Feed Area
	151.202	1	MA	Feed Area
	151.246	4	MY	Feed Area
	151.561	1	MY	Feed Area

Table 6 (cont'd)

FALL 1997

Study Sites	Deer ID	Appearances	Sex, Age	Station
Lippert's	150.622	7	FA	Doug's
	150.912	2	FA	Joshua's
	"	3	"	Shell's
	151.193	1	FA	Joshua's
	151.541	3	FA	Doug's
	"	3	"	Shawn's
	150.372	1	MY	Doug's
	150.992	1	MA	Joshua's
	Blue ?	1	?	Shawn's

WINTER 1997/1998

Study Site	Deer ID	Appearances	Sex, Age	Station
Leroy Hunting Club	150.611	4	FA	House
	150.920	4	FA	House
	151.341	2	FA	House
	151.421	5	FA	House
	Yellow 114	1	MA	House
Lippert's	150.590	3	FY	Doug's
	"	1	"	Steve's
	150.622	16	FA	Doug's
	"	2	"	Joshua's
	"	2	"	Steve's
	150.875	5	FY	Joshua's
	150.912	3	FA	Joshua's
	150.942	2	FA	Joshua's
	151.170	2	FA	Doug's
	"	1	"	Shawn's
	"	1	"	Steve's
	151.193	6	FA	Joshua's
	"	1	"	Shawn's
	"	1	"	Shell's
	"	2	"	Steve's
	151.235	7	FY	Doug's

Table 6 (cont'd)

	151.375	2	FY	Shawn's
	"	3	"	Steve's
	"	1	"	Joshua's
	151.541	1	FY	Doug's
	151.571	5	FA	Doug's
	"	2	"	Jarod's
	"	1	"	Shell's
	150.372	1	MY	Doug's
	"	1	"	Steve's
	150.640	1	MA	Jarod's
	150.992	3	MY	Joshua's
	"	1	"	Steve's
	151.405	4	FY	Steve's
	151.411	1	MY	Shawn's
	151.502	1	MY	Doug's
	"	4	"	Joshua's
	"	1	"	Steve's
	151.936	1	MY	Joshua's
	"	1	"	Steve's
	Blue 210	2	FA	Joshua's
	Blue 212	7	MA	Joshua's
	"	2	"	Shell's
Lockwood Lake Ranch	151.350	1	FY	1st Barn's
Strohschein's Farm	150.973	1	MY	Feed Area

FALL 1998

Study Site	Deer ID	Appearances	Sex, Age	Station
Lippert's	150.622	2	FA	Doug's
	"	2	"	Marcha's
	"	1	"	Steve's
	151.193	3	FA	Joshua's
	"	4	"	Shell's

Table 6 (cont'd)

	151.235	2	FY	Doug's
	"	6	"	Marcha's
	"	1	"	Steve's
	151.370	1	FA	Shawn's
	151.405	1	FY	Marcha's
	150.640	1	MA	Joshua's
	150.992	2	MA	Jason's
	"	1	"	Shawn's
	"	1	"	Steve's
	151.936	1	MA	Joshua's
	"	4	"	Steve's
Lockwood Lake Ranch	151.946	1	FA	Blue

[a] = number of times this deer was observed feeding at this praticular station.

FA[b] = female adult, FY = female yearling, MY = male yearling and MA = male adult

[c] = winter feeding or fall baiting station at which observation periods were conducted.

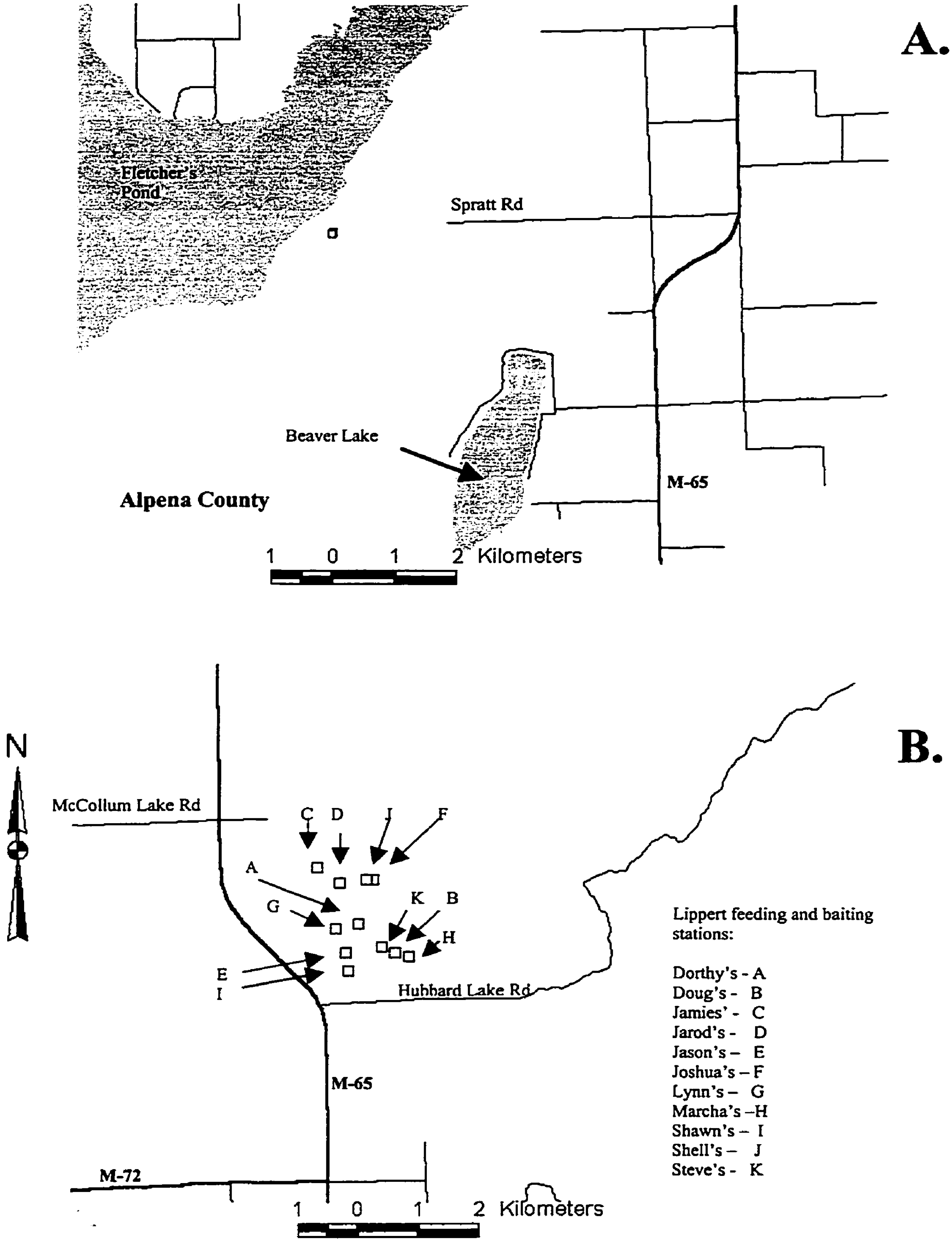


Figure 31. Locations of the winter feeding stations (□) of Leroy Hunting Club (A.) and Lippert's (B.).

from the Leroy Hunting Club. She had a winter range of 681 ha and traveled a distance of approximately 4.7 km to her summer range which was 112 ha in size.

The migratory males (151.472 and 151.725) that were observed feeding at the Leroy Hunting Club house feeding station both moved in a southwestern direction (Appendix Figures 35 and 36). The yearling male (151.472) traveled from the Leroy Hunting Club to just west of M-33 and just north of Oscoda County in Montmorency County. This was a movement of approximately 20.6 km from the Leroy Hunting Club. This yearling male had a winter range of 187 ha and a summer range size of 117 ha. The other male (151.725) traveled from Leroy Hunting Club in a south to southwest direction approximately 13.8 km. His summer range was just south of Turtle Lake and just north of the 4 county intersection (Alcona, Alpena, Montmorency, and Oscoda counties). Not enough locations were gathered on this buck to determine reliable winter or summer range sizes, but sufficient locations were recorded to determine the general area of his winter and summer ranges.

Lippert's

At Lippert's 9 different radio-collared deer were observed feeding at winter feeding stations during the winter of 1996/1997 (Table 6). Two of these deer (150.572 and 150.642) died before winter's end so their seasonal movement was undetermined. These two does were observed multiple times and 150.572 was observed at multiple feeding stations (Figure 31). One of these does (150.642) was observed at one feeding station two different times for a total of 1.6 hours, feeding with a total of 36 other deer and did not make any F2F contacts. After the death of the second doe (150.572) it was discovered that she had been infected with bovine TB. This deer was trapped at one feeding station (Doug's) and was observed feeding at two other winter feeding stations with a total of 1.1 hours of observation, 25 F2F contacts and feeding with a total of 31 other deer.

Five of these 9 radio-collared deer (one yearling female, two yearling males and two adult females) were non-migratory and three of these deer (150.622, 151.541 and 151.033) were observed feeding multiple times and one (150.992) was observed at multiple feeding stations. The mean seasonal ranges for the non-migratory deer observed were 171 ha (n = 5, range = 24 to 558 ha) for the winter and 154 ha (n = 5, range = 37 to 436 ha) for the summer. These 5 deer made a total of 14 appearances and committed 51 F2F contacts (n = 14, range = 0 to 11 contacts). The F2F contacts were committed during a total time 6.4 hours (n =14, range = 5 to 60 minutes) with a total of 88 deer present (n = 14, Range = 2 to 14 deer).

Two of the 9 radio-collared deer that were observed feeding at winter feeding stations moved (one migrated and one dispersed) off of Lippert's for the summer. A yearling male (150.390) moved a distance of 5.1 km in his migratory movement. This deer moved directly south for the summer. His seasonal ranges were 100 ha for the winter and 23 ha for the summer range. He was observed at one winter feeding station for 20 minutes, made 26 F2F contacts with 20 other deer present. A doe (151.184) dispersed from Lippert's north, a movement of 4.1 km. She was observed at one winter feeding station for 5 minutes, made 1 F2F contact with 25 other deer present.

Lockwood Lake Ranch

Two Lockwood Lake Ranch radio-collared deer were observed feeding at winter feeding stations on the property (Table 6). One was a yearling female (151.531) and the other a yearling male (151.915). The yearling male was considered non-migratory, but the female's data were unusable because during the summer of 1997 the yearling female was discovered to have a front leg hung in her collar. The yearling male had a winter range of 249 ha and a summer range of 185 ha. He was observed at a different feeding station than the yearling female (Figure 32). He was observed 2 different times, for a total of 46 minutes and did not make any F2F contacts with 5 other deer present. The yearling female was observed feeding 2 different times (prior to her leg being hung), for a total of 24 minutes and made 7 F2F contacts with 4 deer present.

Strohschein's Farm

At Strohschein's Farm 9 different radio-collared deer were observed feeding at winter feeding stations the winter of 1996/1997 (Table 6). An adult male (151.202) could not be classified into any movement category because of the lack of data. He was observed once at the Strohschein's feeding station for 25 minutes and committed 4 F2F contacts with 18 other deer present (Figure 32). A yearling female died in the late spring before enough data were collected to determine her movement classification. She was observed once for 19 minutes and made 3 F2F contacts with 23 other deer present. Six of the remaining observed radio-collared deer (3 yearling females and 3 yearling males) were non-migratory. Their seasonal ranges were 164 ha (n = 6, range = 122 to 244 ha) for the winter and 310 ha (n = 6, range = 198 to 533 ha) for the summer. An adult female (151.888) was classified as a migratory deer and had moved a distance of 5.0 km to the east. She had seasonal ranges of 416 ha for the winter and 118 ha for the summer. This deer was observed 3 times for a total of 1.7 hours and made 186 F2F contacts with 75 other deer present.

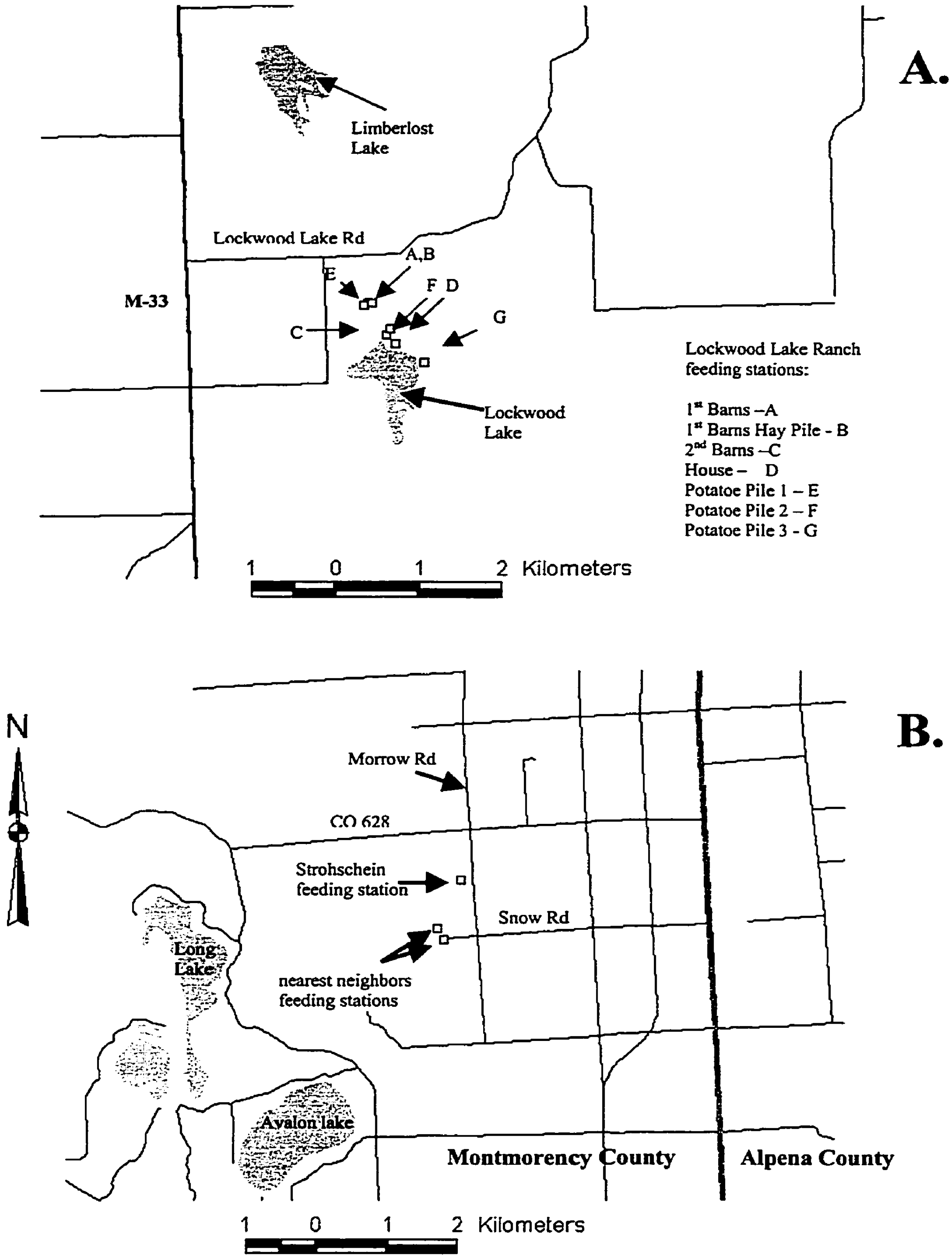


Figure 32. The locations of winter feeding stations (□) at the Lockwood Lake Ranch (A.) and the Strohschein's Farm (B.).

Cordes' Hunting Club

Five different deer were observed during four different observation periods at the Cordes's Hunting Club clubhouse feeding station. These deer were observed for 4.0 total hours and they made 244 F2F contacts (n = 4, Range = 6 to 140) with 147 (n = 4, range = 7 to 62) other deer present.

Fall 1997 Feeding Behavior of Marked Deer at baited stations

No fall baiting information was gathered from the Leroy Hunting Club or the Strohschein's Farm because of the hunting seasons. At the request of the landowners, data was not collected from these properties because they did not want our disturbances to interrupt their hunting seasons. No marked deer were observed feeding at the Lockwood Lake Ranch fall baiting stations. Marked deer were only observed feeding at the Lippert's property during the fall of 1997.

Lippert's

At Lippert's 7 different marked (1 ear-tagged and 6 radio-collared) deer were observed feeding at winter feeding stations in 1996/1997 (Table 6). The ear-tagged deer was observed once for 30 minutes and made 11 F2F contacts with 12 other deer present. Five deer (4 adult females and 1 adult male) were classified as non-migratory and their mean ranges were 200 ha (n = 5, range = 67 to 558 ha) for the winter and 176 ha (n = 5, range = 37 to 436 ha) for the summer. Of these 5 non-migratory deer 3 adult females were observed feeding multiple times at a winter feeding station and two of these 3 deer were observed at multiple feeding stations. These 5 deer were observed a total of 22 times for 7.2 hours and committed 32 F2F contacts (n = 20, range = 0 to 11) with 93 (n =

20, range = 1 to 12) other deer present. The sixth radio-collared deer, a yearling male (150.372), was classified as migratory and had moved 7.6 km southwest from the Lippert's property. His seasonal ranges were 281 ha for the winter and 1,097 ha for the summer.

Winter 1997/1998 Feeding Behavior of Marked Deer

Leroy Hunting Club

During the winter of 1997/1998 5 adult females (4 radio-collared and 1 ear-tagged) were observed feeding at the Leroy House feeding station. All of these females, with the exception of the ear-tagged doe, were observed multiple times feeding at the same winter feeding station. No seasonal ranges were determined for the ear-tagged adult male (Yellow 114). He was observed feeding at a feeding station once for 28 minutes, but he did not make any F2F contacts with 7 other deer present. The other 4 deer (all adult females) that were observed feeding at the winter feeding station were classified as non-migratory. Their mean seasonal ranges were 188 ha (n = 4, range = 99 to 330 ha) for the winter and 127 ha (n = 4, range = 38 to 284 ha) for the summer. They were observed 15 times for a total of 6.8 hours and committed 26 F2F (n = 15, range = 0 to 4) contacts with 98 (n = 15, range = 1 to 19) other deer present.

Lippert's

At Lippert's 20 different marked deer (2 ear-tagged and 18 radio-collared) were observed feeding at winter feeding stations the winter of 1997/1998 (Table 6). The ear-tagged deer were observed on 11 different occasions for a total of 2.8 hours and made 109 F2F contacts (n = 11, range = 0 to 62) with 157 (n = 11, range = 1 to 35) other deer present. A radio-collared yearling male (151.411) was not classified in any movement pattern because of limited data. He was observed once for 7 minutes and made 4 F2F contacts with 16 other deer present. Ten of the observed radio-collared deer were non-migratory and their mean seasonal ranges were 159 ha (n = 10, range = 55 to 404 ha) for the winter and 222 ha (n = 8, range = 75 to 524 ha) for the summer. These deer were observed 52 times for 15.3 hours and made over 263 F2F contacts (n = 52, range = 0 to 34) with 347 (n = 52, range = 1 to 27) other deer present.

Four of these observed radio-collared deer were determined to be migratory. All 4 deer were observed multiple times, but only one was observed feeding at multiple sites. They were observed 13 times for a total of 2.9 hours and committed 21 F2F contacts (n = 13, range = 0 to 9) with 128 other deer (n = 13, range = 1 to 66) present. One of these migratory deer was a yearling female (150.875) that moved 6.9 km to the southwest. Another migratory deer was an adult female (150.942) that moved 9.2 km to the southeast. One of the remaining migratory deer was a yearling male (151.405) that moved south 5.7 km. The remaining migratory deer was an adult male (150.372) that moved 7.6 km to the southwest.

Three of the radio-collared deer observed feeding at winter feeding stations were unclassified because they died before enough data were gathered to determine their movement category. All three of these deer were observed multiple times at multiple sites. They were observed 14 different times for 7.1 hours and made 107 F2F contacts (n = 14, range = 0 to 29) with 381 (n = 14, range = 1 to 27) other deer present.

Lockwood Lake Ranch

One radio-collared deer (151.350) was observed feeding at a Lockwood Lake Ranch winter feeding station. This yearling female was determined to be a non-migratory deer and had seasonal ranges of 150 ha for the winter and 183 ha for the summer. She was observed once for 14 minutes and made 17 F2F contacts with 2 other deer present.

Strohschein's Farm

One radio-collared deer (150.973) was observed feeding at the Strohschein's Farm winter feeding station. This yearling male was determined to be a non-migratory deer and had seasonal ranges of 121 ha for the winter and 39 ha for the summer. He was observed once for 28 minutes and made 0 F2F contacts with 12 other deer present.

Fall 1998 Feeding Behavior of Marked Deer at baited stations

No fall baiting information was gathered from the Leroy Hunting Club or the Strohschein's Farm because of the hunting seasons. One marked deer was observed feeding at the Lockwood Lake Ranch fall baiting stations. Multiple marked deer were observed feeding at the Lippert's property during the fall of 1998.

Lippert's

Eight radio-collared deer were observed feeding at Lippert's fall baiting stations the fall of 1998. One adult male radio-collared (150.640) deer was not classified into a movement pattern. He was observed once for 24 minutes and made 2 F2F contacts with 8 other deer present. Five other radio-collared deer were non-migratory with mean seasonal ranges of 139 ha (n = 5, range = 55 to 214 ha) for the winter and 185 ha (n = 5, range = 96 to 248 ha) for the summer. All of these non-migratory deer were observed multiple times and at multiple stations. They were observed 29 times for a total of 6.5

hours and made 279 F2F contacts (n = 29, range = 0 to 37) with 136 other deer (n = 29, range = 1 to 11) present.

Two of these observed radio-collared deer (151.370 and 151.405) were determined to be migratory. They were observed one time each and each was at a different station. They were observed for a total of 14 minutes and committed 17 F2F contacts with 8 other deer present. Both of these deer migrated south (4.8 km and 5.7 km) for the summer.

Lockwood Lake Ranch

One radio-collared deer (151.946) was observed feeding at a Lockwood Lake Ranch fall baiting station. This adult female was determined to be a non-migratory deer and had seasonal ranges of 385 ha for the winter and 530 ha for the summer. She was observed once for 15 minutes and made 0 F2F contacts with 1 other deer present.

Fidelity of Marked Deer To Winter Feeding Stations Within The Winter of 1996/1997

Leroy Hunting Club

During the winter of 1996/1997 3 radio-collared deer were recorded to have fed multiple times (150.611 n = 3, 150.920 n = 3 and 151.612 n = 2) throughout the winter at the Leroy feeding station.

Lippert's

Five radio-collared deer were recorded to have fed multiple times throughout the winter at one of 3 Lippert's winter feeding stations. Three of these deer were recorded feeding multiple times and only at Shawn's feeding station (150.642 n = 3, 151.541 n = 3 and 151.033 n = 4). One radio-collared deer (150.992) was recorded to have fed multiple times (n = 2) at Shawn's, but on one occasion was observed feeding at Doug's winter feeding station. The fifth Lippert's radio-collared (150.622) deer that was recorded as feeding multiple times (n = 3) at the same station was faithful to feeding at Doug's feeding station.

Lockwood Lake Ranch

Two radio-collared deer were observed feeding multiple times at the same Lockwood Lake Ranch's winter feeding stations. One radio-collared deer (151.531) was recorded to have fed multiple times (n = 3) at the Lockwood House feeding station. The other deer (151.915) was recorded to have fed multiple times (n = 2) at the 2^{nd} Barn's feeding station.

Strohschein's Farm

Four radio-collared deer were observed feeding multiple times at the Strohschein's winter feeding station. Their numbers of appearances were n = 6, 4, 4 and 4, respectively throughout the winter months.

Fidelity - Fall Baiting Stations in 1997

Lippert's

One radio-collared (150.622) deer was recorded to have fed multiple times (n = 7) throughout the fall at one of Lippert's fall baiting stations (Doug's feeding station). Two other radio-collared deer were recorded multiple times at multiple sites. Radio-collared deer 150.912 was recorded feeding at Joshua's 2 times and Shell's winter feeding station 3 times. Radio-collared deer 151.541 was recorded feeding at Doug's 3 times and Shawn's fall baiting station 3 times.

Fidelity - Winter Feeding Stations in 1997/1998

Leroy Hunting Club

During the winter of 1997/1998 4 radio-collared deer were recorded to have fed multiple times (n = 4, 4, 2 and 5 respectively) throughout the winter at the Leroy Hunting Clubhouse feeding station.

Lippert's

Six marked deer (1 ear-tagged and 5 radio-collared) were recorded to have fed multiple times (n = 5, 3, 2, 7, 4 and 2 respectively) throughout the winter at one of 3 Lippert's winter feeding stations (Doug's, Joshua's or Steve's feeding stations). Five other radio-collared deer were recorded to have fed multiple times each at two of 4 different winter feeding stations (Doug's, Joshua's, Shell's or Steve's) on the Lippert's property. In addition, one ear-tagged and 5 radio-collared deer were observed feeding multiple times each at three of the six different winter feeding stations (Doug's, Jarod's, Joshua's, Shawn's, Shell's or Steve's) throughout the Lippert's property. One radio-collared deer (151.193) fed at four different winter feeding stations (Joshua's, Shawn's, Shell's and Steve's). She was recorded multiple times (n = 6 and 2) at two of the winter feeding stations (Joshua's and Steve's).

Fidelity - Fall Baiting Stations in 1998

Lippert's

Two radio-collared deer were recorded to have fed multiple times throughout the fall at two of three Lippert's fall baiting stations (Joshua's, Shell's or Steve's feeding station). Three other radio-collared deer were recorded multiple times at three of five stations (Doug's, Jason's, Marcha's, Shawn's, or Steve's feeding station).

Fidelity - Winter Feeding Stations Throughout Two Winters

Leroy Hunting Club

Three marked deer (adult females) that were observed at the Leroy House feeding station during the winter of 1997/1998 had been observed at this station the winter before (winter 1996/1997). One of these females had completed a migratory trip and she was documented as feeding 1 time in the winter of 1996/1997 and 5 times at this station in the winter of 1997/1998. The other 2 deer were non-migratory females and they had been documented as feeding multiple times (n = 3, 3) in the winter of 1996/1997 and multiple times (n = 4, 4) in the winter of 1997/1998.

Lippert's

Four radio-collared deer (all non-migratory adult females) that were observed at the Lippert's feeding stations during the winter of 1997/1998 had been observed feeding at the Lippert's winter feeding stations the winter before (winter 1996/1997). One doe (150.912) was recorded as feeding once at Joshua's station during the winter of 1996/1997 and 3 times at Joshua's during the winter of 1997/1998. Another doe marked as 150.622 was documented feeding 3 times the winter of 1996/1997 at the Doug's station and 16 times at Doug's, 2 times at Joshua's and 2 times at Steve's in the winter of 1997/1998. The doe marked as 151.541 was documented feeding 3 times at the Shawn's station the winter of 1996/1997 and one time at Doug's during the winter of 1997/1998.

Lockwood Lake Ranch and Strohschein's Farm

No deer from either Lockwood Lake Ranch or Strohschein's Farm were observed during both winters.

Fidelity - Fall Baiting Station Throughout Two Falls

Lippert's was the only study site at which radio-collared deer presented themselves during both years of fall baiting observations.

Lippert's

Three radio-collared deer (2 females and 1 male, all adults and non-migratory) were observed at Lippert's fall baiting stations during both falls. The doe numbered 150.622 was recorded once in 1997 at Doug's baiting station and 2 times at Doug's station in the fall of 1998. She was also observed 2 times at Marcha's and 1 time at Steve's fall baiting stations in the fall of 1998. The second doe was observed feeding 1 time the fall of 1997 and 3 times the fall of 1998 at Joshua's fall baiting station. Also, she was observed 4 times at Shell's baiting station during the fall of 1998. The buck (150.992) was observed feeding at Joshua's station during the fall of 1997 and three different stations (twice at Jason's, once at Shawn's and once at Steve's baiting stations) on Lippert's during the fall of 1998.

Fidelity – Every Season and Every Year

A non-migratory doe numbered 150.622 from Lippert's was observed the winter of 1996/1997 (n = 3), the fall of 1997 (n = 7), the winter of 1997/1998 (n = 16), and the fall of 1998 (n = 2) at the Doug's feeding and baiting station. The first winter and fall she was only observed feeding at the Doug's station, but the second winter and fall she fed at 3 other stations. A non-migratory buck (150.992) from Lippert's was observed during every season and every year, but was not faithful to just one station. In the winter of 1996/1997 he was recorded feeding at Doug's (n = 1) and Shawn's (n = 2) stations. He was only recorded 1 time at Joshua's station the fall of 1997. In the winter of 1997/1998 he was recorded feeding at Joshua's (n = 3) and Steve's (n = 1) stations. In the fall of 1998 he was recorded feeding at Jason's (n = 2), Shawn's (n = 1) and Steve's (n = 1) fall baiting stations.

A Radio-collared Deer Determined To Have Been Bovine TB Positive

Only one marked mortality (150.572) of all examined was determined to be positive with bovine TB. This was a 12.5 year old female that was radio-collared on Lippert's February 9, 1997. She was found dead April 16, 1997 on the Lippert's property and it was determined that she had died of complications of having full-blown bovine TB. No ranges were determined for this deer because only 17 point locations were recorded before she died. This deer was observed twice feeding at a winter feeding station and each time was at one of 2 different stations (Joshua's and Shawn's). She was observed February 20, 1997 feeding at Joshua's winter feeding station at 9:20 AM to 10:05 AM (45 minutes) and made 19 F2F contacts. There were 21 other deer feeding there as well, one of which was another radio-collared deer (150.912). The bovine TB positive deer was observed a second time March 28, 1997 feeding at Shawn's winter feeding station at 6:08 PM to 6:15 PM (7 minutes) and made no F2F contacts while 21 other deer were feeding there as well. Two other radio-collared deer (150.992 and 151.033) were recorded feeding at this station during the same observation period.

Figure 33 shows the Lippert's winter feeding stations, the TB positive radio-collared deer's point locations and her point locations that were at the winter feeding stations. Two of the point locations that were on winter feeding stations were those that

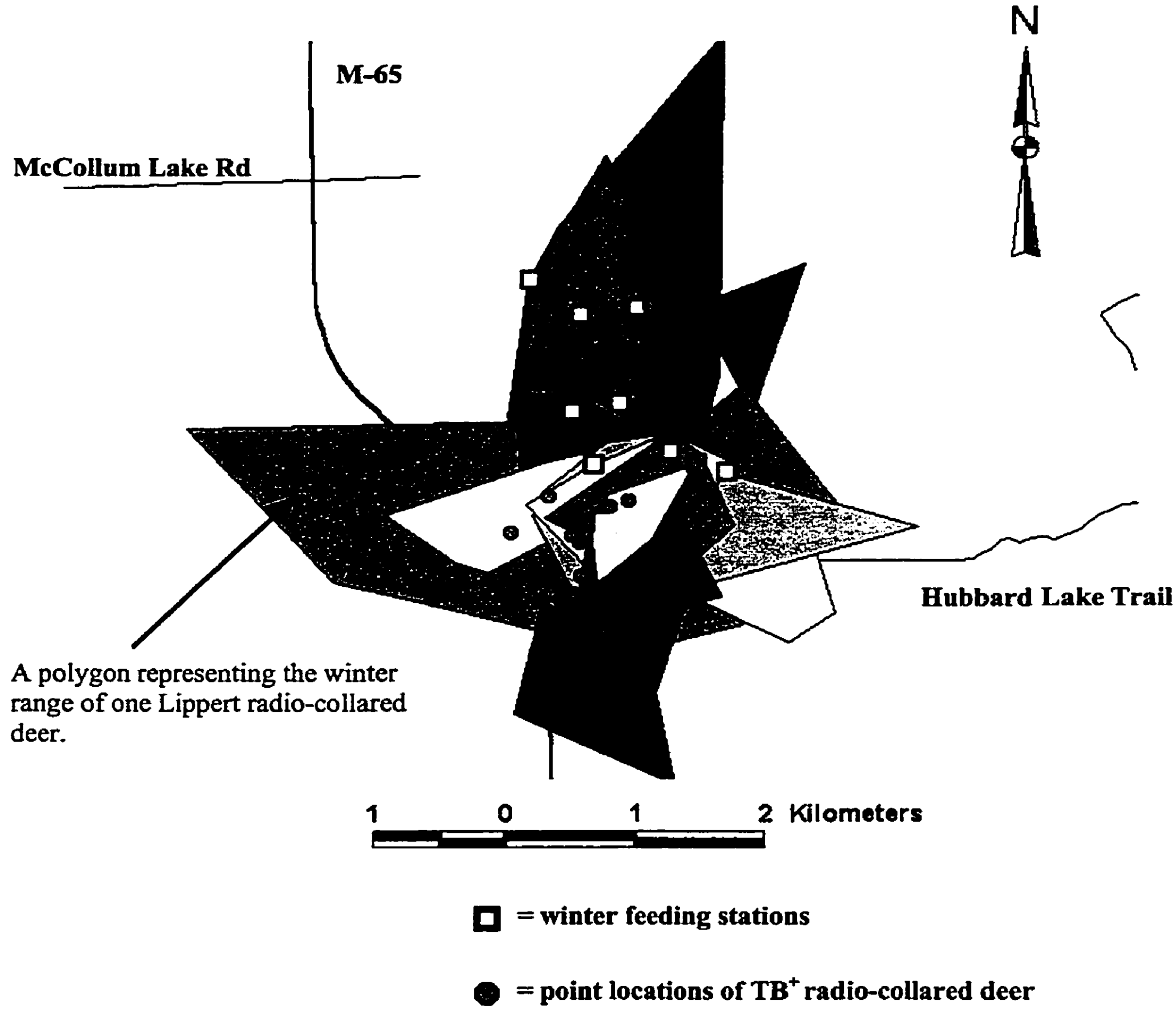


Figure 33. Point locations of bovine TB deer, winter feeding stations and winter ranges of Lippert's radio-collared deer (n = 15) the winter of 1996/1997.

were recorded during winter feeding observation periods, but the third was an incidental recording (noted while driving through area) of her feeding at the Doug's feeding station. The 15 shaded polygons represent the winter ranges of the other radio-collared that were on the Lippert's property during the same winter 1996/1997 as the bovine TB positive radio-collared deer (150.572). Also, notice how the TB positive radio-collared deer passed through in close proximity to areas of other winter feeding stations even though she was only observed three times.

Others From Prior Studies Found To Be Bovine TB Positive

A radio-collared doe (150.595) that survived beyond the conclusion of the Sitar (MSU graduate student) research project was found to have bovine TB (Sitar 1996). This deer was non-migratory and stayed on or close to the Carlson's property (in Montmorency county) where she was trapped in February of 1995 (Figure 34). When recovered in 1996 it was suspected that she was road-killed and she was taken to the MDNR for a necropsy.

Two other radio-collared deer were determined to have had bovine TB. These deer were trapped by the MDNR the winter of 1995/1996 on the Charlies Clan property (Montmorency county). One of these deer was non-migratory (151.333) and the other (151.444) was migratory (Figure 34).

DISCUSSION

During this study it was discovered that some individuals showed strong fidelity to one and only one feeding station and this was their behavior for multiple years, but there were as many deer that fed at multiple feeding stations throughout one winter

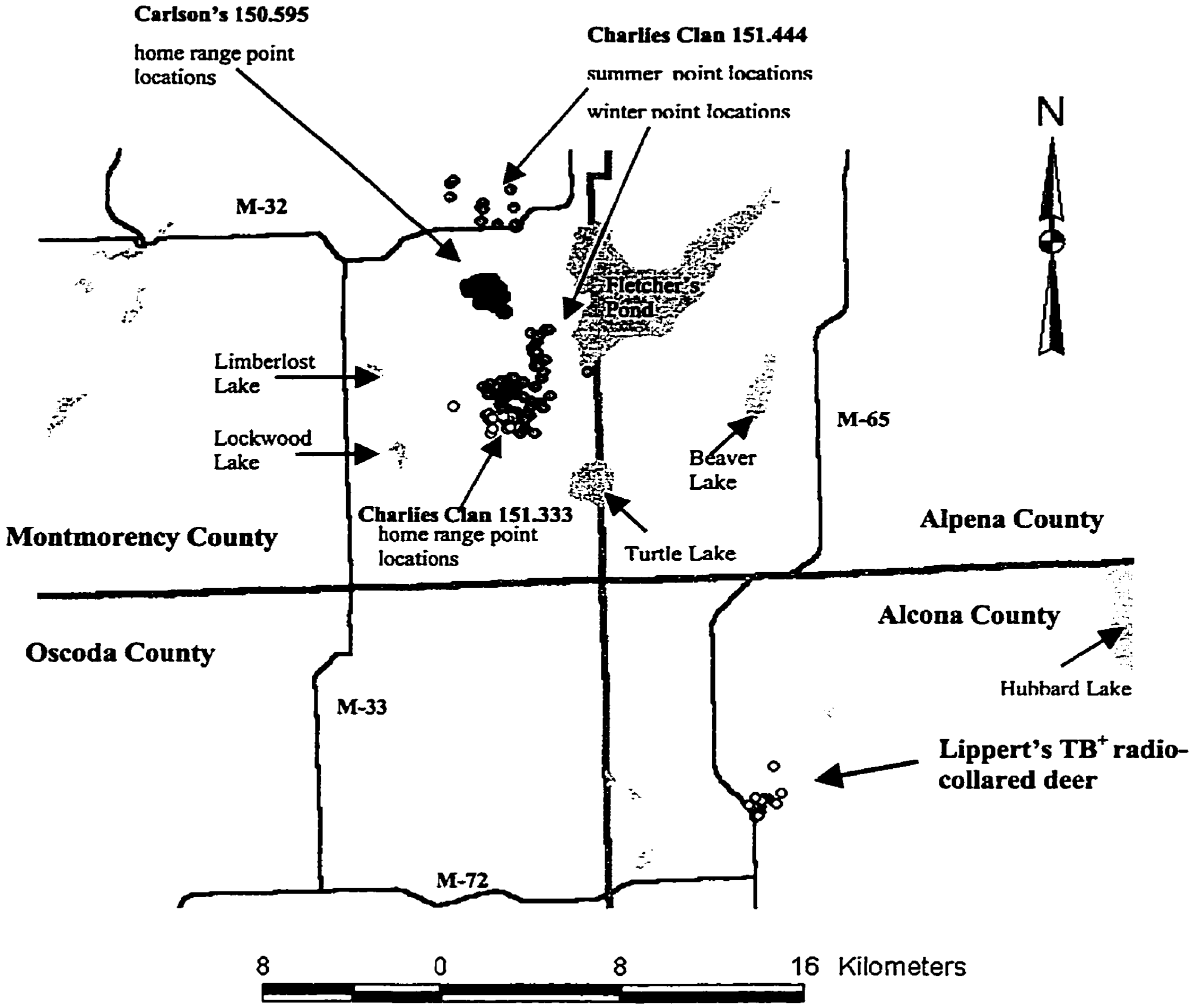


Figure ??. Point locations of the 4 radio-collared deer (of this project and two prior projects) that were found to be positive with bovine TB.

season (Table 6). Therefore, both behaviors (station fidelity and use of multiple feeding stations) were well represented by radio-collared deer. It was possible that a limited number of deer might have been infected with bovine TB by individuals that fed at only one feeding station, but it was also likely that many deer might have been infected by individuals that frequented multiple feeding stations throughout the winter seasons.

Of the migratory deer that survived to complete their migratory cycle, there were none that were observed feeding at winter feeding stations in two consecutive winter seasons. There were 2 migratory Lippert's radio-collared deer that completed their migration and were observed feeding at fall baiting stations. One migratory deer (151.405) was observed feeding at Steve's (n = 4) the winter of 1997/1998 and at a different station, Marcha's (n = 1) in the fall 1998. The other was observed feeding at Doug's (n = 1) the fall of 1997 and at Doug's (n = 1) and Steve's (n =1) in the winter of 1997/1998. These deer did not show strong station fidelity even though they did show strong fidelity to the Lippert's study site. Since study site fidelity was high among the migratory radio-collared deer and feeding or baiting station fidelity was not, this would indicate that infected deer were likely to contact many other deer thereby increasing the likelihood of disease transmission.

As with the winter feeding data it was discovered that some individuals showed strong fidelity to one and only one baiting station and this was their behavior for multiple years, but there were as many deer that fed at multiple baiting stations throughout one fall season. Both behaviors (baiting station fidelity and use of multiple baiting stations) were well represented by radio-collared deer. It was possible that a limited number of deer might have been infected with bovine TB by individuals that fed at only one feeding station, but it was also likely that many deer might have been infected by individuals that frequented multiple feeding stations throughout the fall seasons.

I suspect that the results from sites that had fewer feeding or baiting stations would show more fidelity of deer to particular stations because of the greater distances between stations. I suspect that the frequency of stations would also affect the deer density per station which in turn may affect the fidelity of individuals.

The following findings of other research projects might aid in attempting to answer the question of why some marked deer did show fidelity to one station while others did not. Regardless, it will be apparent how difficult it is to determine why these behaviors occurred. During the winter months it is important for deer to conserve energy and one way they achieve this is by restricting their movement (Mautz 1978, Moen 1978). Feeding and energy loss directly affects movement patterns of deer (Montgomery 1963, Moen 1978). Even though some deer fed at multiple sites while others were faithful to one site I suspect that they were selective in choosing the stations at which they fed. Since the deer density was high in the DMU 452, in some areas winter feeding was probably needed by deer in order for them to survive winter months. At most sites large numbers of deer were concentrated in limited areas because of the practice of winter feeding. It seemed that at some of the study sites browse for deer during the winter months was lacking. The consequences of browsing by a high deer density is likely to negatively affect regeneration (Diefenbach et al. 1997, Tilghman 1989). Less palatable plants will be consumed by deer when there is nothing else to eat (Conover 1997).

It appears from the results of this study that because of the history of the DMU 452 (movement patterns, high deer density and supplemental feeding), deer for the most part had predictable patterns of where they wintered. Deer behavior is characterized by daily patterns that are highly consistent (Porter 1997). Darrow (1993) found deer feeding behavior at baiting stations to be relatively constant throughout the fall months. Some marked deer were only observed feeding once at a winter feeding or fall baiting station and if deer are creatures of habit, it is very likely that there were visits that were not documented. It is likely that the marked deer that were observed at only one station visited others without being observed and those that visited multiple stations visited even more stations more frequently than observed. In Canada, deer were predicted to achieve an energy maximizing diet in natural wintering areas by selecting a mixture of deciduous and coniferous browse (Schmitz 1990). In Mississippi, deer were recorded as being aware of bait stations and choosing not to use them and this suggested that bait may not be attractive enough to cause a deviation from historical activities and/or ranges (Darrow 1993). High deer densities resulted in poorer deer health due to a lower level of nutrition caused by increased competition (Kie and Bowyer 1999). Darrow (1993) suspected that deer may have changed preferred activities and/or ranges and used baiting stations when their normal range was low in nutrition or poorly productive. I believe that once in their winter habitat deer in the DMU 452 found feeding stations and chose to frequently feed at them (whether one or many) because some places were over browsed and they could conserve energy by staying close to a reliable source of food.

Lewis (1990) believed that in northwestern Wisconsin there was an upper limit to the number of deer that will feed at a station. If this is true in the DMU 452, then the fall hunter harvests could have influenced the number of deer feeding at fall baiting stations and the harvests could have affected the fidelity of individuals at stations by fluctuating the number of deer within a given area. If it were true that there was an upper limit at stations where food was supplied then survival could have influenced the activity, fidelity or lack of fidelity at winter feeding and fall baiting stations.

Deer may have chosen to feed or avoid stations due to the presence of aggressive deer. Many times at different study sites deer (usually larger and/or older individuals) were observed aggressively keeping other deer (always smaller, weaker and/or younger) from feeding. Important changes in deer social dynamics can occur in fragmented populations or high-density herds in the absence of harvest or natural morality (Miller 1997). These changes in dynamics may have played a major role in deer being faithful or not to feeding or baiting stations.

Many other factors may have also influenced our ability to observe marked deer at fall baiting stations. Darrow (1993), for example, found that some deer were nocturnal in their use of baiting stations. The planting of fall forage has been used to lure deer to specific areas (Waer et al. 1997). It was likely that some properties in close proximity to the study sites used fall forage to lure deer. Hunting pressure itself quite possibly could have kept deer from feeding at specific baiting stations. During the rut males increase their movement in search of females in estrus (Downing et al. 1969, Kammermeyer and Marchinton 1976, Nelson and Mech 1981, Fleischer and Schwede 1984). Females have been document as having switched into a search mode if they reach the onset of their estrus without being found by a potential mate (Holzenbein and Schwede 1989). It is difficult to identify exactly why deer practiced particular feeding behavior in the DMU 452. It was very likely that a combination of multiple factors played a role in whether deer chose to feed at one station or multiple stations.

4 Bovine TB Positive Radio-collared Deer

Two of the four TB positive radio-collared deer were trapped at the Charlies Clan Hunting Club during the winter of 1995/1996. Charlies Clan Hunting Club is located in the northwestern portion of the TB Core area. Seven deer were radio-collared by the MDNR at Charlies Clan Hunting Club. Only 3 moratilites have been recovered from the original 7 collared deer and they were taken in for necrospies. Two of the 3 taken in for necropies were later found to be bovine TB positive. It was apparent that bovine TB was more frequent in deer of the Charlies Clan Hunting Club than any of the study sites I trapped on since 2 of 3 tested were positive with TB. The frequency of TB positive deer appeared to be lower at the study sites on which I worked. Of the recovered mortalities, only one was determined to be TB positive (Appendix Table 1).

When considering these 4 radio-collared deer that were found to be TB positive one must keep in mind the F2F contacts made by the Lippert's TB positive radio-collared deer and its relationship to the other Lippert's radio-collared deer winter ranges. One must consider that one of these 4 deer was a migratory deer and how these 4 deer could have spread bovine TB in the DMU 452. Some possible scenarios for the spread of bovine TB are by deer being (1) non-migratory and feeding at many stations, (2) migratory and feeding at many stations, or (3) non-migratory and feeding at one station while many other deer were passing through the area and feeding at this particular station. There were many possible scenarios and all most likely played some part in the maintenance of bovine TB in the DMU 452 area. Also, consider the documented movement patterns in Figures 15 and 16 (Chapter 3) of the radio-collared deer of this project and how they moved and interacted with other deer. Finally, consider all the deer surveyed by the MDNR (from 1995 through 2000) that were found to be positive with bovine TB (n = 325+ deer) and it is easy to see bovine TB has sustained itself and spread in the DMU 452 area.

General Discussion

Some things must be understood when considering the findings of this research project. One is that the numbers of F2F contacts recorded were actually a minimum estimate of the number actually committed at winter feeding and fall baiting stations. The practice of the observers was to record only the F2F contacts observed. If there were situations where the observed deer were too crowded to record all the contacts then only the observed contacts were recorded. No additional estimates were calculated even though it was highly likely that in some situations less than half of the F2F contacts were documented due to over-crowding.

Another consideration is that not all dead radio-collared deer were recovered and available for total necropsies. Some marked deer were suspected to be hunter harvested and no samples were available for evaluation. Only one recovered radio-collared deer trapped from my study sites was determined to have had bovine TB, but this does not mean that only one radio-collared deer was infected with bovine TB.

MANAGEMENT IMPLICATIONS

Marked deer as well as unmarked deer in the DMU 452 were very active at winter feeding and fall baiting stations whether they were migratory or non-migratory. A better understanding of what kind of contacts an individual could make has been attained after having observed and recorded the behavior of marked deer at winter feeding and fall baiting stations. After reviewing the information in this chapter, wildlife managers should be aware of how higher densities of deer in limited areas could enhance the spread of any disease. Wildlife managers need to be aware that the deer density in the DMU 452 may have negatively impacted the plant species to a point that the habitat will not support the number of deer per hectare now that it naturally would because of being over-browsed. Van Deelen et al. (1997) suggest that impacts of high deer densities on browse can be better controlled with strategic hunter harvests. A strategy of the wildlife managers to eradicate bovine TB from the free-ranging white-tailed deer in the DMU 452 is to decrease the deer density to the point that the disease is not sustained in the area. To simply better control bovine TB is not the only reason the deer density needs to be decreased. The deer density also needs to be decreased to protect the heavily damaged plant species of the DMU 452. Wildlife managers need to understand that the hunter harvests need to be adjusted to better support the desired deer density of the DMU 452. Deer herds in most states will likely continue to be primarily regulated by harvest, not by habitat (Roseberry and Woolf 1998).

Some of the marked deer were faithful to one station while others were faithful to many or no stations. This too should give wildlife managers a better understanding of how higher densities of deer would increase the frequency of F2F contacts thus increasing the likelihood of spreading or contracting a disease. Before this information was available, it was unclear if deer would feed at multiple stations.

Many F2F contacts occurred at winter feeding and fall baiting stations. The general rule was if there was feed or bait present then the deer would be attracted to that particular location and F2F contacts would occur. The findings of this research project should strengthen the argument that any deer (not just migratory deer in the DMU 452) is important in the attempt to eradicate bovine TB from the deer population. Looking back, wildlife managers should see how optimal conditions for the spread of bovine TB were created and this better awareness should be applied to future management strategies.

Chapter 5: MANAGEMENT SUMMARY

Winter feeding and fall baiting of deer had been practiced for many decades in the DMU 452 prior to their ban in 1998 (Peyton 2000, Schmitt et al. 1997). Prior to the TB outbreak winter feeding in particular had been encouraged and was significant in the management of the deer population in the DMU 452. There was a classic response to one of the fundamental principles taught in the field of wildlife management: when supplemental feeding becomes common practice to the extent that a higher than normal density is maintained, diseases will likely become a problem. High deer densities alone have a great potential for spread of disease without the added complications of supplemental feeding attracting large numbers of deer to limited space or geographical areas. For example, Lyme disease and human babesiosis are a threat to humans especially throughout much of the eastern states and a high density of deer is very important to the distribution and abundance of the vectors (i.e., black-legged tick (*I. scapularis*)) that carry these diseases (Wilson and Childs 1997).

Similar circumstances regarding feeding wildlife, high animal densities and disease are being faced in some of the western states. Colorado and Wyoming wildlife managers are confronting the problem of chronic wasting disease (CWD) which is classified as a transmissible spongiform encephalopathy in the free-ranging mule deer (*Odocoileus hemionus*), white-tailed deer and rocky mountain elk (*Cervus elaphus nelsoni*) and they suspect that feeding of wildlife by local residents may be contributing to the spread and maintenance of this disease (Spraker et al. 1997). Winter feeding of especially elk has been practiced for many years in some western states (e.g., Colorado, Idaho, Oregon, Utah, Washington and Wyoming (Smith 2001)) and as in Michigan, winter feeding has been a controversial topic of conversation among many opposing stakeholders (i.e., wildlife managers, policy makers, farmers, hunt club members, and the general public). Also, as Smith explains in detail, the reasons individuals practiced winter feeding in the western states are very similar to those reasons for winter feeding in Michigan with the exception of one: in the western states feeding alters winter distribution of elk, helping to keep elk away from places where they are not wanted (i.e., farms, orchards, roads).

As with bovine TB in Michigan, the mode of transmission of CWD in the western states has been identified to be between animals and it was suspected that feeding stations were a major contributor for these close associations among animals (Spraker et al. 1997). It is suspected that the CWD agent enters these animals by way of oral exposure to infectious secretions or excretions (e.g., saliva, feces, urine) (Miller et al. 1998). Wildlife managers are now confident that lateral transmission is what drives the progress of CWD (Miller et al. 2000). Wildlife managers who have been working with the issues concerning CWD in the western states are now convinced that CWD can be sustained in free-ranging cervid populations for decades (Miller et al. 2000). Both CWD (in the western states) and bovine TB (in Michigan) in free-ranging wildlife are potential threats to domestic livestock (Morris and Pfeiffer 1995, Schmitt et al 1997, Thorne et al. 1997). Managers involved in the western CWD situation are concerned that sampling agendas to detect levels of the disease could rapidly lead to over harvesting of uncontaminated animals, but they are aware of the potential progress of CWD in high densities of free-ranging animals (Gross and Miller 2001, Miller et al. 2000).

Results from the study clearly document that in the DMU 452 F2F contacts did occur at winter feeding and fall baiting stations. In every case, supplemental feeding practices that were observed increased the number of F2F contacts well above what natural situations would cause. Winter feeding and fall baiting stations were areas that attracted increased numbers of deer. Once 2 or more individuals began feeding at a station, F2F contacts were highly probable. According to our data, as the number of deer increased at a feeding or baiting station so did the number of F2F contacts. There were observation periods during which no deer or just one deer were observed and this was most likely in the fall during the hunting seasons when other forage was available.

It is suspected that the most likely avenue for contracting of bovine TB is by the aerosol route through close contact with infected animals (Schmitt et al. 1997). At this point little is known about bovine TB being contracted by deer that simply feed at a contaminated station. Little is known about how long *M. bovis* survives outside a living animal and in/on the supplemental feed piles in the DMU 452 in particular. However, the United States Department of Agriculture (USDA) has completed controlled studies in Aimes, Iowa that determined that *M. bovis* outside of an animal and in a frozen condition can live up to 16 weeks (Whipple and Palmer 2000).

There has been concern about the interactions between livestock (especially beef and diary cattle) and the free-ranging deer of the DMU 452. The concern is that since any free-ranging deer has the potential to spread the disease then precautions must be taken to avoid cattle and deer associations. Personnel of the Michigan Department of Agriculture have stressed to farmers within the DMU 452 the need to be responsible in their methods of feeding their livestock. In other words, it was recommended that they not feed cattle too close to wooded areas where deer might dwell and keep cattle feeds closer to barns or dwellings. These practices should decrease the likelihood that a contaminated deer would feed on cattle feed and leave residue for a possible deer-to-cattle transmission. Nixon (1988) found that deer in Illinois avoided fields that were occupied with cattle, but once the cattle were removed the deer moved into those fields and foraged. Nixon also found that deer preferred cattle grazed fields because in those fields a greater plant diversity was found. Since it is likely that *M. bovis* survives outside a living animal and in/on the supplemental feed piles in the DMU 452, there is every reason to believe that areas such as heavily foraged fields by deer and cattle have potential to cause deer-to-deer as well as deer-to-cattle transmissions.

Bovine TB probably would sustain itself if supplemental feeding were practiced in the DMU 452 even with a lower density of free-ranging deer. It is quite possible that bovine TB could sustain itself without the practice of supplemental feeding in the DMU 452 with a higher density of free-ranging deer. Again, I stress that it is apparent that the combination of the use of supplemental feeds and high deer density was a disaster waiting to happen.

Wildlife managers have gained much knowledge about the situation in the DMU 452 since 1994 through the research conducted by many groups. Management strategies include: a ban on fall baiting and winter feeding and an increase in fall deer harvests. I recommend that the emphasis be taken off of free-ranging deer that move (migrate or disperse). I suspect that bovine TB would readily spread in the DMU 452 between deer that did not migrate (those that are classified non-migratory) simply because of their networking. I believe that neither migratory nor dispersing deer have the advantage over non-migratory deer in spreading bovine TB. Just because migratory and dispersing deer travel further linear distances does not mean that they have more close contacts with different individuals. Non-migratory deer have just as much potential to spread TB to other deer. The results of the study showed how complex the overlapping home ranges of non-migratory can be. The net-working of the overlapping home ranges of the non-migratory deer could easily spread and maintain bovine TB in DMU 452 without the movement and home ranges of the migratory and dispersal deer. Every deer should be considered and taken seriously because any deer has the potential to contract and/or transmit bovine TB.

I agree with the MDNR that if the objective is to decrease the incidence of bovine TB in deer in the DMU 452 the first two things to do would be to change the practice of supplemental feeding and to decrease the deer density by increasing hunter harvest. Since these factors (supplemental feed and deer density) have been adjusted to better support the interest of the MDNR's objective, the incidence of bovine TB should be drastically decreased.

Also, I recommend that the surveys of bovine TB in free-ranging deer (i.e., collecting samples from hunter harvests) be changed from every year to every other year. I suggest this because these surveys have been conducted since 1995 and managers know the relative distribution of the disease and the relative status of the disease in the free-ranging deer population, especially in DMU 452. I do not think at this point the knowledge gained justifies the expense of the yearly surveys. I am aware that with the present system designed by the Natural Resources Commission (NRC) that if one surveyed deer is found positive in a county then fall baiting will be banned in that particular county. This ban will remain in effect until the NRC orders otherwise. I think that surveys conducted every other year would give ample information about the progress or status of bovine TB in the free-ranging deer population of the DMU 452. I do not think conducting surveys every other year would "enhance" the possible spread of bovine TB for one more year. If supplemental feeding continues to be banned and there continues to be an increased hunter harvest, the progression of the disease should continue to decrease. The surveys only give us an estimate of how frequent bovine TB is found in the deer population and how far it has spread or where it is geographically. The yearly survey does not alter the progression (up or down) of bovine TB at all. Again, I do not think that the yearly harvest surveys especially in DMU 452 justify the expense. We know bovine TB is well established in DMU 452. What would be the risk of not knowing one year of survey information? I think that if one year were skipped the next year would easily "catch us up to speed". Surveys of free-ranging deer outside of DMU 452 or statewide surveys to determine the status of bovine TB outside of DMU 452 may still be necessary. I am not sure that the samples that we have taken statewide (outside the DMU 452) give us a reliable understanding of the status of bovine TB in free-ranging deer statewide. Much money has been and will be spent on these yearly surveys. If the surveys were conducted only every other year then more money would be available for more needed research.

The only argument that I believe has enough significance that might justify the expense of continuing the harvest survey would be that the hunters might need to know if their harvested animal is positive or negative for bovine TB. Many claim hunters will not consume their harvested deer from DMU 452 until they know it is negative. I have not harvested a deer from the DMU 452, but I suspect that for many of those who have, by the time they receive this information (because of turn-around time) their harvested deer has been processed and packaged, is in their freezer and likely partially consumed. I do not know if this argument should be significant enough to justify the expense of continuing the harvest survey. For years deer hunters, especially those of DMU 452, have been told (by the MDNR and Michigan Department of Health) that they should cook their harvested venison until the juices run clear and if they do so there will not be any risk of contracting bovine TB.

Also, I recommend that the free-ranging deer movement studies be discontinued because I suspect that the deer movement at this point is unpredictable. I suspect that once the deer adjust to the lack of supplemental feed and lower densities their behavior will be more consistent. I am not sure if or how long after banning supplemental feed movement behavior changes will be identified. I think that it would be in the best interest of the MDNR to evaluate the movement behavior of free-ranging deer in the DMU 452 after some time (i.e., approximately 5 years) has passed, but continuing the movement study may be unnecessary. If the bovine TB surveys were to be conducted every other year and the movement study was postponed for a few years then money would be available for much needed other research. For example, more money would be available to better assess the roles of carnivores and bovine TB in the DMU 452. Even though these species are considered "dead-end species" they still have a niche to fill and are important. For example, questions that could be addressed include: Once bovine TB is contracted by a carnivore does it spread to other members within its species? How long can different carnivores that have contracted bovine TB survive in the DMU 452? Does the higher deer density in the DMU 452 greatly increase carnivore survival? Do the soils immediate to the cattle and diary farms that have been found to be positive for bovine TB sustain the disease for long periods of time after the farm has been depopulated?

There are many more questions that are unanswered and need attention. My question to those in-charge of the bovine TB funding is: are there better ways to be distributing the money? Does the outcome justify the expense? If so, continue the distribution and studies that are on going. If not, let us re-evaluate the data we have, determine those things that could be done and continue the things that need to be continued.

Since the objective of the wildlife managers was to eradicate bovine TB from the free-ranging white-tailed deer, I do strongly agree that supplemental feeding as had been practiced in the DMU 452 could not continue. Also, I agree that wildlife managers had to address the issue of deer density in the DMU 452 the way they did by increasing the hunter harvests. With these strategies underway, the eradication of bovine TB is becoming more possible.

APPENDIX TABLE

Appendix Table 1. **Identification or radio-collar number, sex, age (at capture), first recorded location, last recorded location, number of recorded locations, migratory status, if data were used in estimates, and fates of radio-collared deer in the northeastern corner of the lower peninsula of Michigan.**

Birch Creek Hunting Club

Frequency	Sex	Age at capture (months)	First Location (capture date)	Last Location	Number of Locations	Migratory status	Used in Estimates	Fate
150.970	F	20	02/08/99	11/29/99	48	Y[a]	Y[b]	Alive[c]
151.030	F	44	02/06/99	12/02/99	61	N[d]	Y	Alive
151.246	F	8	02/07/99	12/02/99	43	Y	Y	Alive
151.344	F	56	02/04/99	11/23/99	69	Y	Y	Alive
151.444	F	128	02/02/99	12/28/99	79	U[e]	Y	Roadkill
151.560	F	8	02/09/99	12/02/99	59	N	Y	Alive
151.590	F	32	02/07/99	12/02/99	71	N	Y	Alive
151.870	F	32	02/04/99	12/02/99	76	Y	Y	Alive
151.896	F	56	02/08/99	12/02/99	64	N	Y	Alive
150.570	M	8	02/02/99	12/02/99	73	Y	Y	Alive
151.200	M	8	02/08/99	06/08/99	31	N	Y	Dead
151.530	M	8	02/06/99	10/29/99	53	Y	Y	Alive
Females Used:					570		9	
Males Used:					157		3	
Total Used:					727		12	

Appendix Table 1. (cont'd)

Black's Farm

Frequency	Sex	Age at capture (months)	First Location (capture date)	Last Location	Number of Locations	Migratory status	Used in Estimates	Fate
150.440	F	68	02/28/99	06/25/99	11	U	Y	Dead - Unknown
150.912	F	44	02/21/99	10/28/99	43	N	Y	Alive
151.090	F	45	03/07/99	03/07/99	1	U	N[f]	Alive
151.175	F	8	02/23/99	02/25/99	2	U	N	Predator kill
151.210	F	44	02/26/99	08/23/99	62	D[g]	Y	Alive
151.240	F	8	02/20/99	03/01/99	4	U	N	Predator kill
151.370	F	A[h]	02/20/99	10/28/99	35	D	Y	Alive
151.411	F	20	02/27/99	11/27/99	31	Y	Y	Hunter harvest
151.520	F	8	02/10/99	02/13/99	2	U	N	Threw collar
151.600	F	A	02/01/99	10/28/99	43	Y	Y	Alive
151.797	F	56	02/03/99	03/25/99	24	Y	Y	Alive
150.685	M	8	02/27/99	12/16/99	60	N	Y	Hunter harvest
150.980	M	32	02/19/99	06/25/99	11	U	Y	Roadkill
151.090	M	8	02/20/99	02/23/99	3	U	N	Threw collar
151.225	M	8	02/23/99	02/25/99	2	U	N	Dead - Starvation
151.387	M	44	02/27/99	10/28/99	43	U	Y	Censored
151.396	M	8	02/07/99	02/08/99	2	U	N	Roadkill
151.400	M	21	03/03/99	10/28/99	31	U	Y	Hunter harvest
151.520	M	20	02/15/99	10/27/99	49	U	Y	Censored
151.530	M	8	02/03/99	02/21/99	3	U	N	Threw collar
151.915	M	44	02/22/99	10/28/99	34	U	Y	Hunter harvest

Appendix Table 1. (cont'd)

Females Used:					249		7	
Males Used:					228		6	
Total Used:					477		13	

Canada Creek Ranch

Frequency	Sex	Age at capture (months)	First Location (capture date)	Last Location	Number of Locations	Migratory status	Used in Estimates	Fate
151.175	F	57	03/15/99	04/02/99	13	U	N	Dead - Starvation
151.193	F	9	03/29/99	03/30/99	2	U	N	Dead - put-down
151.210	F	8	02/16/99	02/24/99	3	U	N	Dead - Unknown
151.215	F	9	03/17/99	12/01/99	63	N	Y	Alive
151.225	F	69	03/26/99	12/01/99	43	D	Y	Alive
151.570	F	56	02/16/99	11/16/99	69	N	Y	Dead - Unknown
151.225	M	9	03/03/99	03/10/99	3	U	N	Dead - Starvation
151.240	M	9	03/03/99	07/28/99	40	N	Y	Dead - Poached
151.375	M	8	02/16/99	02/22/99	2	U	N	Predator kill
Females Used:					175		3	
Males Used:					40		1	
Total Used:					215		4	

Appendix Table 1. (cont'd)

Garland AAA Four Diamond Resort Complex

Frequency	Sex	Age at capture (months)	First Location (capture date)	Last Location	Number of Locations	Migratory status	Used in Estimates	Fate
150.590	F	57	03/17/99	01/03/99	73	N	Y	Hunter harvest
151.396	F	57	03/14/99	12/01/99	67	N	Y	Alive
151.946	F	57	03/26/99	11/18/99	52	N	Y	Hunter harvest
Females Used:					192		3	
Males Used:					0		0	
Total Used:					192		3	

Koenig's Farm

Frequency	Sex	Age at capture (months)	First Location (capture date)	Last Location	Number of Locations	Migratory status	Used in Estimates	Fate
151.551	F	A	02/06/97	12/01/99	270	D	Y	Alive
Females Used:					270		1	
Males Used:					0		0	
Total Used:					270		1	

Appendix Table 1. (cont'd)

Leroy Hunting Club

Frequency	Sex	Age at capture (months)	First Location (capture date)	Last Location	Number of Locations	Migratory status	Used in Estimates	Fate
150.501	F	7	01/14/97	12/02/99	276	A[i]	Y	Alive
150.610	F	103	01/06/97	02/14/97	3	U	N	Predator kill
150.611	F	32	02/19/97	12/02/99	316	N	Y	Alive
150.920	F	45	03/10/97	12/02/99	324	N	Y	Alive
151.212	F	69	03/13/97	07/15/98	159	D	Y	Predator kill
151.232	F	9	03/12/97	02/06/98	205	A	Y	Roadkill
151.341	F	32	02/04/97	03/02/99	233	A	Y	Predator kill
151.368	F	45	03/04/97	04/08/99	241	N	Y	Threw Collar
151.421	F	68	02/06/97	12/02/99	293	A	Y	Alive
151.502	F	69	03/06/97	03/25/97	5	U	N	Dead - Starvation
151.612	F	56	02/05/97	12/02/99	265	N	Y	Alive
151.622	F	45	03/20/97	12/02/99	208	A	Y	Alive
150.981	M	9	03/10/97	03/18/97	2	U	N	Predator kill
151.356	M	21	03/10/97	09/25/97	14	Y	Y	Hunter harvest
151.472	M	9	03/14/97	10/20/98	104	Y	Y	Hunter harvest
151.725	M	9	03/05/97	12/01/98	11	Y	Y	Hunter harvest
151.936	M	9	03/07/97	03/21/97	1	N	N	Dead - Starvation
Females Used:					2520		10	

Appendix Table 1. (cont'd)

Lippert's

Frequency	Sex	Age at capture (months)	First Location (capture date)	Last Location	Number of Locations	Migratory status	Used in Estimates	Fate
150.421	F	68	02/07/97	12/03/97	101	N	Y	Hunter harvest
150.422	F	18	12/29/98	12/02/99	86	N	Y	Alive
150.572	F	152	02/09/97	04/16/97	15	U	Y	Dead - Bovine TB
150.590	F	8	02/05/98	10/06/98	69	N	Y	Predator kill
150.590	F	6	12/30/98	01/23/99	21	U	N	Dead - Unknown
150.595	F	31	01/14/97	06/03/97	68	N	Y	Roadkill
150.621	F	115	01/22/97	01/25/99	226	N	Y	Dead - Hepatitis
150.642	F	151	01/05/97	03/24/97	11	U	N	Dead - Starvation
150.680	F	32	02/05/98	12/02/99	158	N	Y	Alive
150.875	F	8	02/01/98	02/28/99	74	Y	Y	Censored
150.912	F	43	01/06/97	02/26/99	125	N	Y	Censored
150.942	F	7	01/24/97	11/23/99	191	Y	Y	Roadkill
151.095	F	32	02/10/98	11/02/99	137	Y	Y	Threw Collar
151.170	F	16	10/17/98	12/04/99	64	N	Y	Roadkill
151.184	F	45	03/09/97	08/11/99	308	D	Y	Dead - Pneumonia
151.221	F	9	03/12/97	07/29/97	59	N	Y	Dead - Unknown
151.235	F	8	02/01/98	12/02/99	173	N	Y	Alive
151.286	F	8	02/05/98	04/02/98	17	U	Y	Threw Collar
151.370	F	16	10/11/98	12/02/99	97	Y	Y	Alive
151.375	F	8	02/01/98	10/21/98	66	U	Y	Roadkill
151.405	F	8	02/06/98	12/02/99	159	Y	Y	Alive
151.411	F	32	02/06/98	03/31/98	21	U	N	Threw Collar

151.375	F	8	02/01/98	10/21/98	66	U	Y	Roadkill
151.405	F	8	02/06/98	12/02/98	159	Y	Y	Alive
151.411	F	32	02/06/98	03/31/98	21	U	N	Threw Collar

Appendix Table 1. (cont'd)

151.472	F	44	02/08/97	03/05/97	5	U	N	Threw Collar
151.502	F	91	01/10/98	01/16/98	2	U	N	Dead - Pneumonia
151.541	F	8	02/09/97	02/05/98	167	N	Y	Dead - Pneumonia
151.541	F	8	02/16/98	03/06/98	10	U	N	Dead - Starvation
151.571	F	7	01/10/98	02/09/98	7	U	N	Threw Collar
151.571	F	20	02/16/98	07/16/98	42	U	Y	Predator kill
151.947	F	9	03/08/97	11/18/97	91	N	Y	Hunter harvest
150.372	M	7	01/08/97	05/11/97	40	Y	Y	Threw Collar
150.390	M	8	02/09/97	11/20/97	168	Y	Y	Hunter harvest
150.572	M	16	10/19/97	11/09/97	10	U	N	Hunter harvest
150.590	M	28	10/17/98	10/30/98	6	U	N	Hunter harvest
150.640	M	17	11/08/97	09/24/97	75	N	Y	Hunter harvest
150.640	M	16	10/17/98	11/22/98	8	U	N	Hunter harvest
150.972	M	15	11/09/97	11/12/97	4	U	N	Dead - Clostridium
150.992	M	7	01/30/97	04/29/99	243	N	Y	Dead - Unknown
151.033	M	8	02/06/97	09/07/97	83	N	Y	Dead - Unknown
151.171	M	8	02/05/98	08/18/98	52	U	Y	Dead - Starvation
151.205	M	7	01/11/98	01/13/98	1	U	N	Predator kill
151.221	M	7	01/11/98	03/29/98	25	U	N	Threw Collar
151.285	M	6	12/29/98	12/02/99	80	Y	Y	Alive
151.411	M	6	12/28/98	01/07/99	5	U	N	Predator kill
151.502	M	28	10/25/97	10/31/97	5	U	N	Dead - Dart injury
151.502	M	7	01/21/98	11/13/98	65	U	Y	Hunter harvest

151.915	M	7	01/11/98	05/11/98	27	U	Y	Threw Collar
151.936	M	7	01/08/98	11/16/99	171	N	Y	Hunter harvest

Appendix Table 1. (cont'd)

Females Used:	2493	22
Males Used:	1004	10
Total Used:	3497	32

Lockwood Lake Ranch

Frequency	Sex	Age at capture (months)	First Location (capture date)	Last Location	Number of Locations	Migratory status	Used in Estimates	Fate
150.582	F	31	01/24/97	11/18/98	178	A	Y	Dead - Eradicated
150.595	F	7	01/28/98	12/01/99	181	N	Y	Alive
150.685	F	31	01/22/98	12/29/98	78	N	Y	Roadkill
150.871	F	7	01/27/98	11/18/98	36	N	Y	Hunter harvest
151.350	F	7	01/11/98	06/09/98	43	N	Y	Censored
151.380	F	8	02/06/98	12/01/99	157	N	Y	Alive
151.462	F	32	02/27/97	12/01/99	260	N	Y	Alive
151.676	F	45	03/07/97	11/18/98	180	N	Y	Dead - Eradicated
151.946	F	7	01/11/98	12/21/98	56	N	Y	Dead - Unknown
151.955	F	A	03/11/97	09/28/98	177	N	Y	Predator kill
150.981	M	9	03/27/97	11/05/97	84	N	Y	Hunter harvest
151.090	M	7	01/27/98	12/29/.98	75	N	Y	Dead - Unknown

151.175	M	8	02/16/98	10/04/98	59	N	Y	Hunter harvest
151.205	M	7	01/20/98	11/03/98	66	U	Y	Hunter harvest
151.207	M	9	03/02/97	12/15/97	99	N	Y	Dead - Pneumonia
151.215	M	8	02/06/98	12/21/98	68	N	Y	Censored
151.240	M	7	01/31/98	11/03/98	40	N	Y	Hunter harvest

Appendix Table 1. (cont'd)

151.541	M	9	03/12/98	12/01/99	131	D	Y	Alive
151.797	M	9	03/09/97	11/18/97	110	N	Y	Hunter harvest
151.915	M	8	02/28/97	11/19/97	87	N	Y	Hunter harvest
151.996	M	21	03/20/97	06/25/97	63	U	Y	Dead - Unknown
Females Used:					1346		10	
Males Used:					882		11	
Total Used:					2228		21	

Strohschein's Farm

Frequency	Sex	Age at capture (months)	First Location (capture date)	Last Location	Number of Locations	Migratory status	Used in Estimates	Fate
150.085	F	19	01/31/98	12/01/99	158	N	Y	Alive
150.901	F	8	02/23/97	12/01/99	283	N	Y	Alive
150.952	F	8	02/08/97	11/08/98	182	N	Y	Roadkill
150.970	F	116	02/13/97	03/25/97	10	U	N	Dead - Starvation
150.981	F	8	02/07/97	02/12/97	3	U	N	Threw Collar
151.225	F	31	01/29/98	12/19/98	73	N	Y	Hunter harvest

151.370	F	7	01/23/98	03/18/98	18	U	N	Predator kill
151.370	F	9	03/21/98	04/10/98	10	U	N	Threw Collar
151.386	F	7	01/23/98	12/27/99	168	N	Y	Hunter harvest
151.415	F	68	02/17/98	12/01/99	159	N	Y	Alive
151.425	F	33	03/09/97	11/23/98	182	D	Y	Hunter harvest
151.492	F	140	02/09/97	01/10/99	200	N	Y	Predator kill

Appendix Table 1. (cont'd)

151.512	F	8	02/21/97	12/01/99	276	N	Y	Alive
151.571	F	8	02/05/97	03/28/97	12	U	N	Dead - Starvation
151.582	F	7	01/11/98	12/01/99	160	N	Y	Alive
151.888	F	31	01/24/97	11/12/99	280	Y	Y	Censored
151.985	F	8	02/11/97	06/18/99	246	N	Y	Roadkill
150.370	M	7	01/12/98	11/18/98	68	N	Y	Censored
150.390	M	7	01/12/98	11/05/98	155	N	Y	Hunter harvest
150.440	M	7	01/15/97	11/13/97	108	N	Y	Hunter harvest
150.973	M	7	01/12/98	11/05/99	157	N	Y	Hunter harvest
150.981	M	8	02/20/97	02/28/97	12	U	N	Dead - Starvation
151.202	M	33	03/19/97	11/15/97	6	U	N	Hunter harvest
151.246	M	8	02/25/97	11/21/97	159	N	Y	Censored
151.402	M	7	01/22/98	11/12/98	65	N	Y	Hunter harvest
151.561	M	8	02/06/97	02/14/97	2	U	N	Threw Collar
151.561	M	8	02/20/97	11/19/97	105	N	Y	Hunter harvest
151.601	M	8	02/26/97	11/11/97	98	N	Y	Roadkill
151.622	M	8	02/15/97	03/13/97	6	U	N	Predator kill
Females Used:					2367		12	

Males Used:	915	8
Total Used:	3282	20

Appendix Table 1. (cont'd)

The following are radio-collared deer which were collared by the MDNR prior to this research project starting.
The data of the following deer are included in the results of this research project.

Frequency	Sex	Age at capture (months)	First Location (capture date)	Last Location	Number of Locations	Migratory status	Used in Estimates	Fate
Charlie's Clan Hunting Club								
151.333	F	21	03/21/96			N	Y	TB+
151.444	F	32	02/13/96			N	Y	TB+
Leroy Hunting Club								
150.542	F	9	03/13/96	11/13/97	40	D	Y	Censored
Lippert's								
151.193	F	21	03/19/96	06/24/99	285	N	Y	Dead - Unknown
151.313	M	9	03/20/96	11/13/98	18	Y	Y	Hunter harvest

The following deer was radio-collared by Kristie Sitar and included in her MSU research project (1994 - 1996).
The data of the following deer are included in the results of this research project.

Frequency	Sex	Age at capture (months)	First Location (capture date)	Last Location	Number of Locations	Migratory status	Used in Estimates	Fate
<u>Carlson's</u>								
150.595	M	8	02/16/95	04/17/96		N	Y	Roadkill - TB+

Appendix Table 1. (cont'd)

[a] Y = Migratory, [d] N = Non-migratory, [e] U = Unknown, [g] D = Dispersed, [i] A = Ambiguous

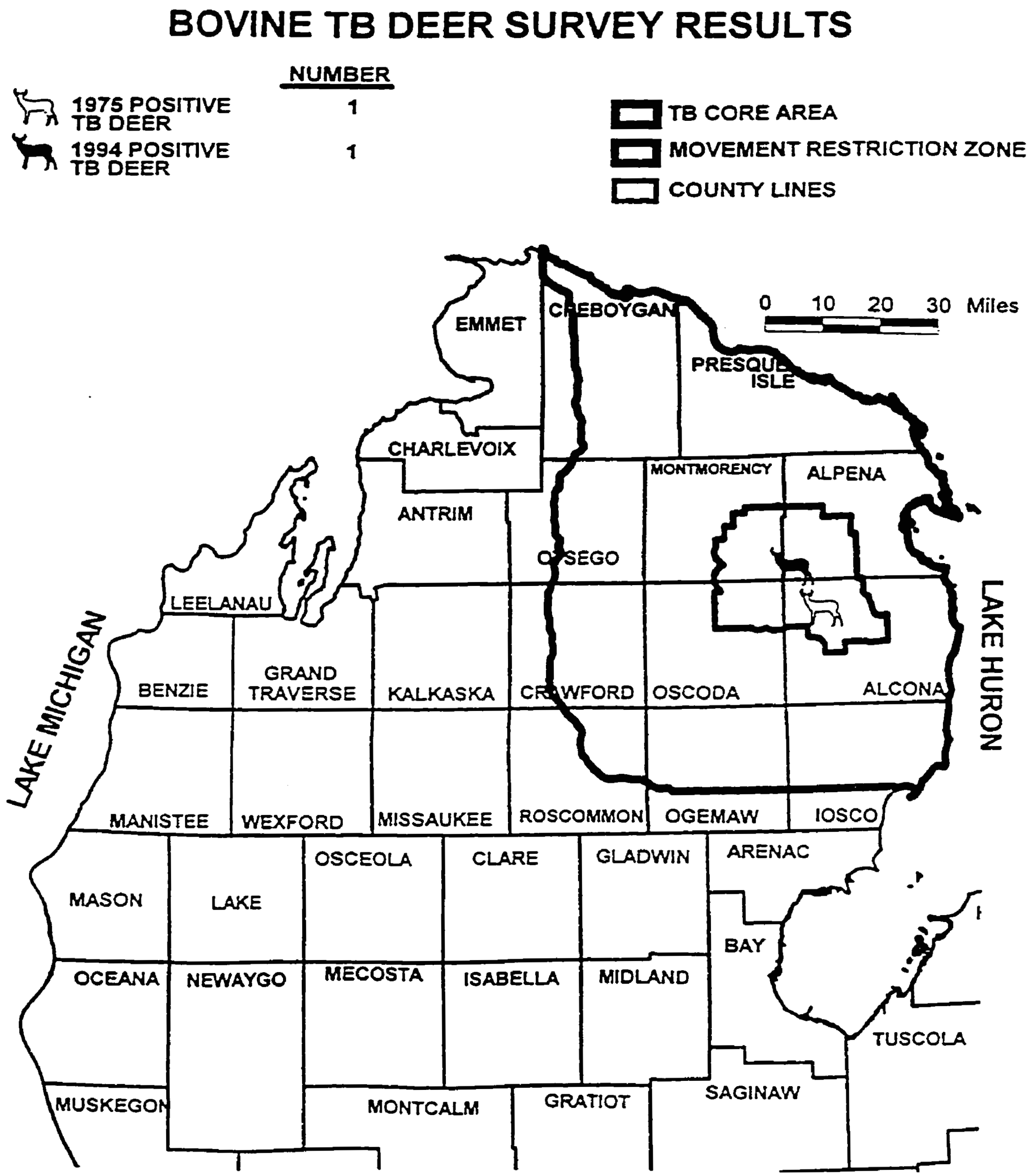
[b] Y = Data were used in this research projects estimates, [f] N = Data were not used in this research projects estimates.

[c] Alive = The radio-collared deer was alive at the time (December 1999) this research project ended.

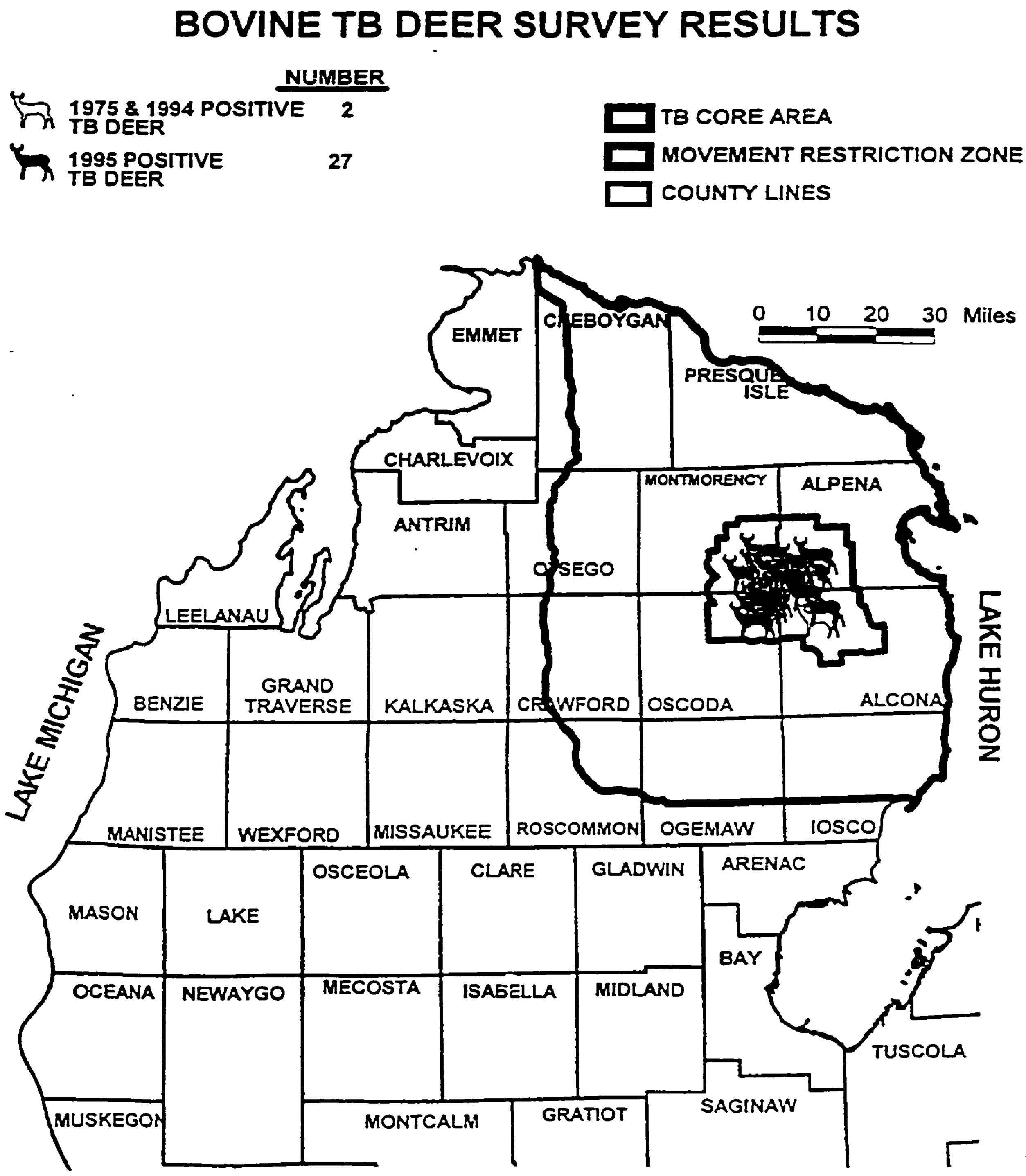
[h] A = Adult

The following radio-collared deer were discovered to have a leg hung in between their radio-collar and their neck.
The data (locations) that were recorded for these deer will not be included in any estimates.
151.520 a 9 month old female radio-collared at Lippert's in 1997 and we had 82 locations recorded on her.
151.531 a 9 month old female radio-collared at Lockwood Lake Ranch and we had 128 locations recorded on her.
151.581 a 9 month old female radio-collared at the Strohschein's Farm in 1997 and we had 93 locations recorded on her.

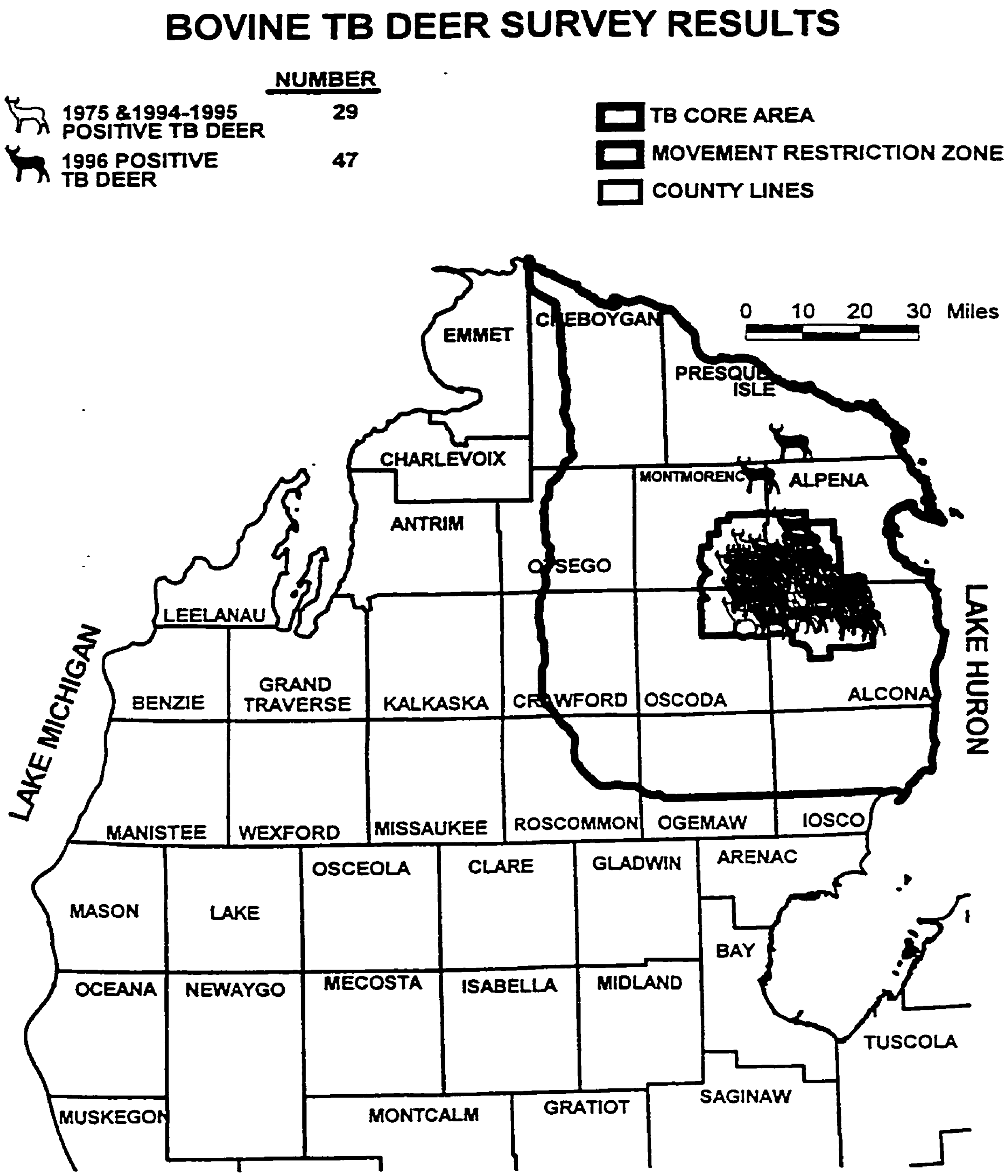
APPENDIX FIGURES



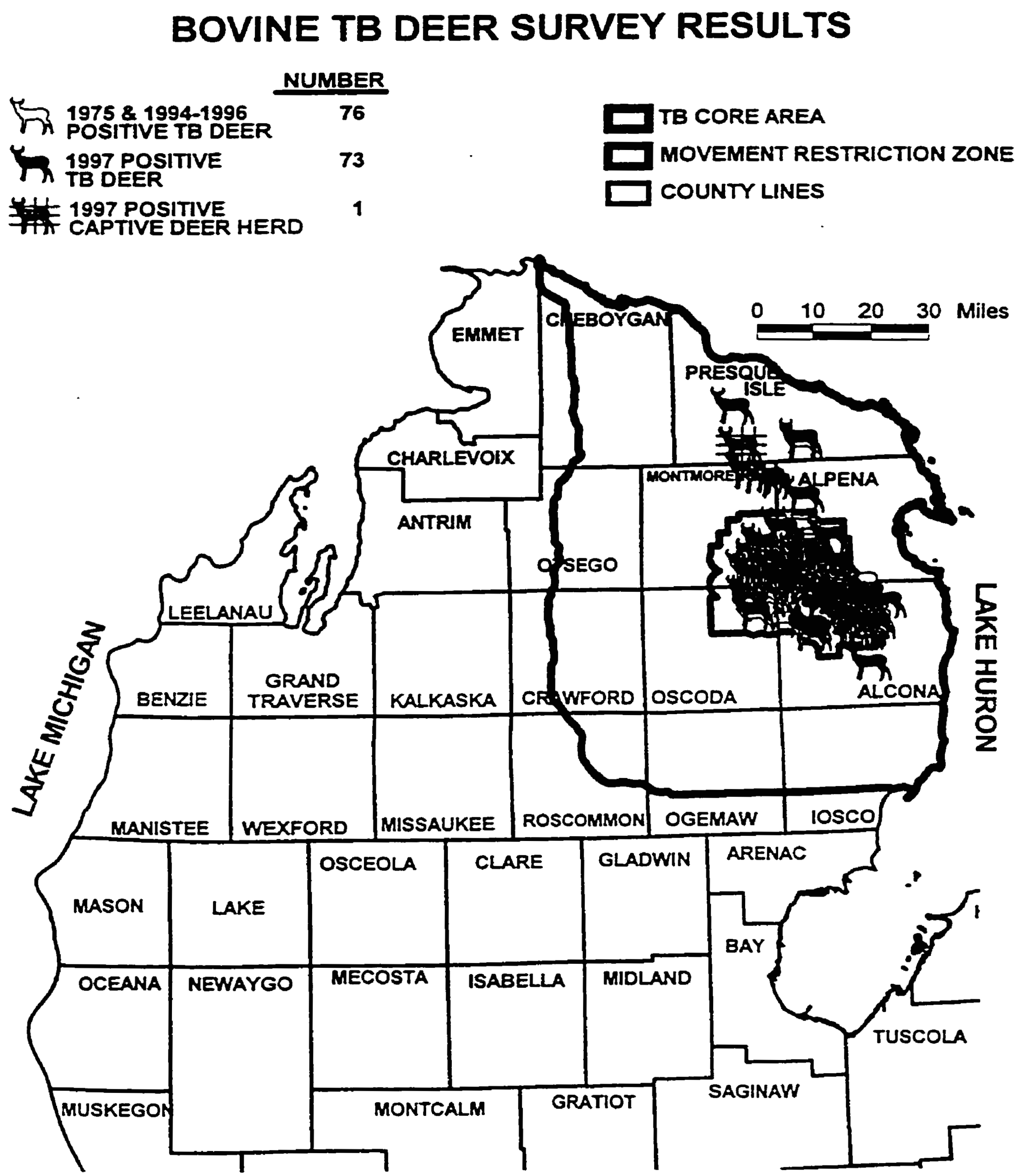
Appendix Figure 1. The free-ranging Michigan white-tailed deer that tested positive for bovine TB in the 1975 and 1994 TB deer surveys conducted by the Michigan Department of Natural Resources.



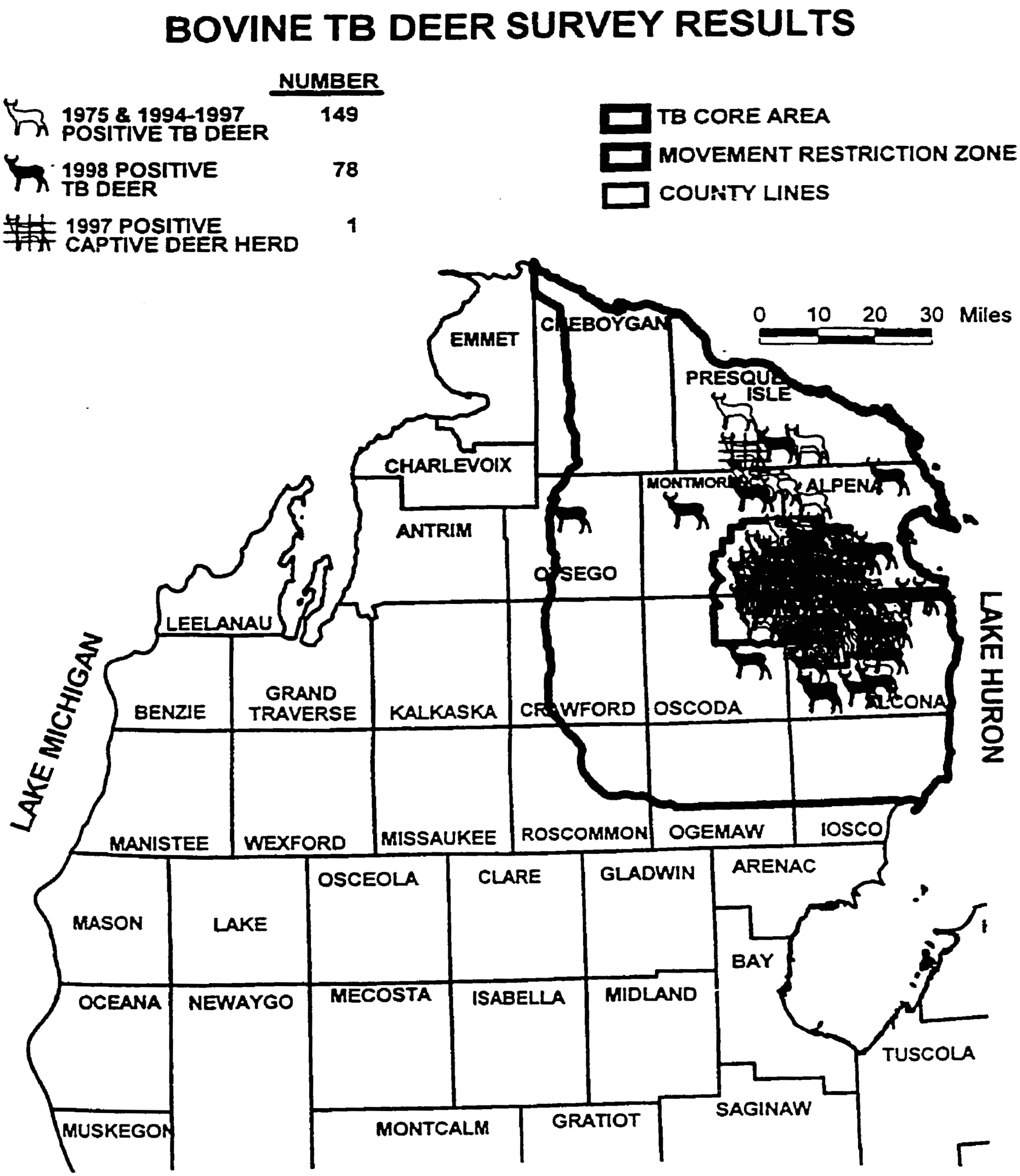
Appendix Figure 2. The free-ranging Michigan white-tailed deer that tested positive for bovine TB in the 1975, 1994 and 1995 TB deer surveys conducted by the Michigan Department of Natural Resources.



Appendix Figure 3. The free-ranging Michigan white-tailed deer that tested positive for bovine TB in the 1975, 1994, 1995 and 1996 TB deer surveys conducted by the Michigan Department of Natural Resources.

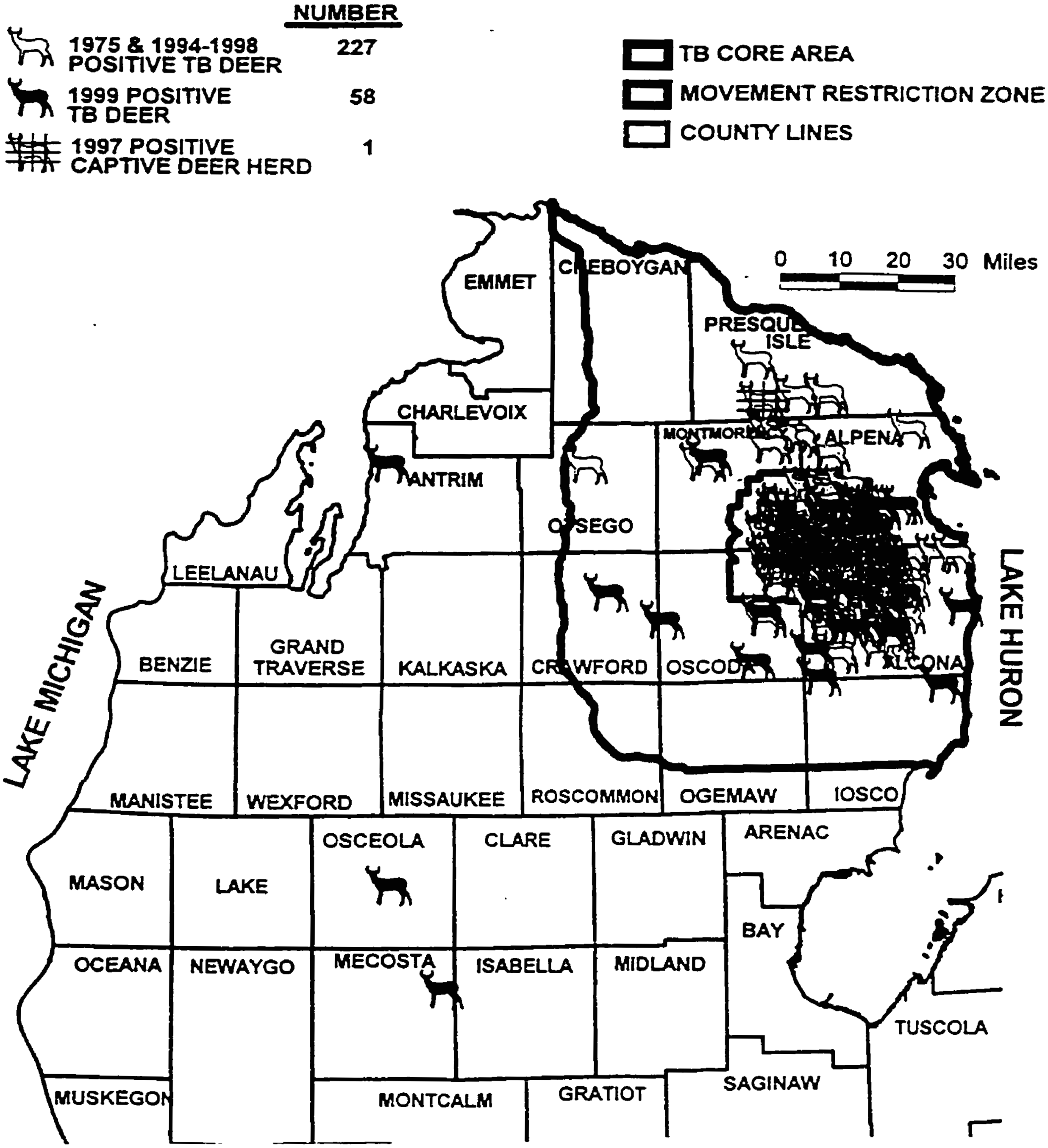


Appendix Figure 4. The free-ranging and captive Michigan white-tailed deer that tested positive for bovine TB in the 1975, 1994, 1995, 1996 and 1997 TB deer surveys conducted by the Michigan Department of Natural Resources and the Michigan Department of Agriculture.



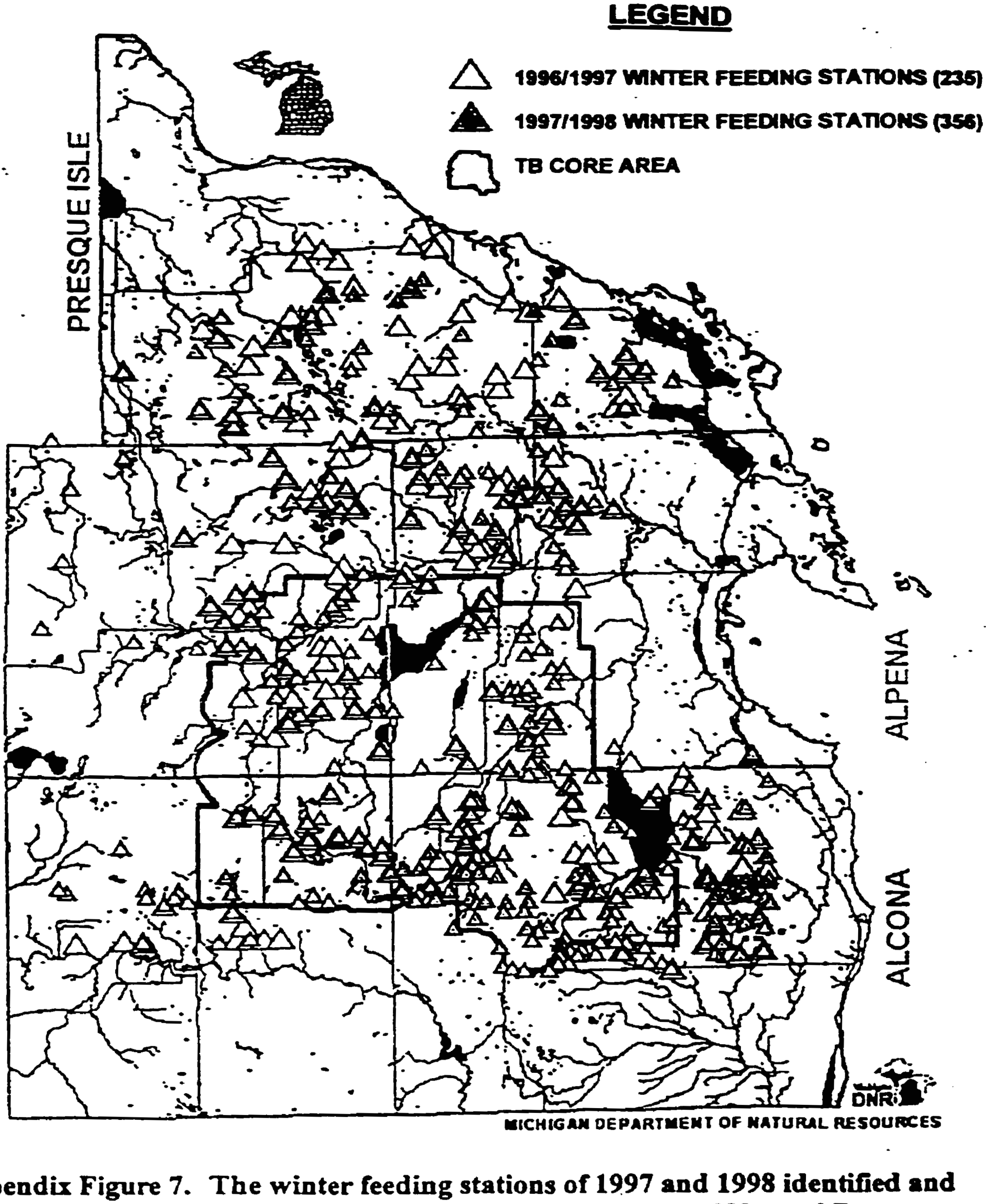
Appendix Figure 5. **The free-ranging and captive Michigan white-tailed deer that tested positive for bovine TB in the 1975, 1994, 1995, 1996, 1997 and 1998 TB deer surveys conducted by the Michigan Department of Natural Resources and the Michigan Department of Agriculture.**

BOVINE TB DEER SURVEY RESULTS

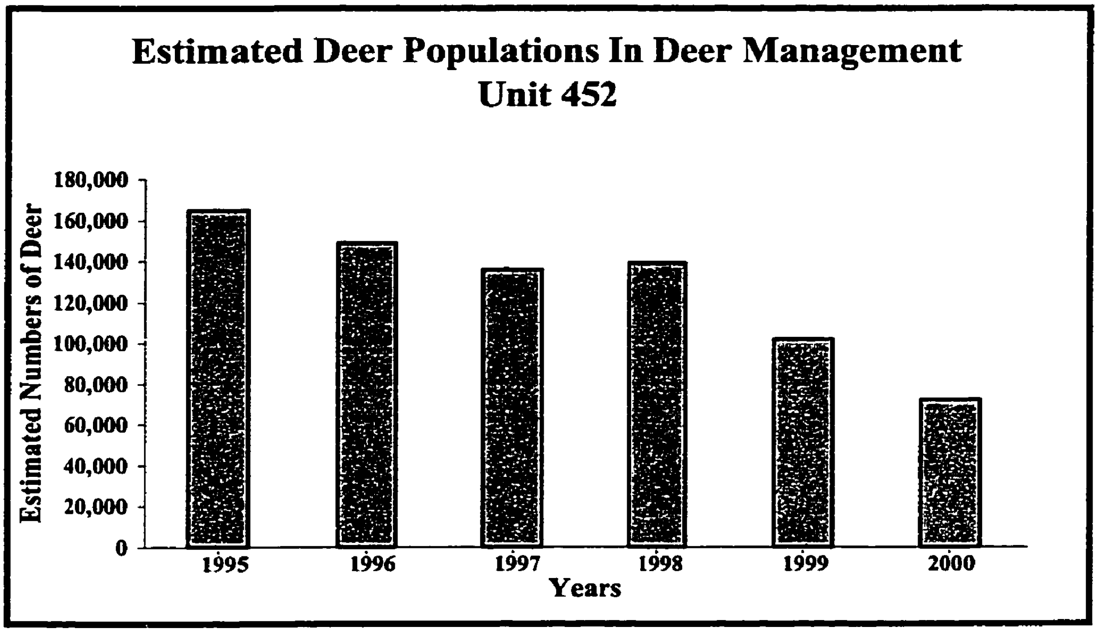


Appendix Figure 6. The free-ranging and captive Michigan white-tailed deer that tested positive for bovine TB in the 1975, 1994, 1995, 1996, 1997, 1998 and 1999 TB deer surveys conducted by the Michigan Department of Natural Resources and the Michigan Department of Agriculture.

BOVINE TUBERCULOSIS
WINTER FEEDING STATIONS SURVEY



Appendix Figure 7. The winter feeding stations of 1997 and 1998 identified and mapped by the Michigan Department of Natural Resources.



Appendix Figure 8. The estimated 1995 to 2000 deer populations in the Deer Management Unit 452.

Site_______________________ Station____________________ Date________

Begin time______________ End time______________ Observer initials_____

Weather___________________ Temperature_______________ Wind________

SPREAD FEED **TYPE______________________________**

TIME (EVERY 5 MIN)	TOTAL # OF DEER FEEDING	SEX & AGE RATIO OF DEER FEEDING	# OF HEAD CONTACTS < 3 FT			**ALL THE TIME # OF PHYSICAL NOSE TO NOSE CONTACTS**		
			2 DEER	3 DEER	4 DEER	**2 DEER**	**3 DEER**	**4 DEER**

PILED FEED **TYPE______________________________**

TIME (EVERY 5 MIN)	TOTAL # OF DEER FEEDING	SEX & AGE RATIO OF DEER FEEDING	# OF HEAD CONTACTS < 3 FT			**ALL THE TIME # OF PHYSICAL NOSE TO NOSE CONTACTS**		
			2 DEER	3 DEER	4 DEER	**2 DEER**	**3 DEER**	**4 DEER**

Appendix Figure 9. Observation data sheet 1.

Appendix Figure 10. Observation data sheet 2.

Site________________ **Station**________________ **Date**________________

Begin time________________ **End time**________________ **Observer initials**____________

Weather________________ **Temperature**________________ **Wind**________________

FREQ OR TAG	TOTAL # DEER FEEDING	SEX & AGE RATIO OF DEER FEEDING	# PHYSICAL NOSE TO NOSE CONTACTS			# OF HEAD CONTACTS < 3 FT			TYPE OF FEED PILE/SPREAD	REMARKS
			2 DEER	3 DEER	4 DEER	2 DEER	3 DEER	4 DEER		

On the following pages you will see the following symbols:

● = locations made during the first winter following trapping and radio-collaring

○ = locations made during the second winter following trapping and radio-collaring

● = locations made during the third winter following trapping and radio-collaring

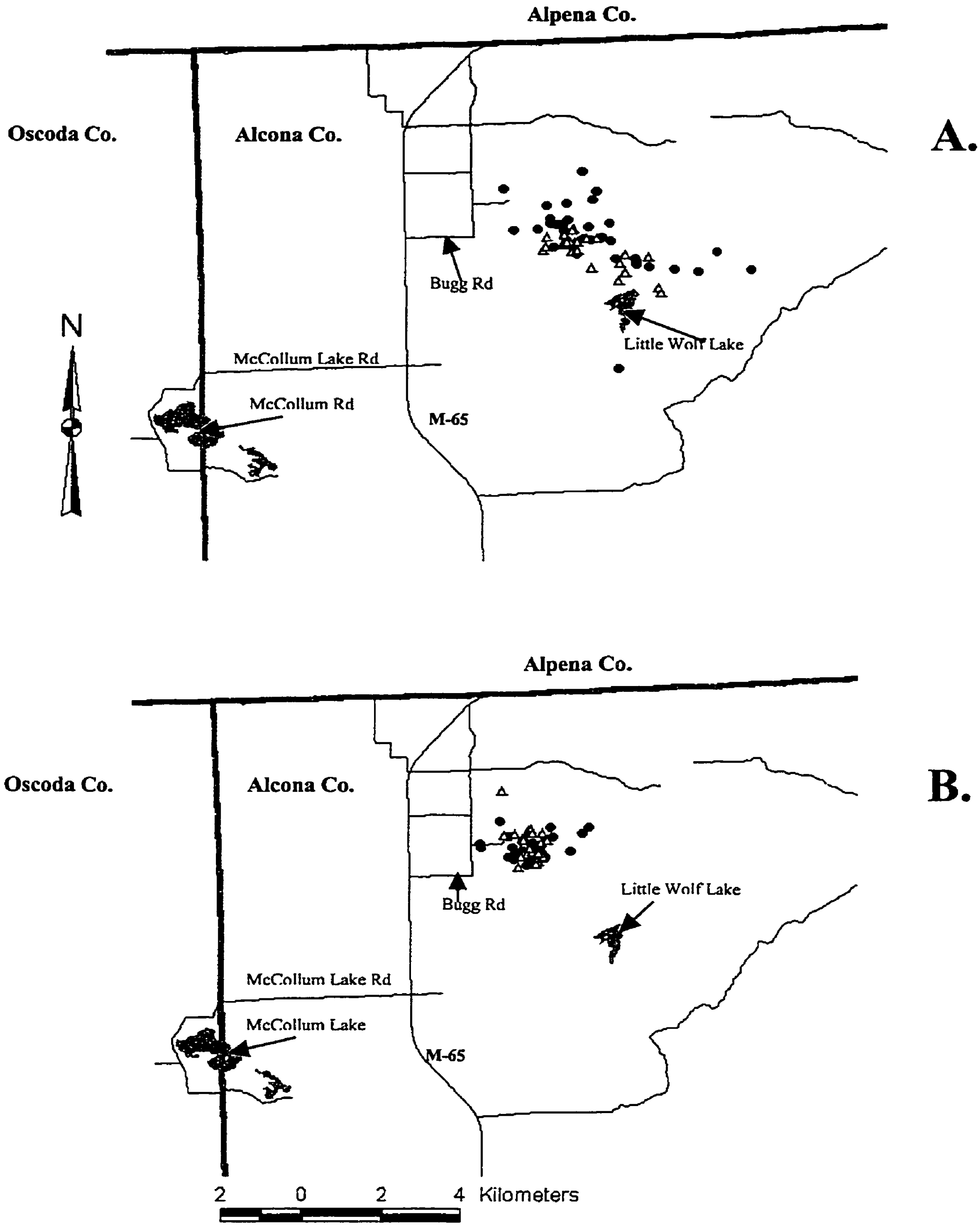
△ = locations made during the first summer following trapping and radio-collaring

▲ = locations made during the second summer following trapping and radio-collaring

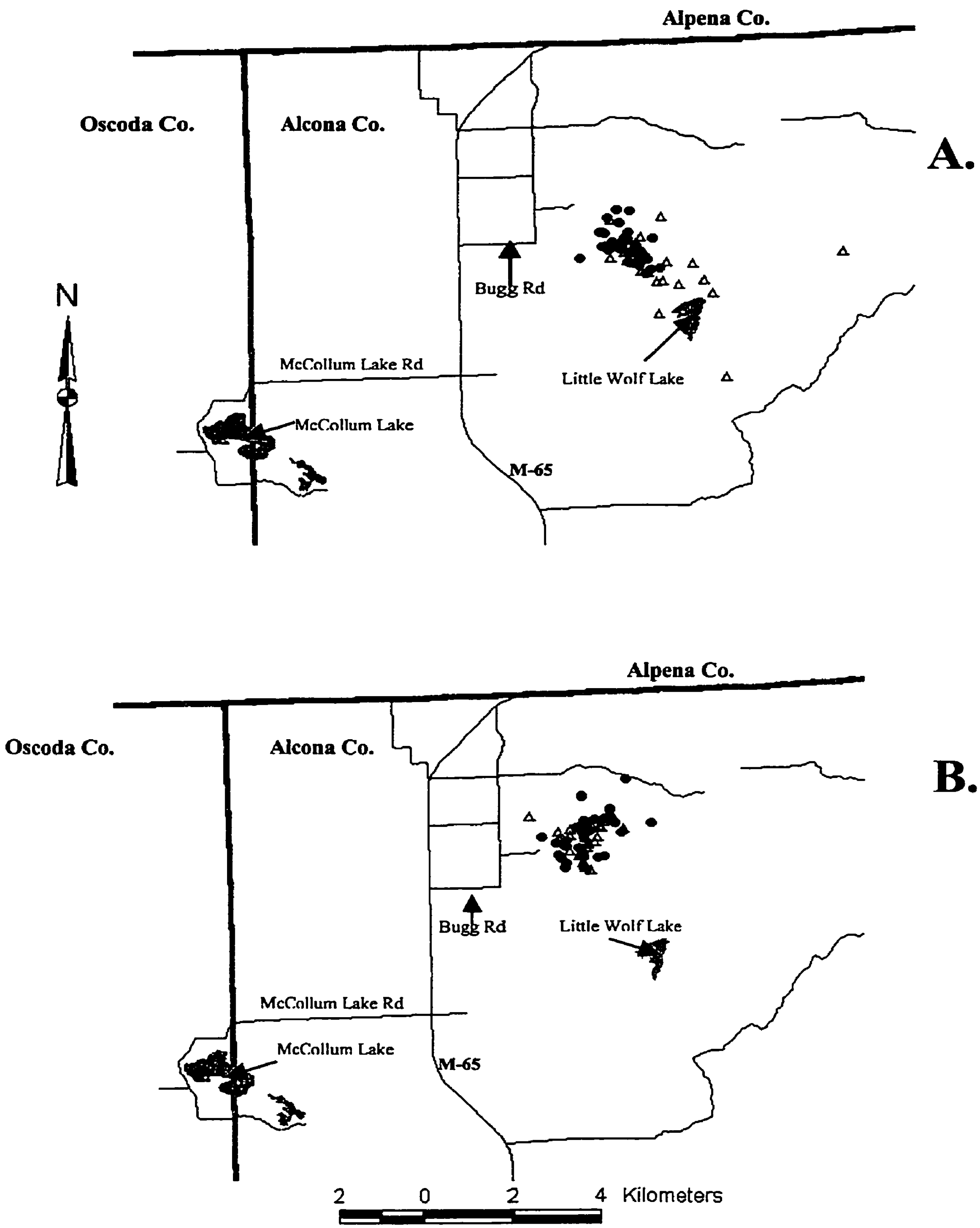
▲ = locations made during the third summer following trapping and radio-collaring

Appendix Figure 11. A legend for the radio-collared deer point location maps. See Appendix Table 1 for actual length of time each deer was observed.

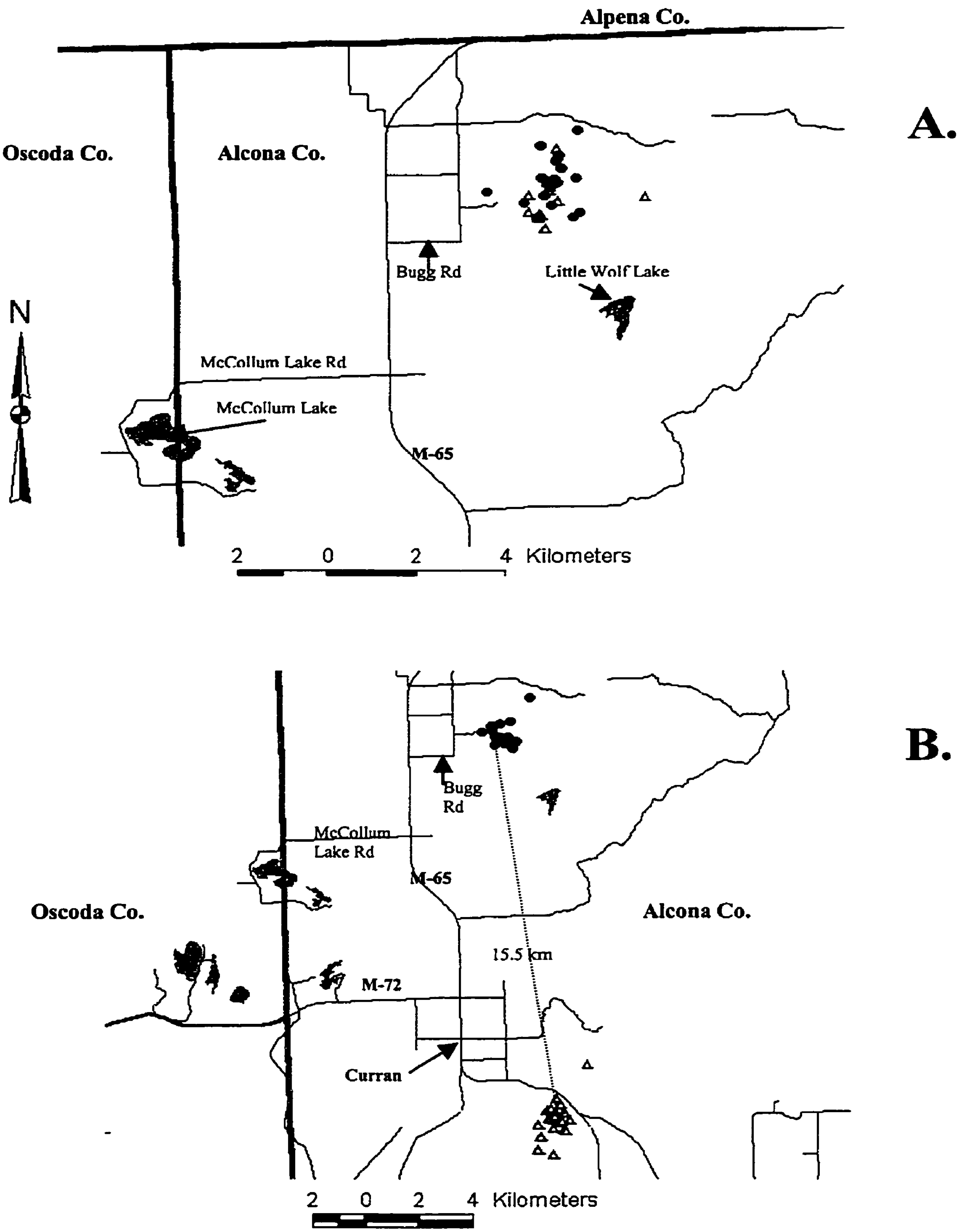
BIRCH CREEK HUNTING CLUB



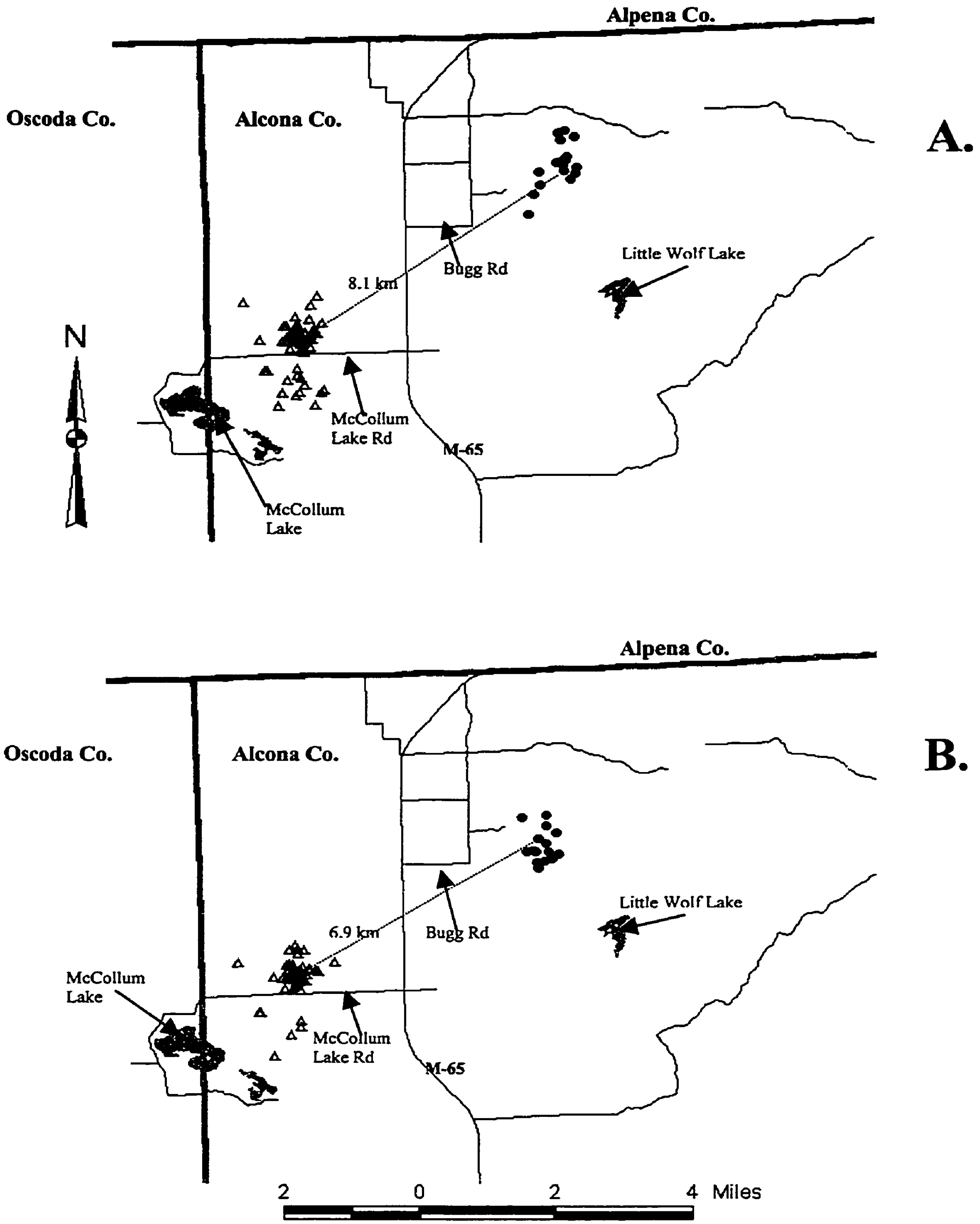
Appendix Figure 12. Point locations for 1.560 (A.) and 1.590 (B.) radio-collared deer.



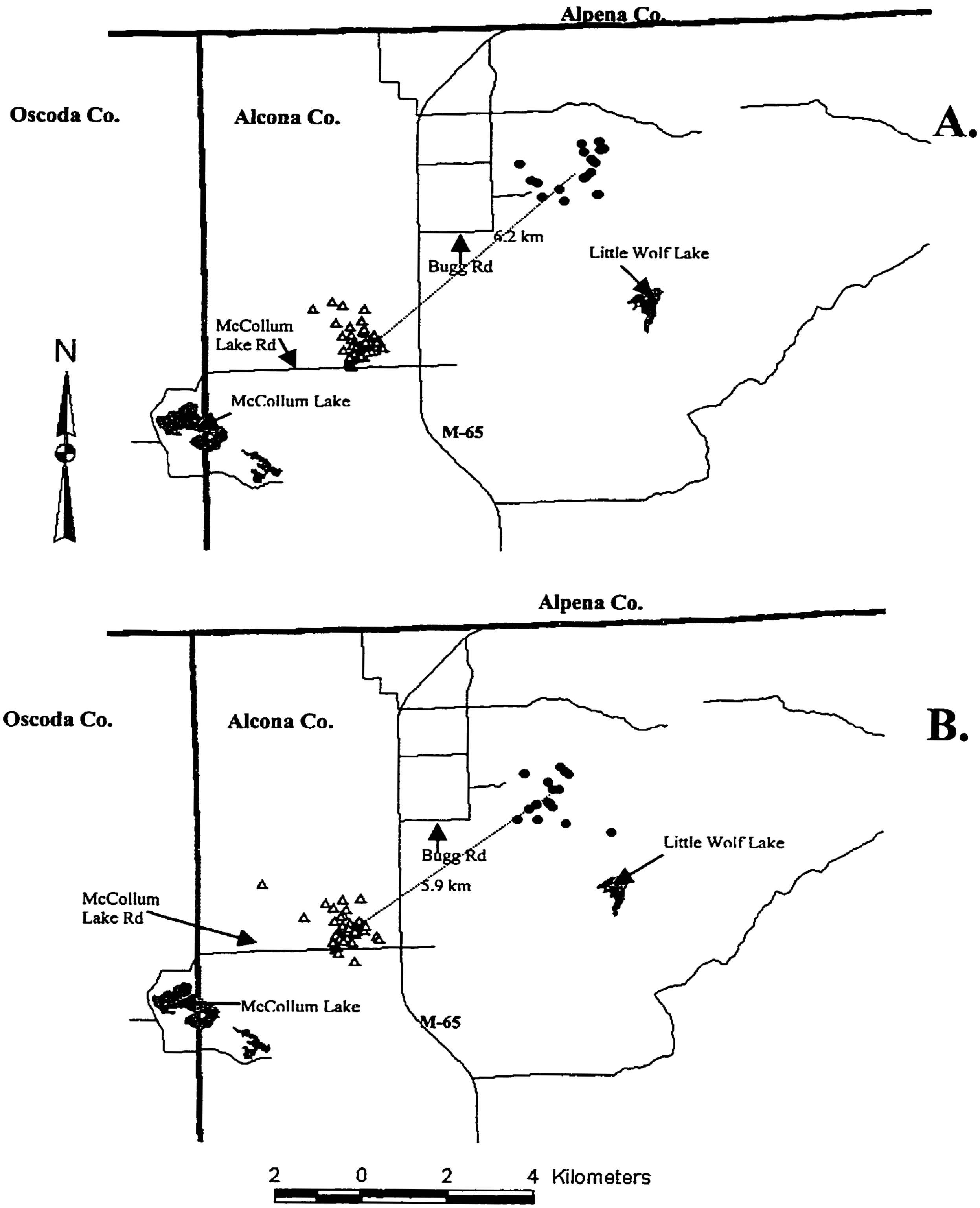
Appendix Figure 13. Point locations for 1.030 (A.) and 1.896 (B.) radio-collared deer.



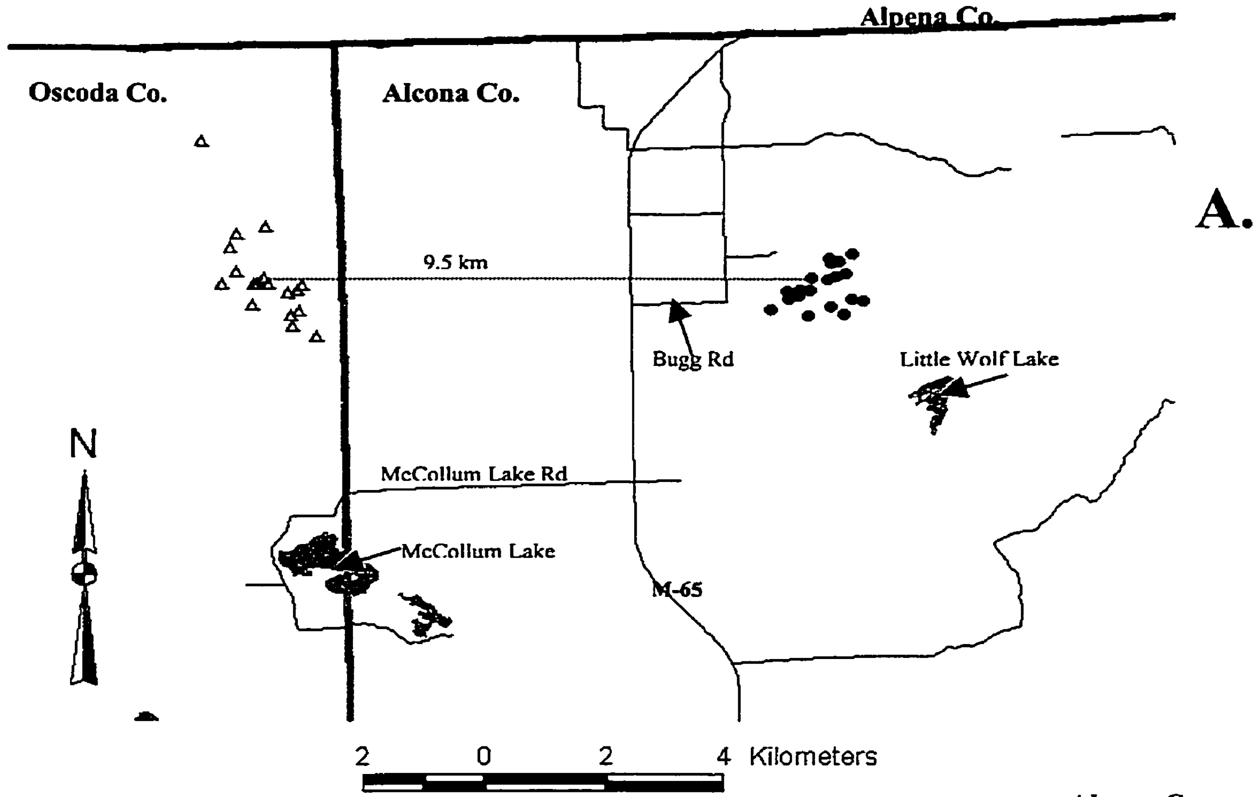
Appendix Figure 14. Point locations for 1.200 (A.) and 1.530 (B.) radio-collared deer.

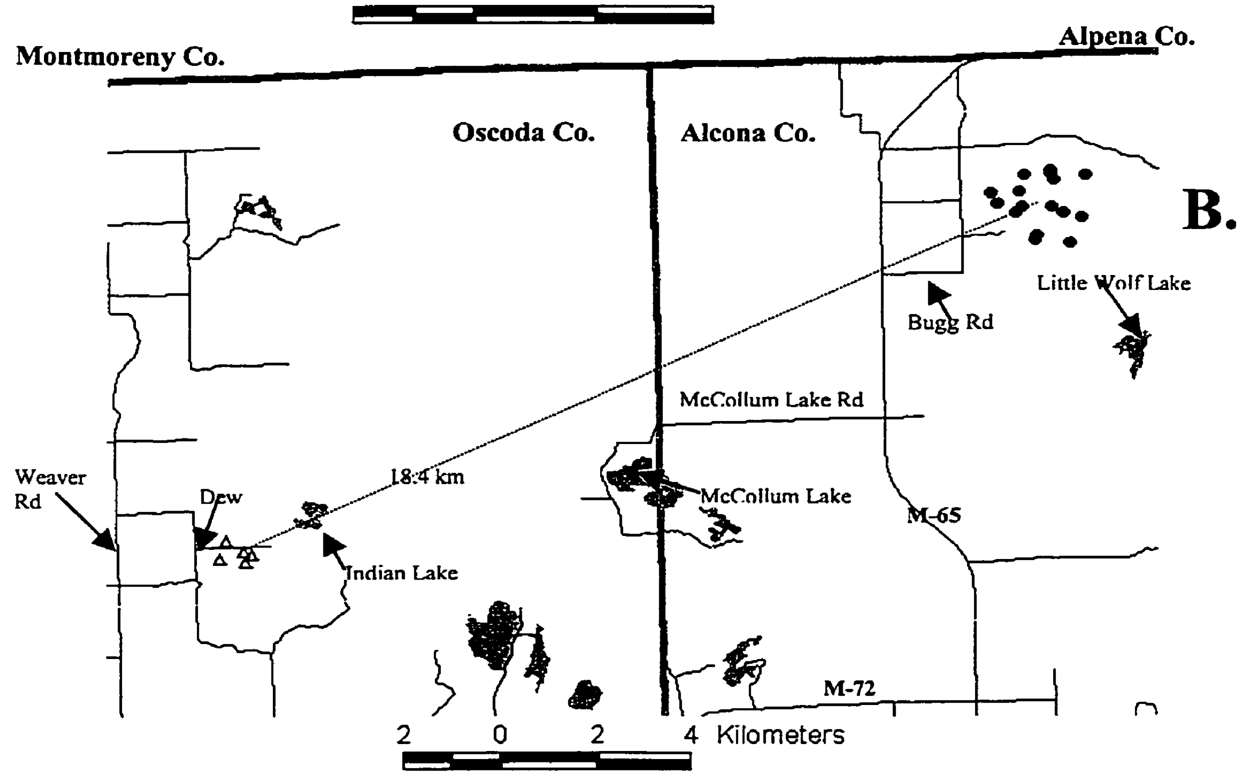


Appendix Figure 15. Point locations for 1.344 (A.) and 1.870 (B.) radio-collared deer.



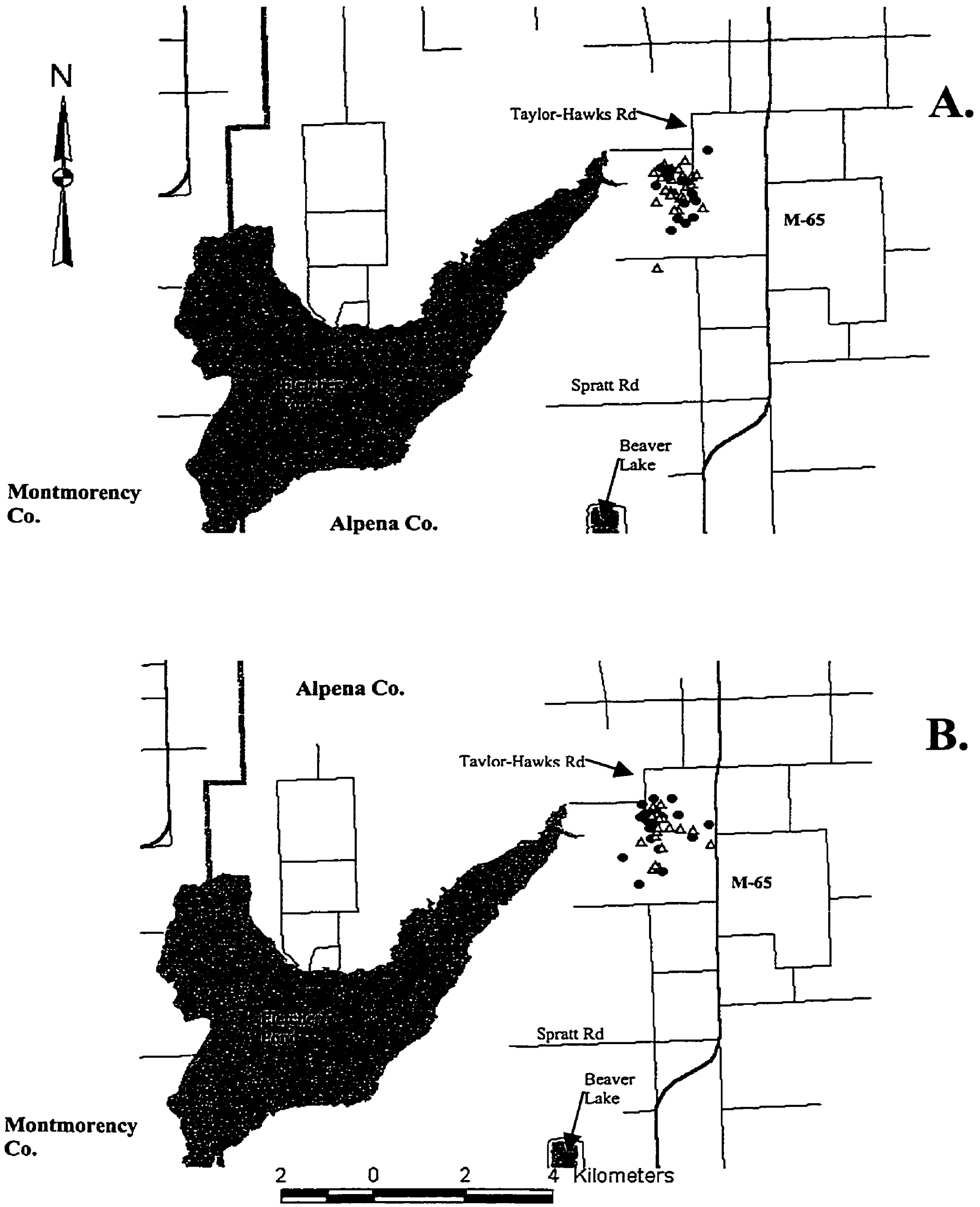
Appendix Figure 16. Point locations for 0.570 (A.) and 1.444 (B.) radio-collared deer.



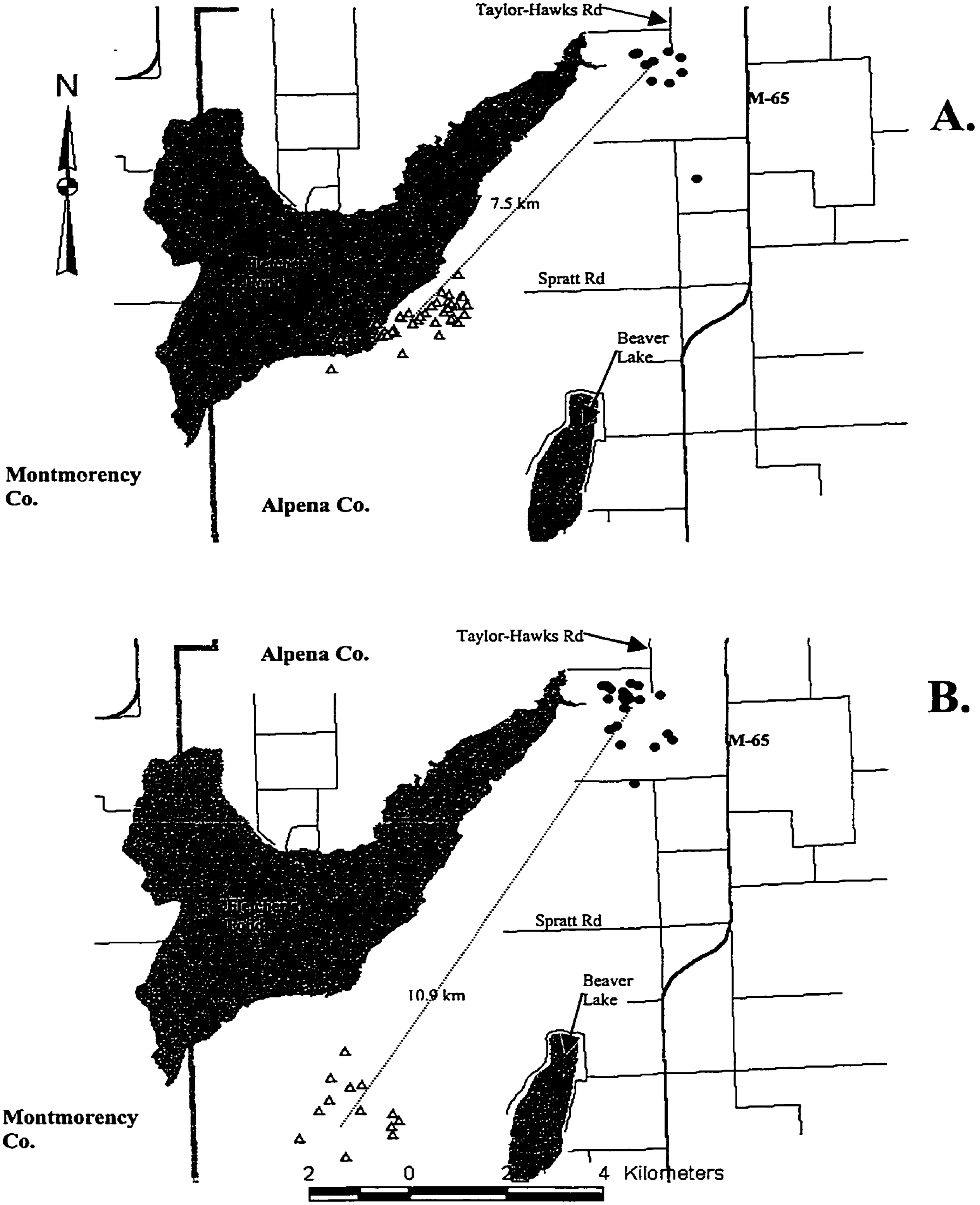


Appendix Figure 17. Point locations for 0.970 (A.) and 1.246 (B.) radio-collared deer.

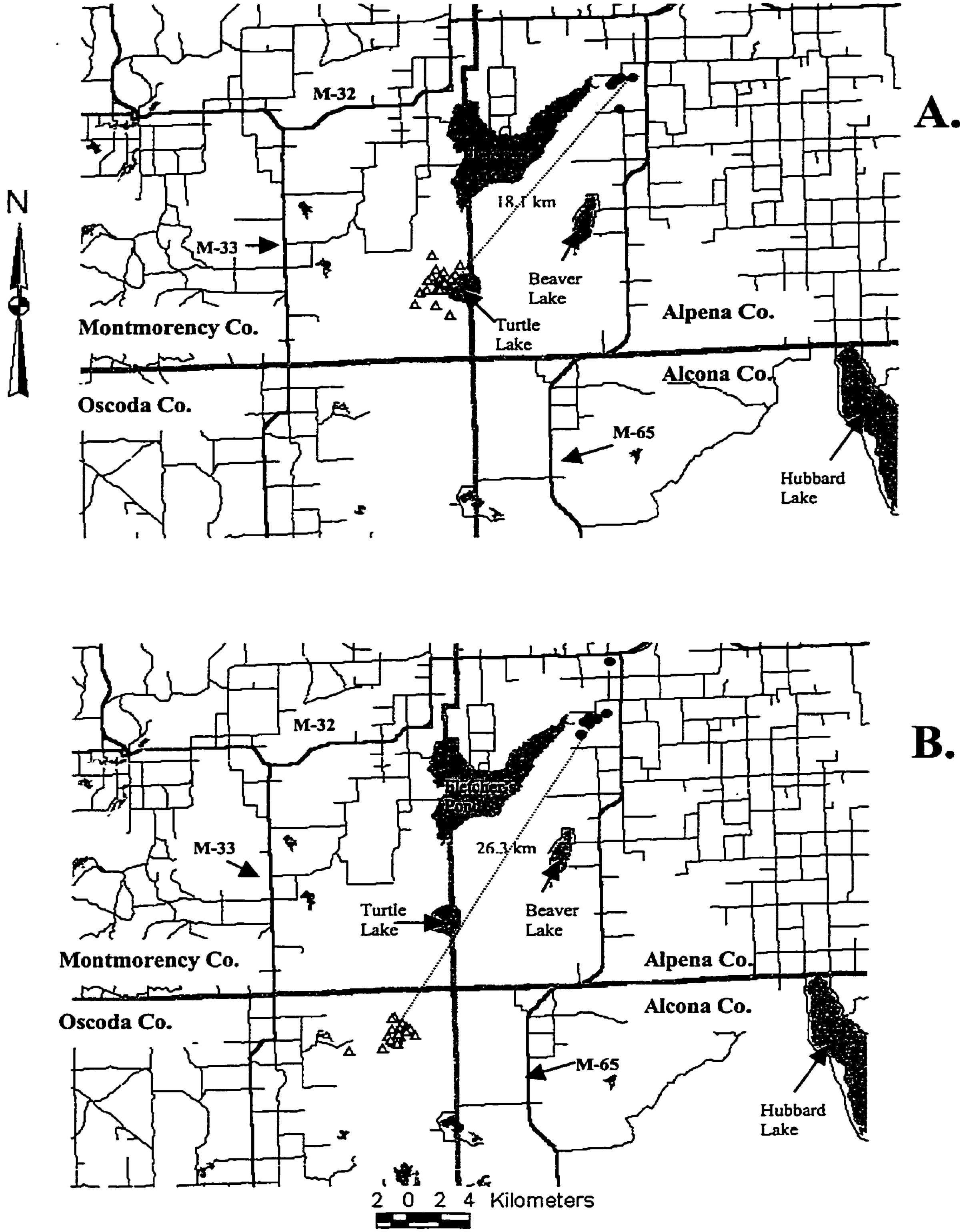
BLACK'S FARM



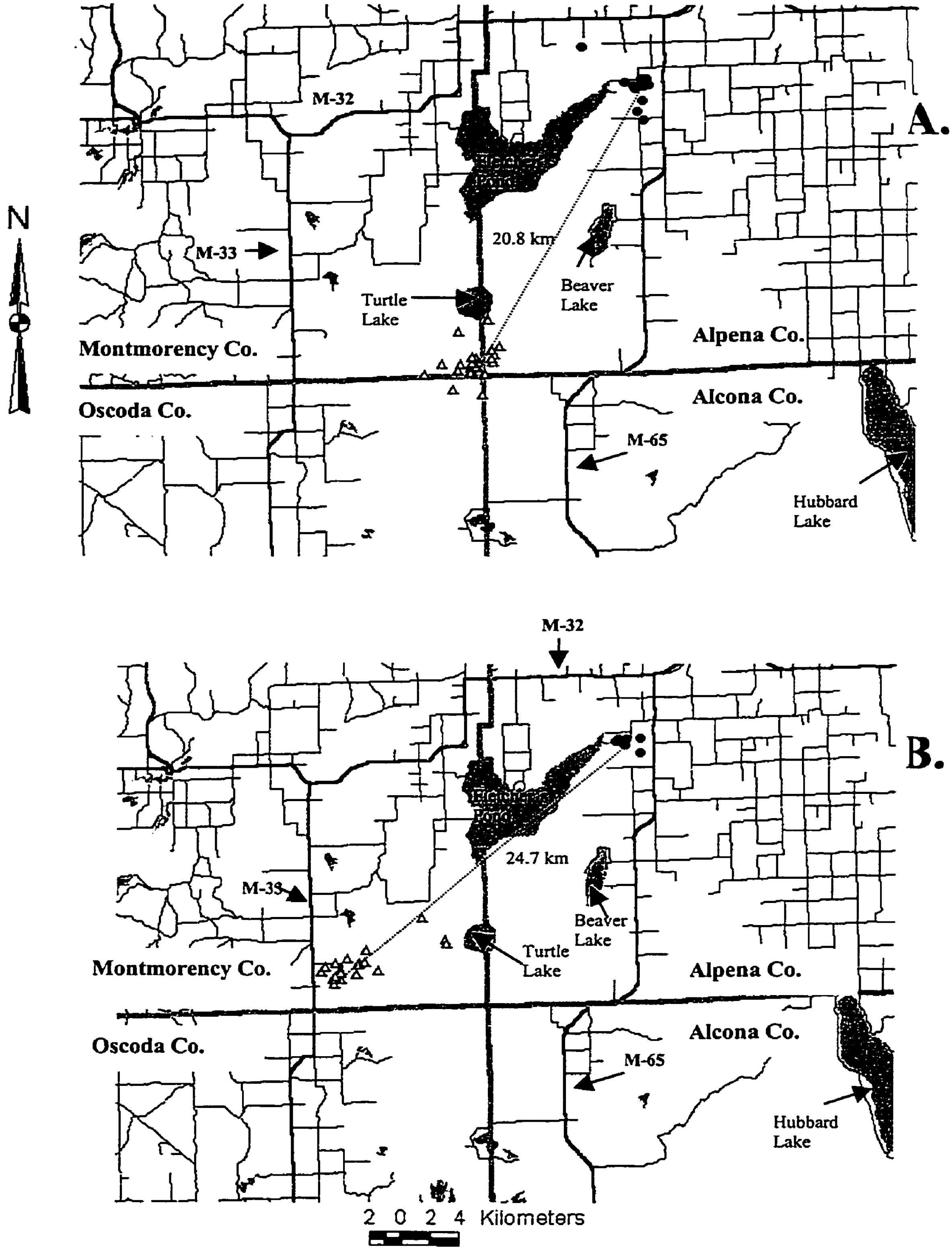
Appendix Figure 18. Point locations for 0.685 (A.) and 0.912 (B.) radio-collared deer.



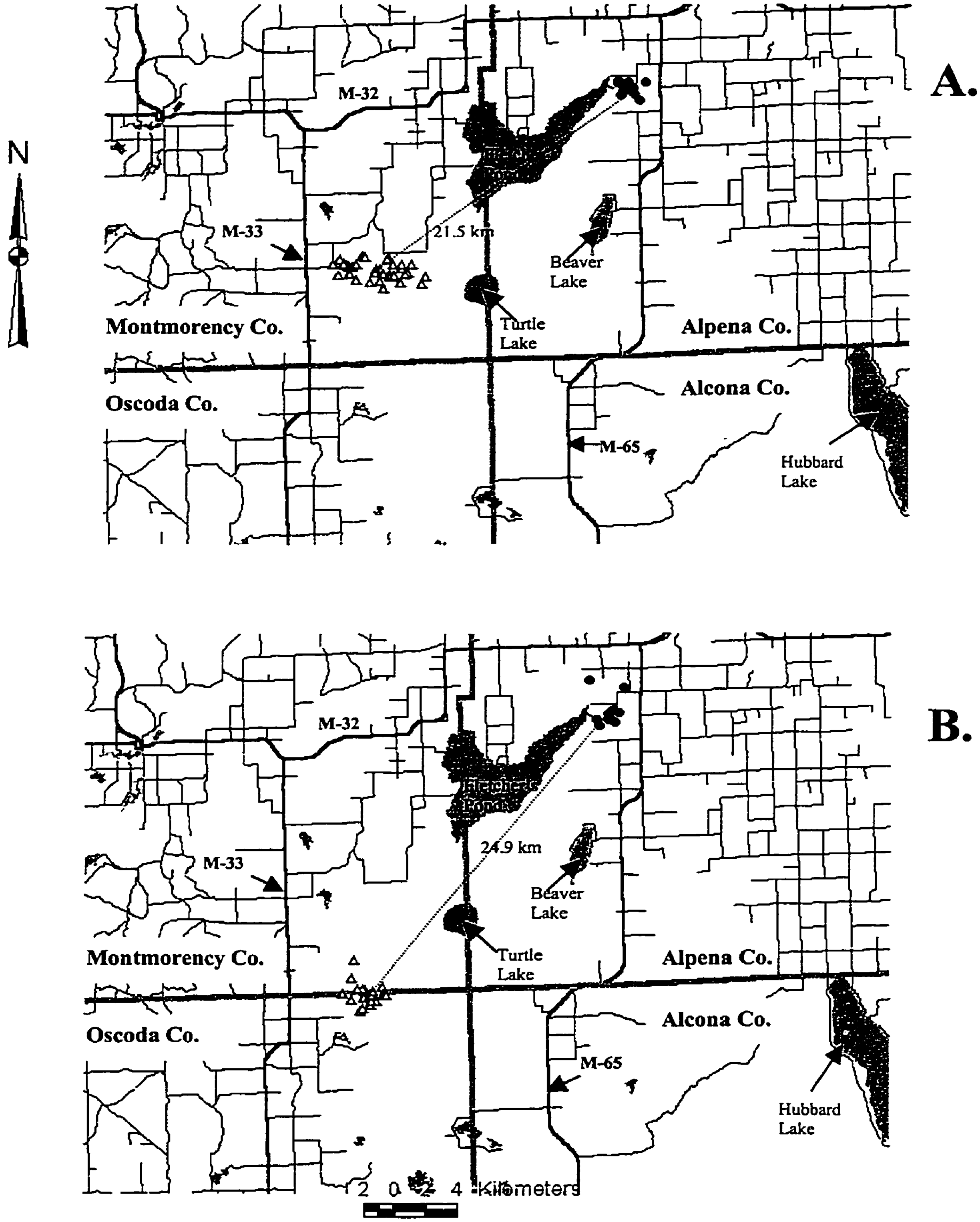
Appendix Figure 19. Point locations for 1.210 (A.) and 1.387 (B.) radio-collared deer.



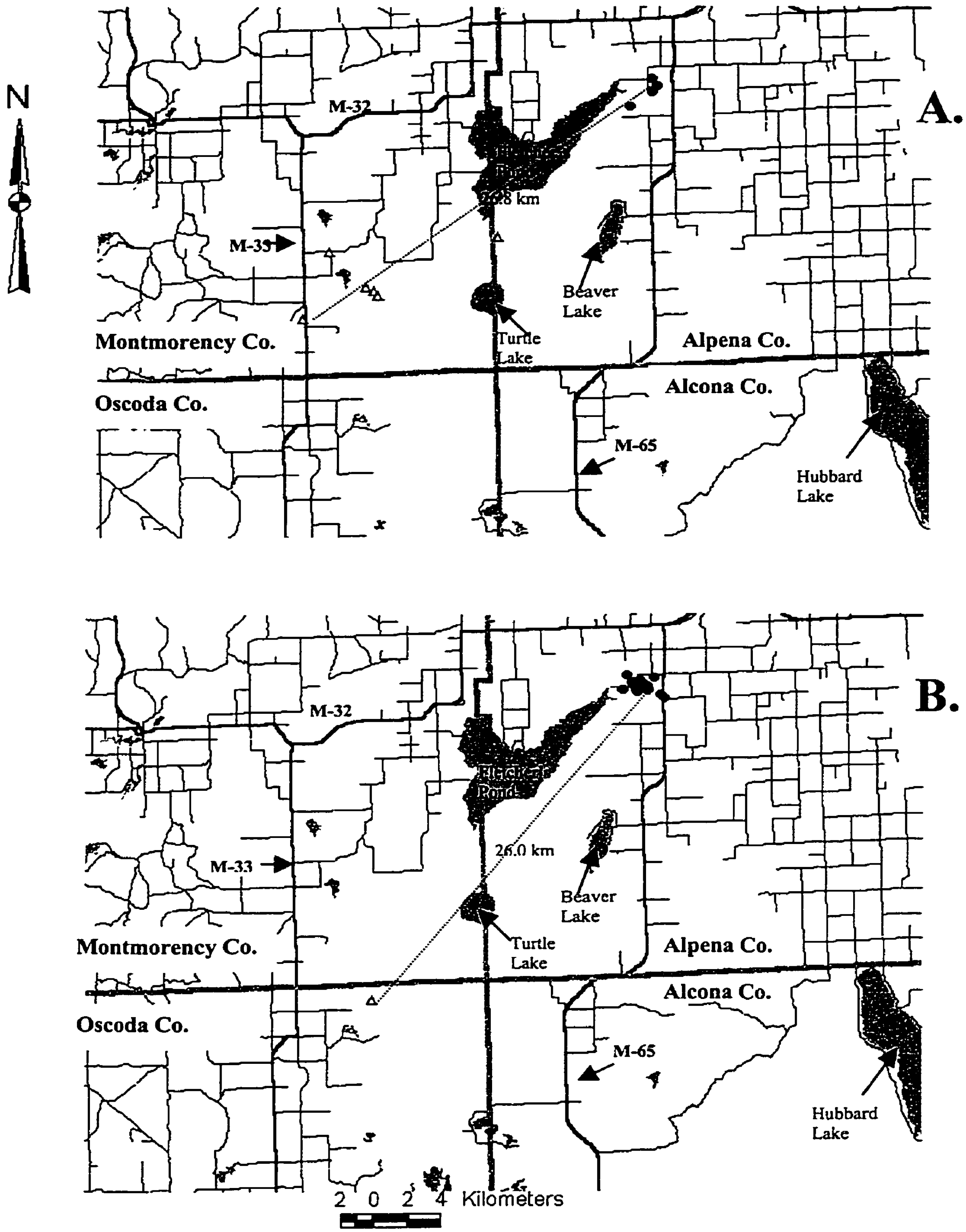
Appendix Figure 20. Point locations for 1.400 (A.) and 1.600 (B.) radio-collared deer.



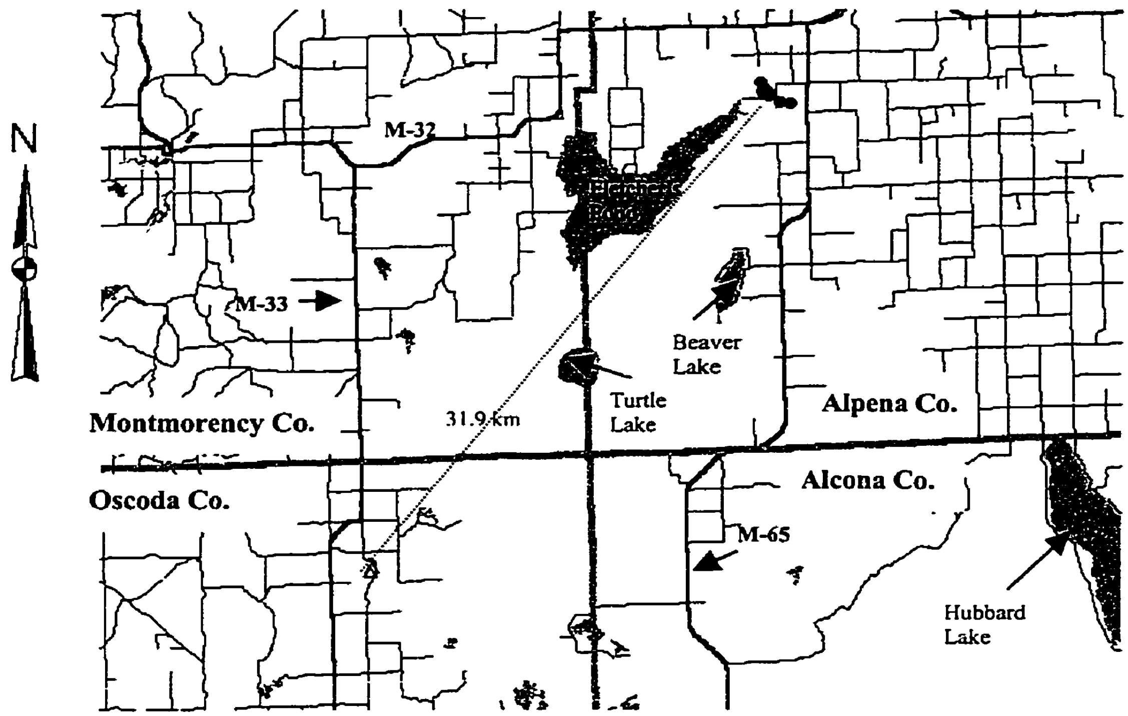
Appendix Figure 21. Point locations for 1.370 (A.) and 1.411 (B.) radio-collared deer.



Appendix Figure 22. Point locations for 1.520 (A.) and 1.915 (B.) radio-collared deer.

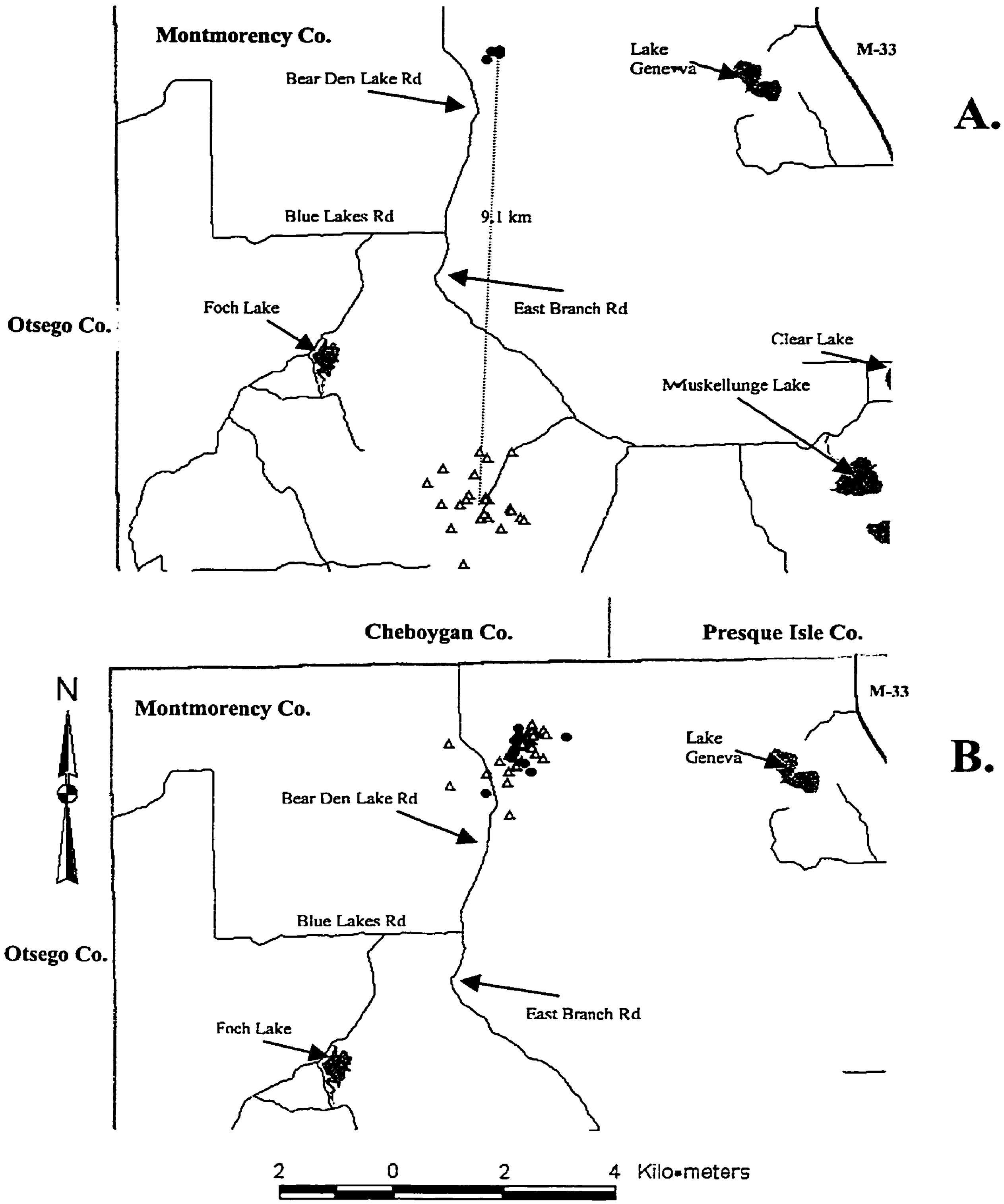


Appendix Figure 23. Point locations for 0.980 (A.) and 1.797 (B.) radio-collared deer.

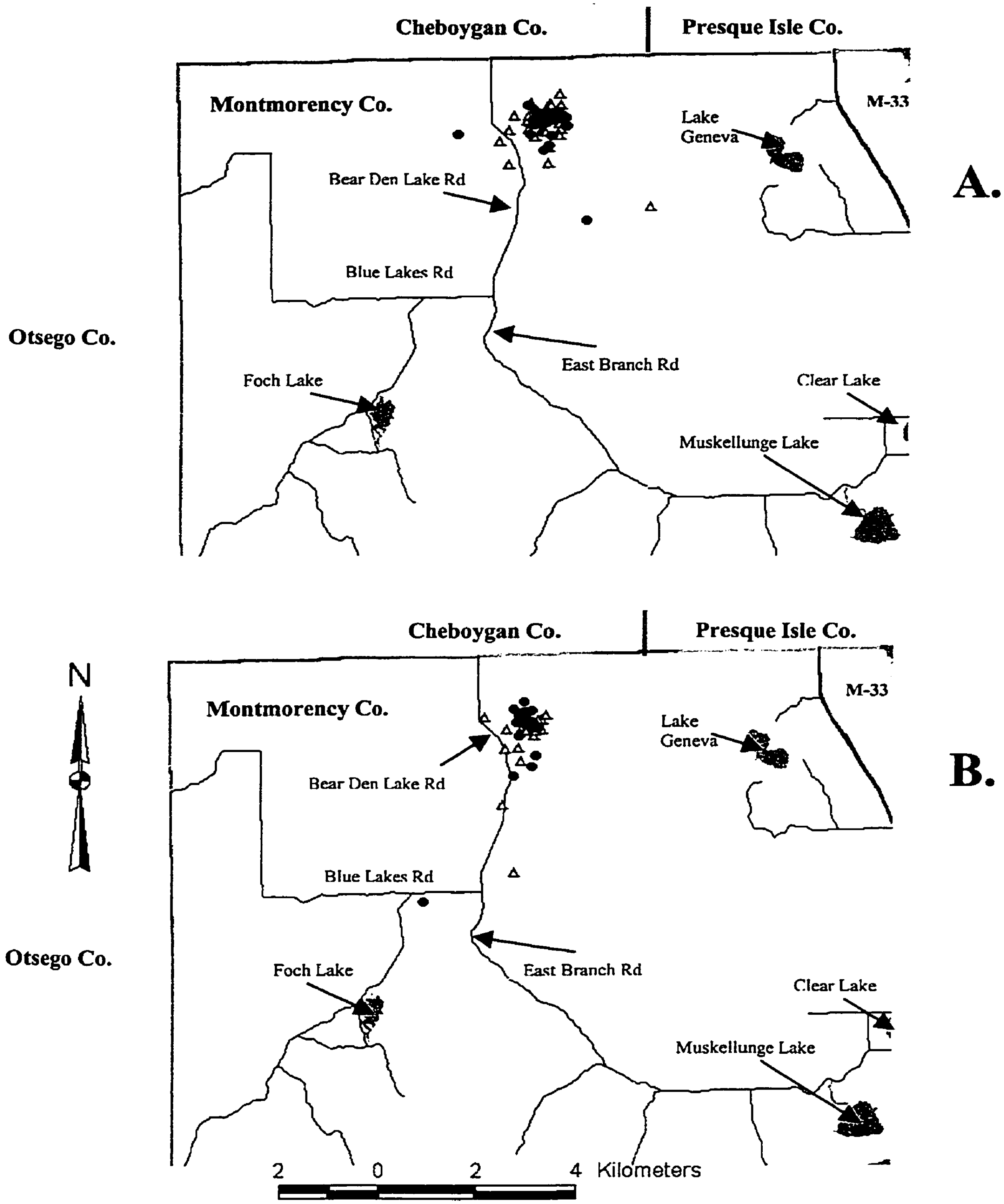


Appendix Figure 24. Point locations for 0.440 a radio-collared deer.

CANADA CREEK RANCH

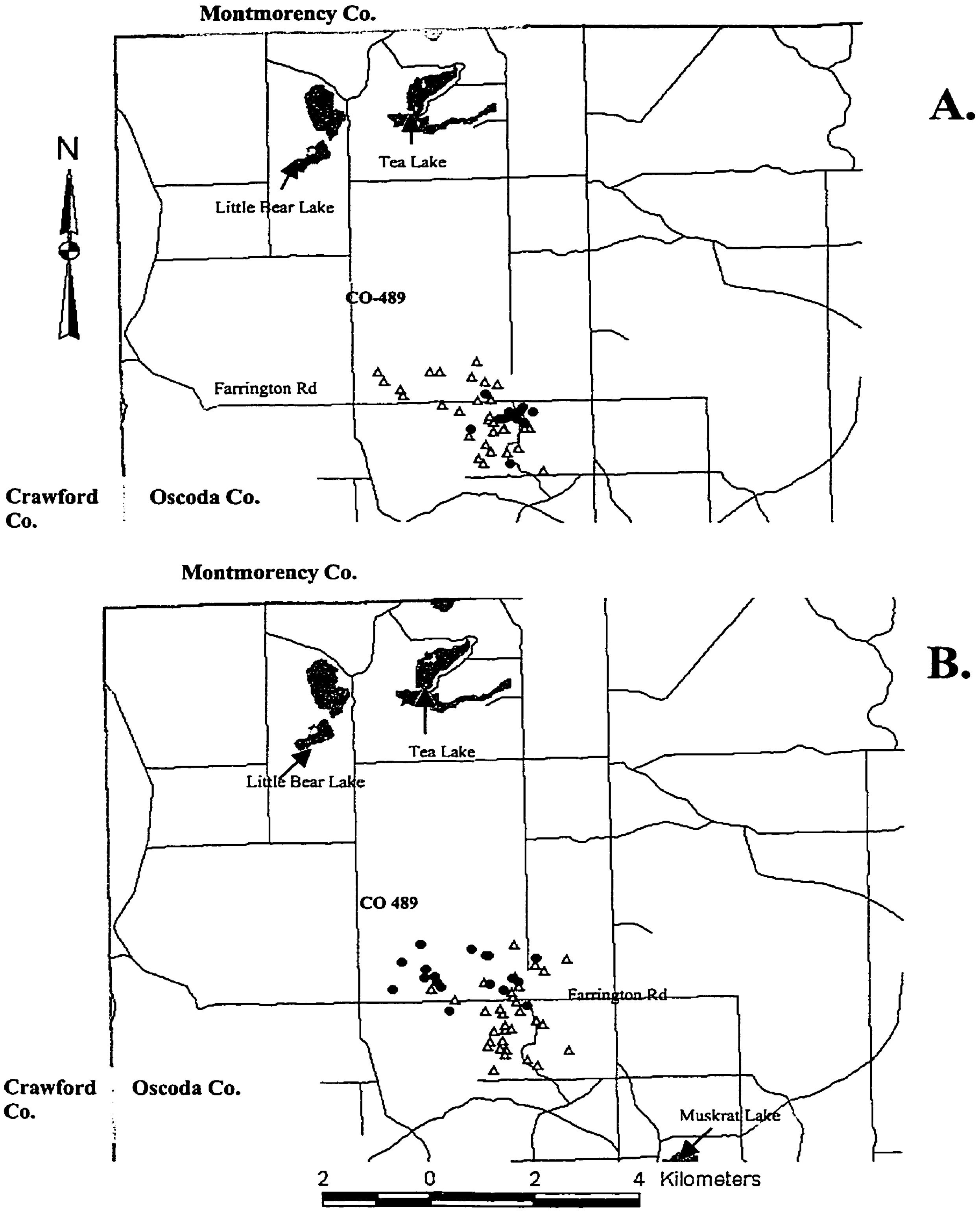


Appendix Figure 25. Point locations for 1.225 (A.) and 1.215 (B.) radio-collared deer.

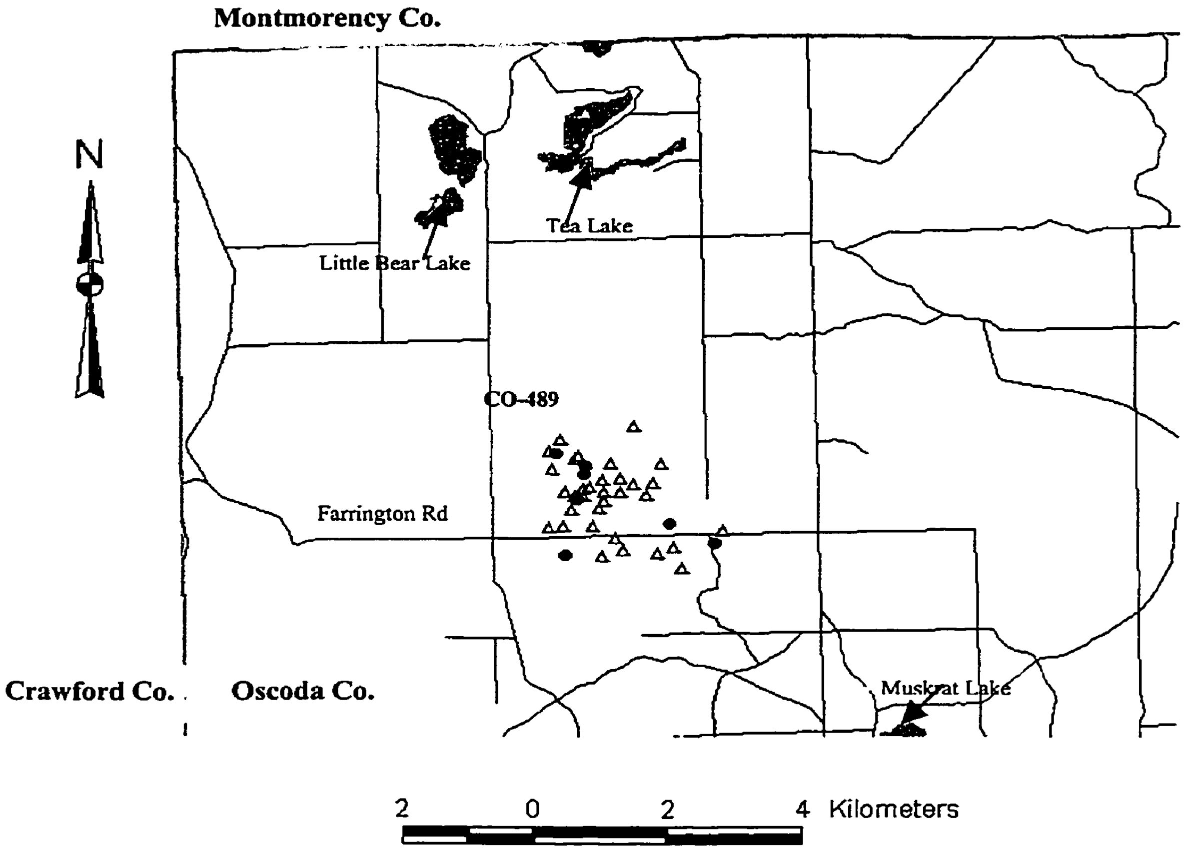


Appendix Figure 26. Point locations for 1.570 (A.) and 1.240 (B.) radio-collared deer..

GARLAND RESORT COMPLEX

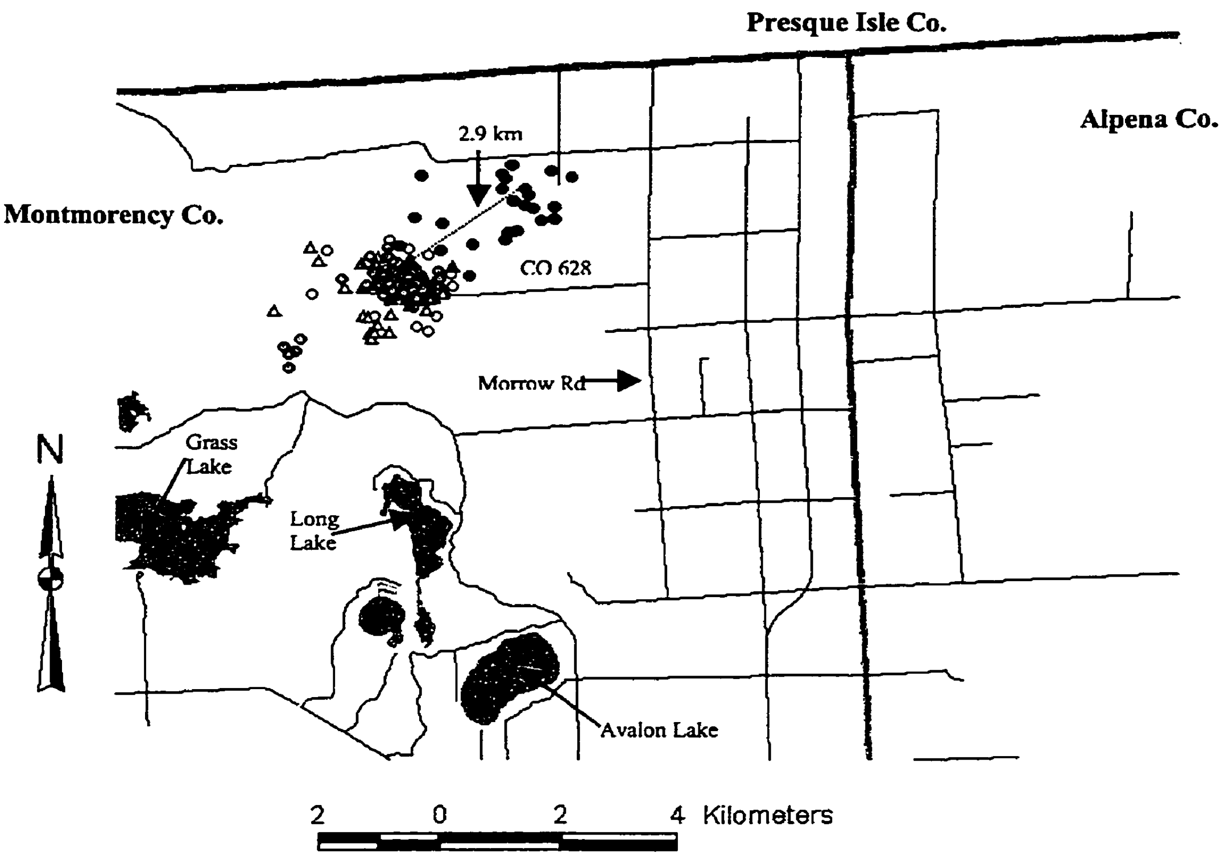


Appendix Figure 27. Point locations for 0.590 (A.) and 1.396 (B.) radio-collared deer.



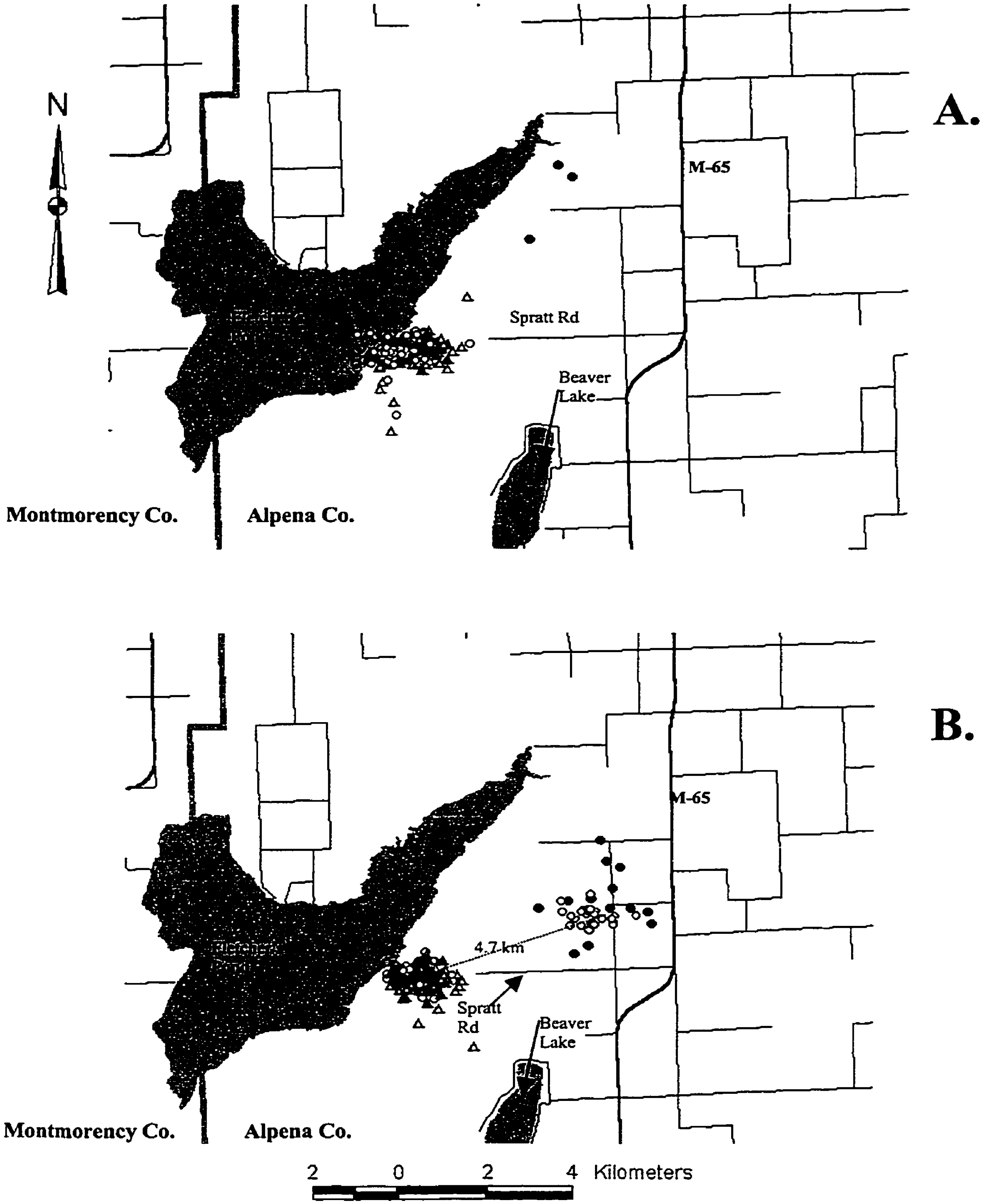
Appendix Figure 28. Point locations for 1.946 a radio-collared deer.

KOENIG'S FARM

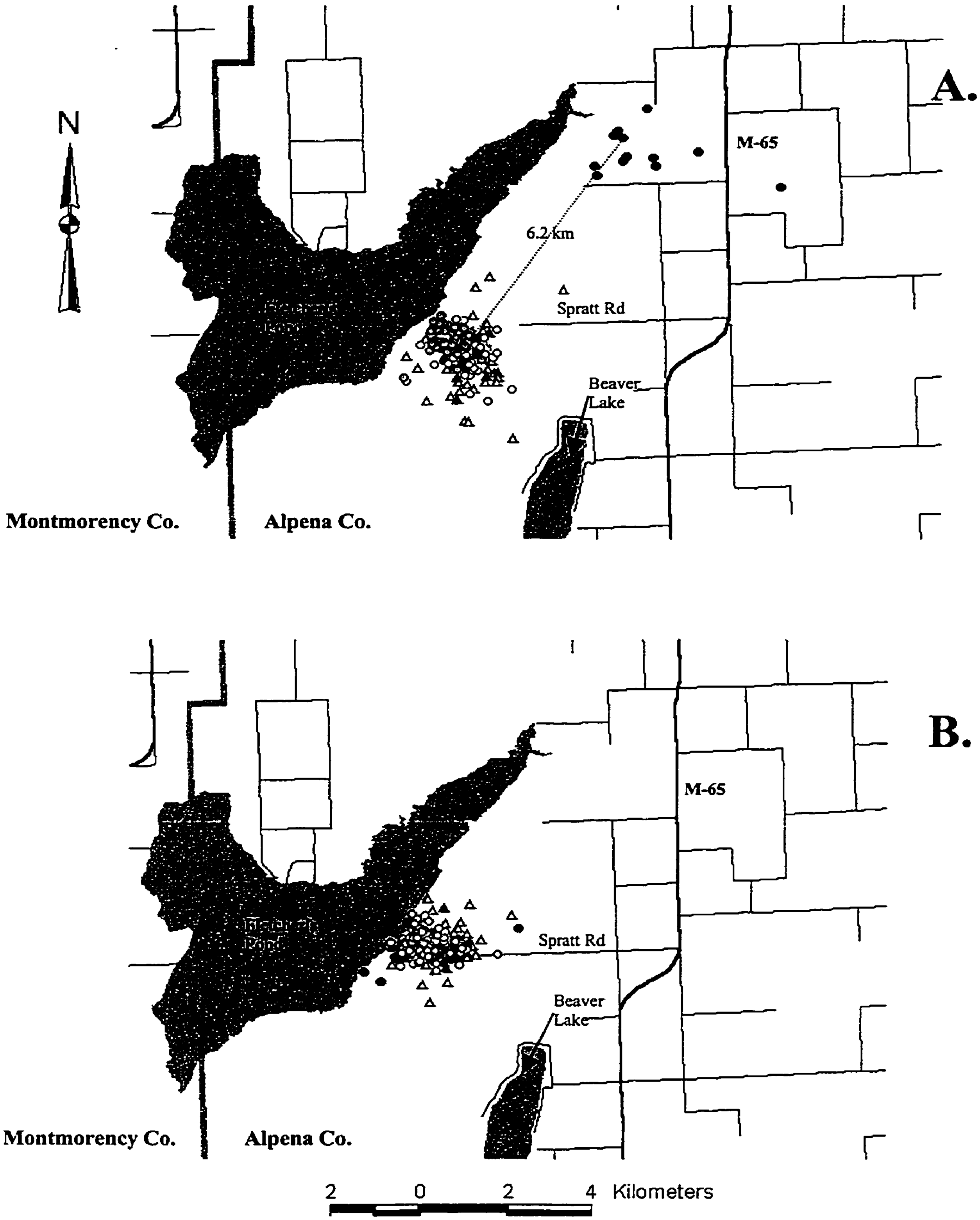


Appendix Figure 29. Point locations for 1.551 a radio-collared deer.

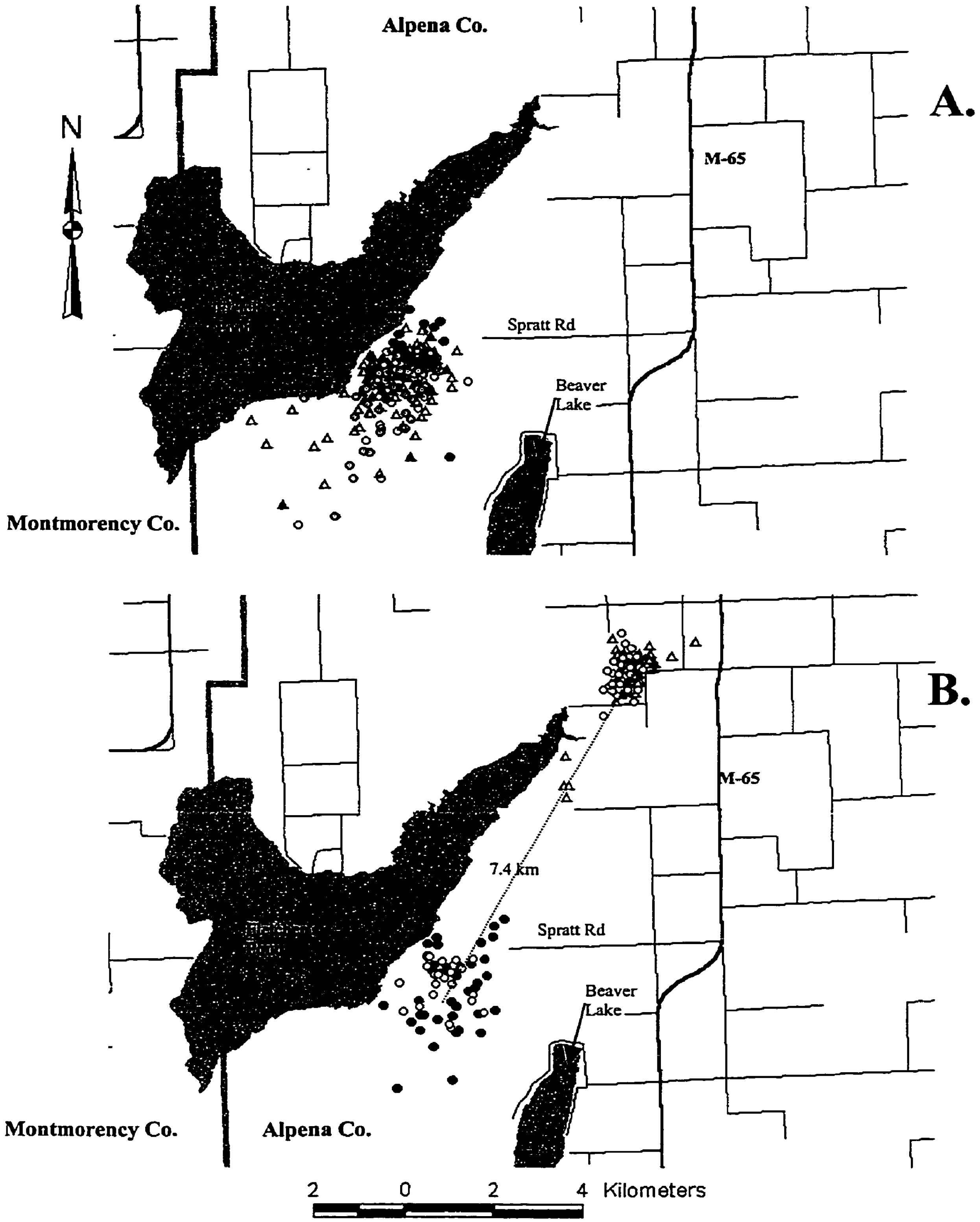
LEROY HUNTING CLUB



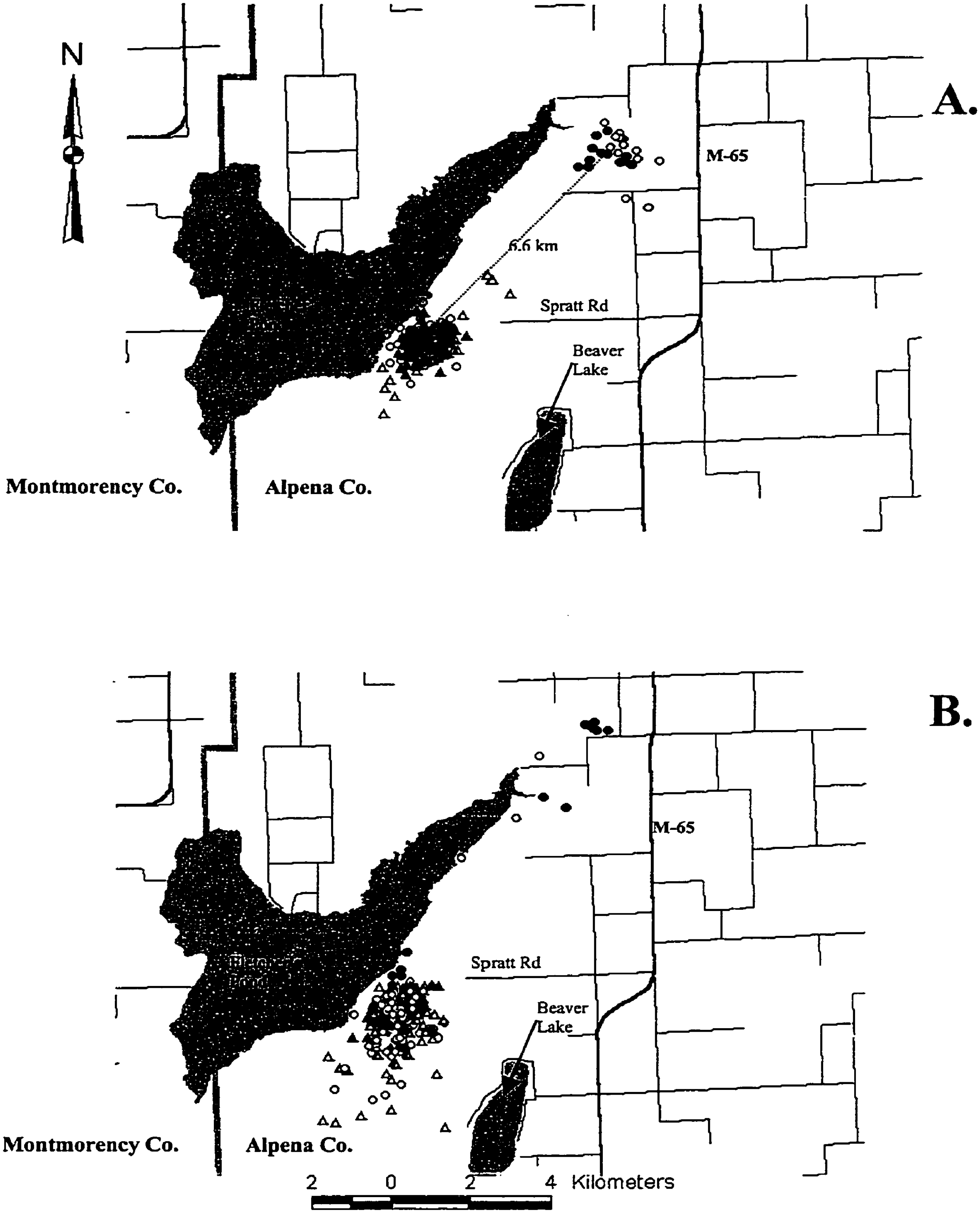
Appendix Figure 30. Point locations for 0.920 (A.) and 1.421 (B.) radio-collared deer.



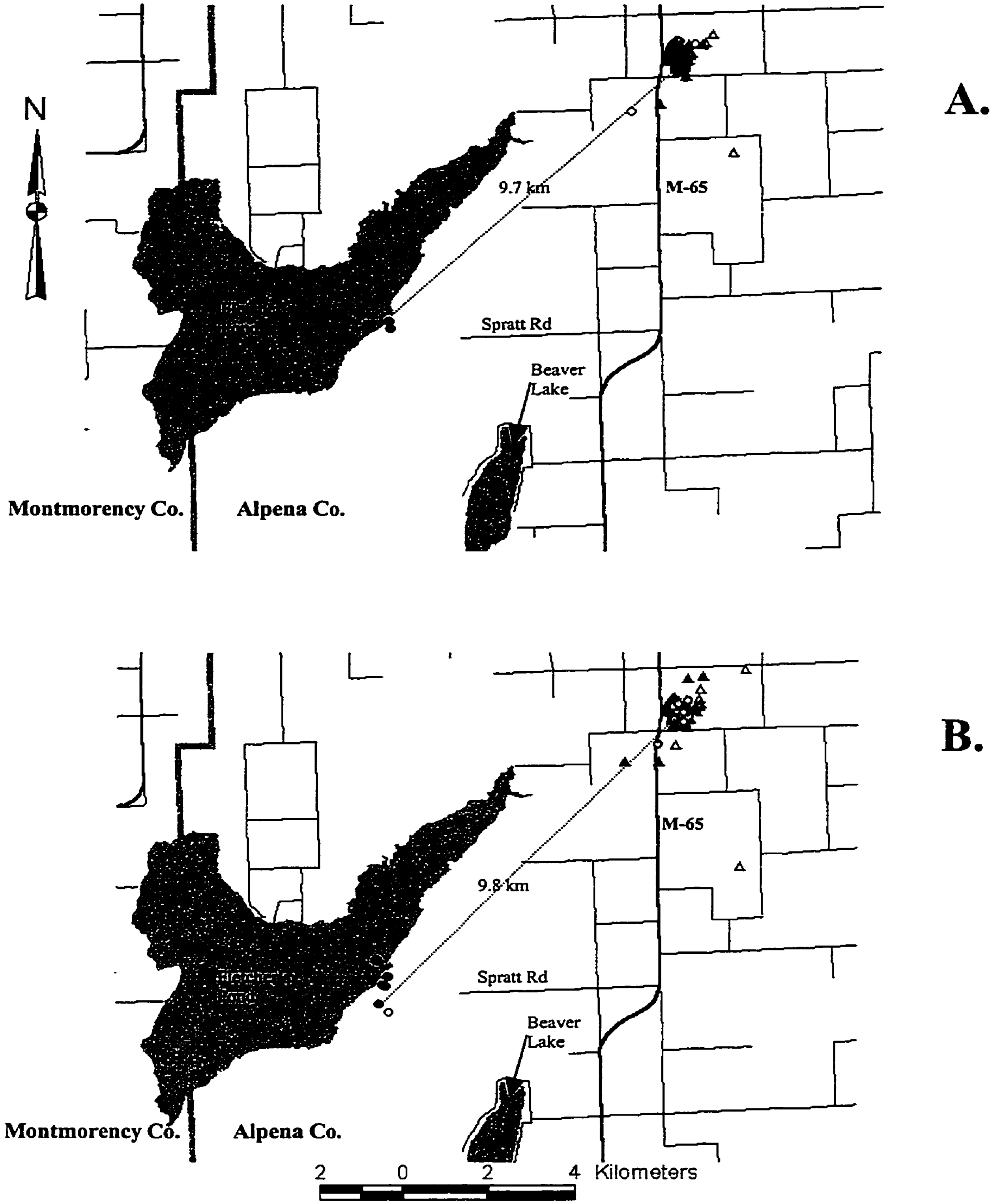
Appendix Figure 31. Point locations for 1.341 (A.) and 1.368 (B.) radio-collared deer.



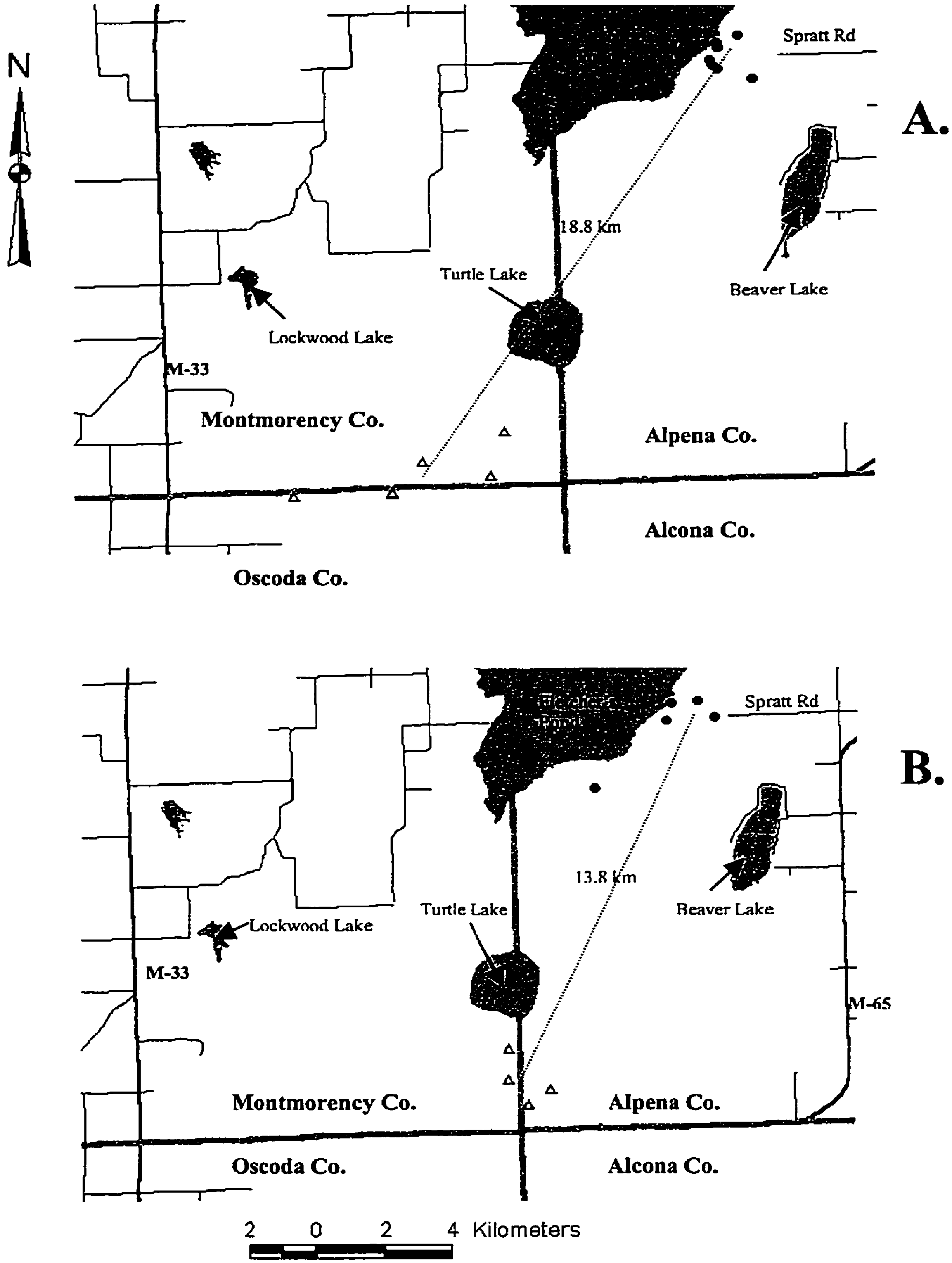
Appendix Figure 32. Point locations for 1.612 (A.) and 1.622 (B.) radio-collared deer.



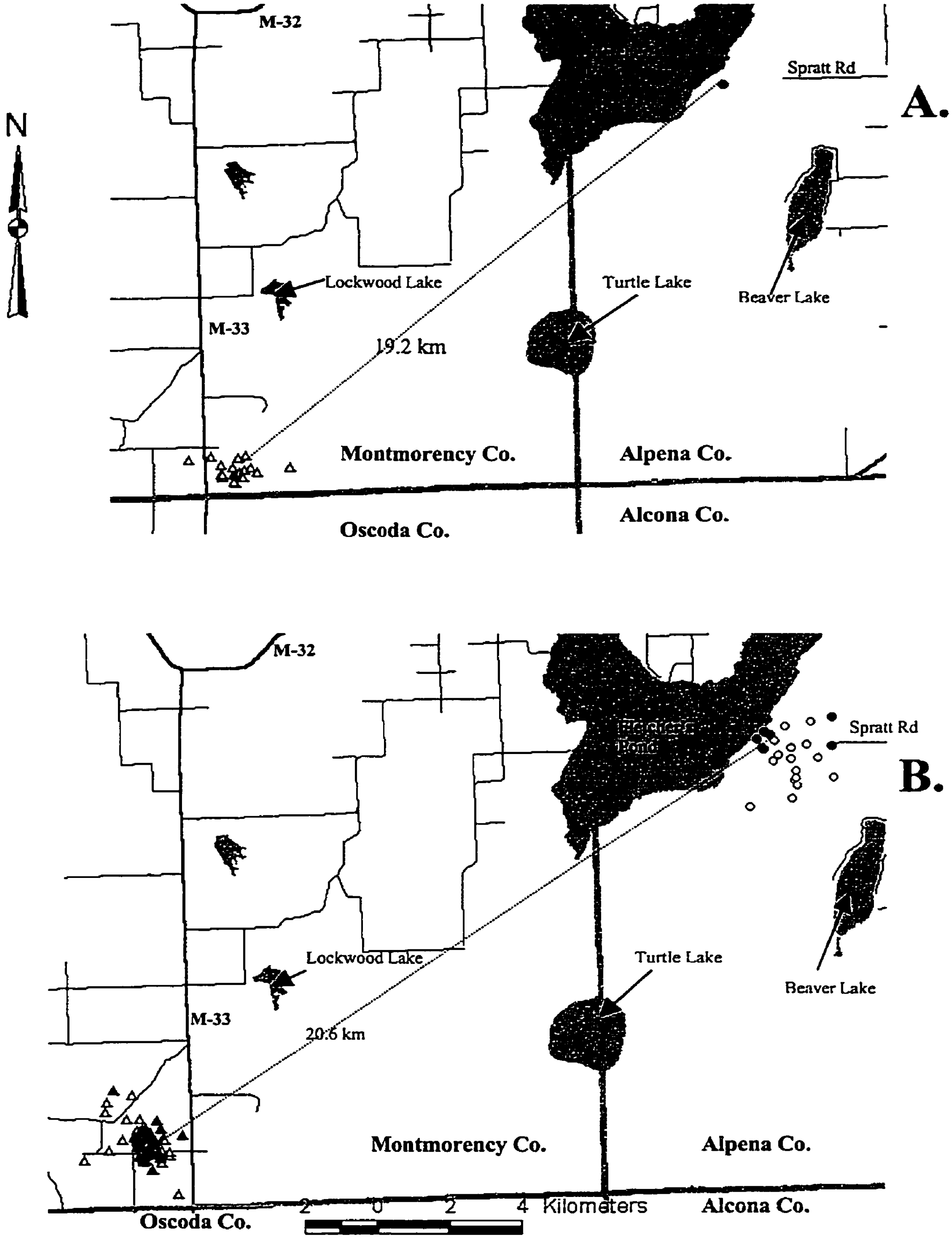
Appendix Figure 33. Point locations for 0.501 (A.) and 0.611 (B.) radio-collared deer.



Appendix Figure 34. Point locations for 1.212 (A.) and 1.232 (B.) radio-collared deer.

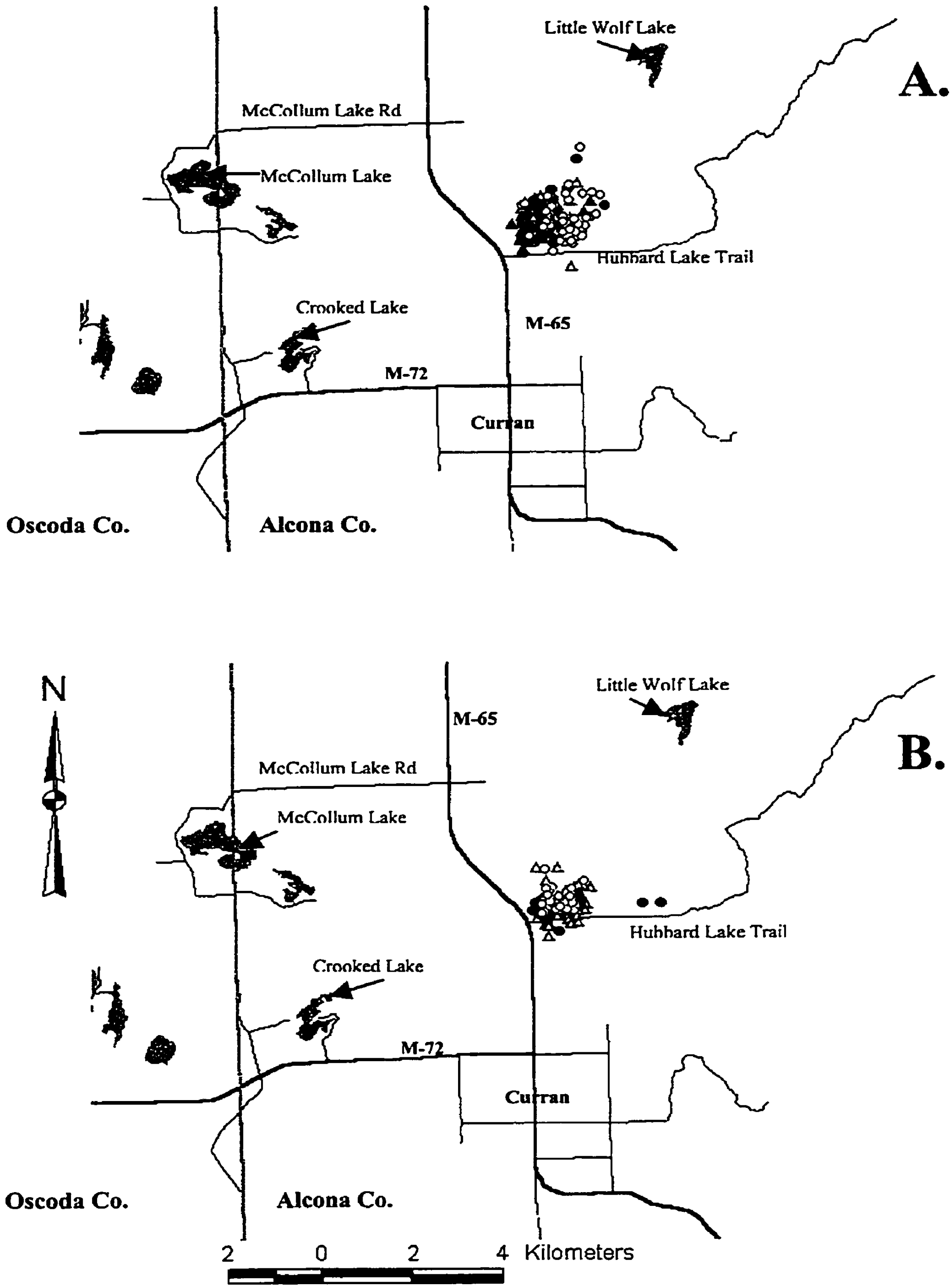


Appendix Figure 35. Point locations for 1.356 (A.) and 1.725 (B.) radio-collared deer.

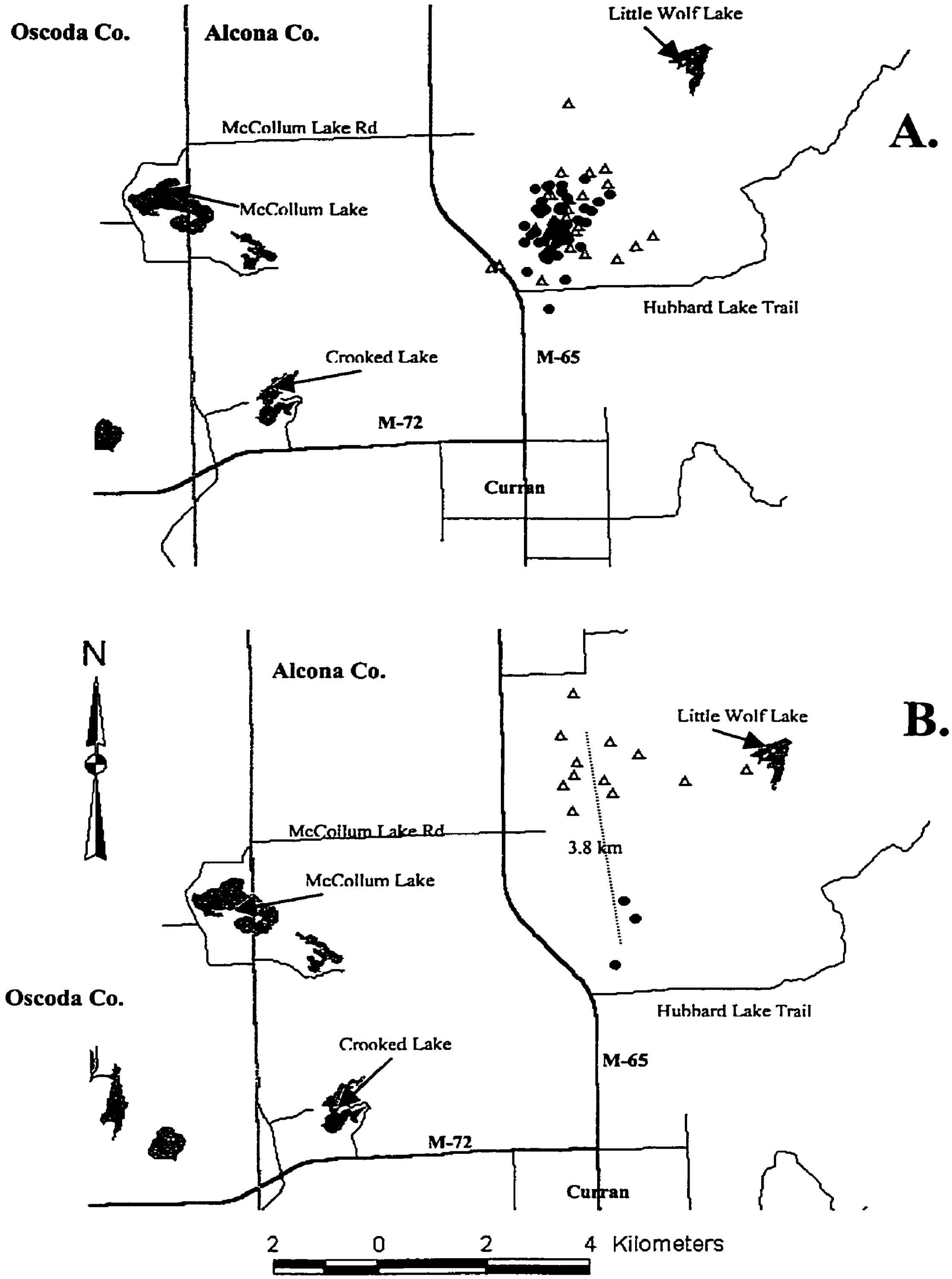


Appendix Figure 36. Point locations for 0.542 (A.) and 1.472 (B.) radio-collared deer.

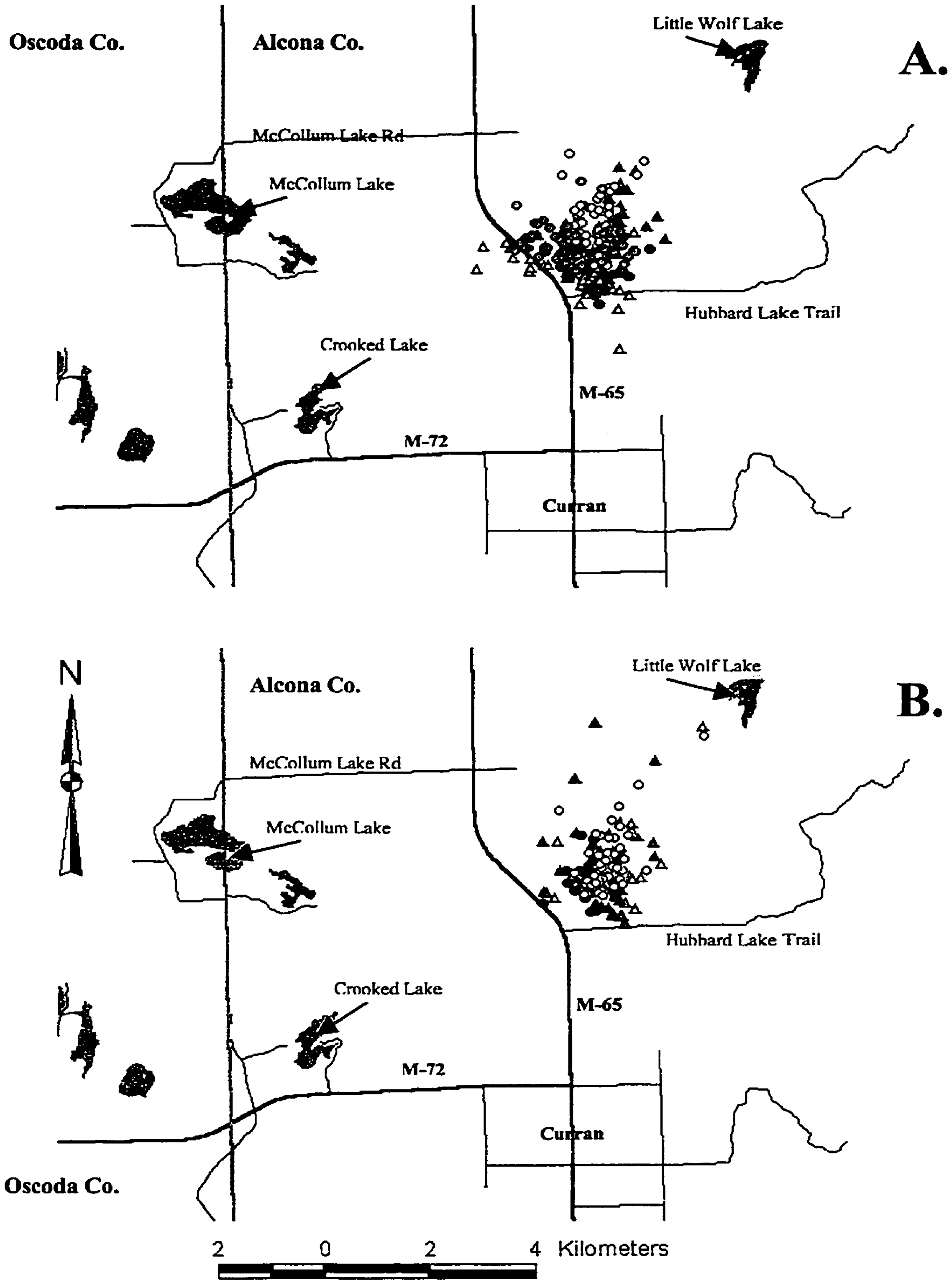
LIPPERT'S (NORTH FORK RANCH)



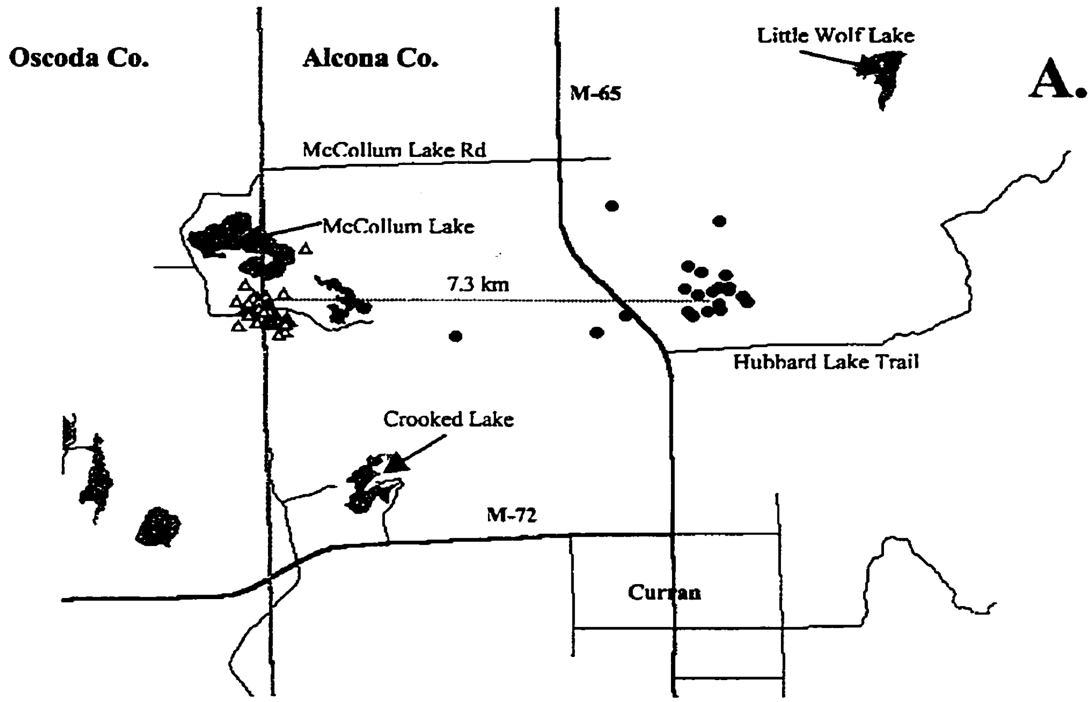
Appendix Figure 37. Point locations for 1.235 (A.) and 1.541 (B.) radio-collared deer.

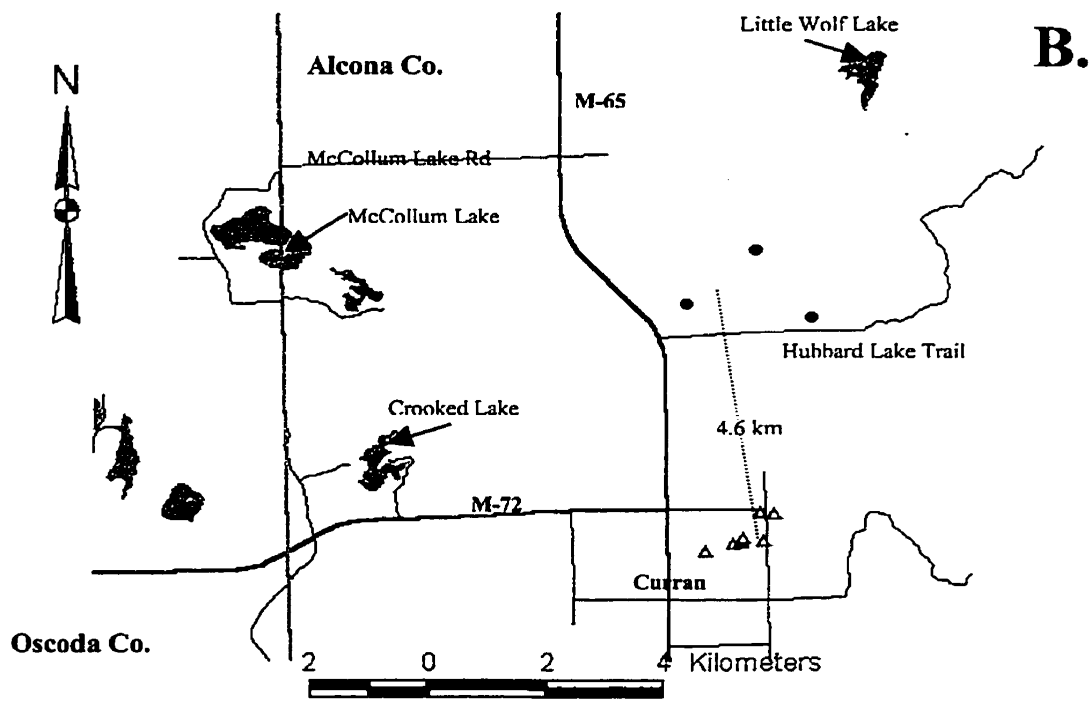


Appendix Figure 38. Point locations for 0.640 (A.) and 1.286 (B.) radio-collared deer.

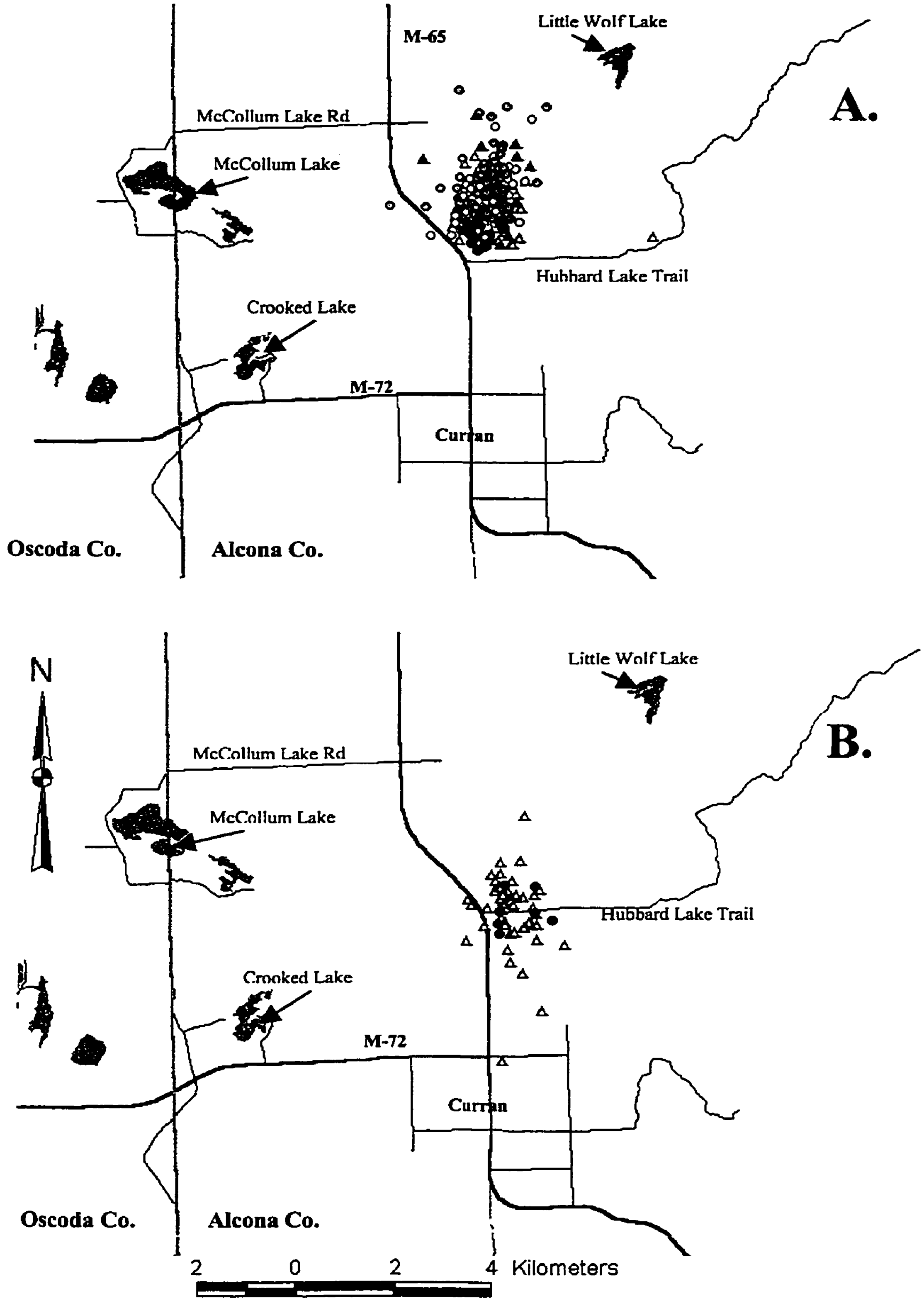


Appendix Figure 39. Point locations for 0.992 (A.) and 1.936 (B.) radio-collared deer.

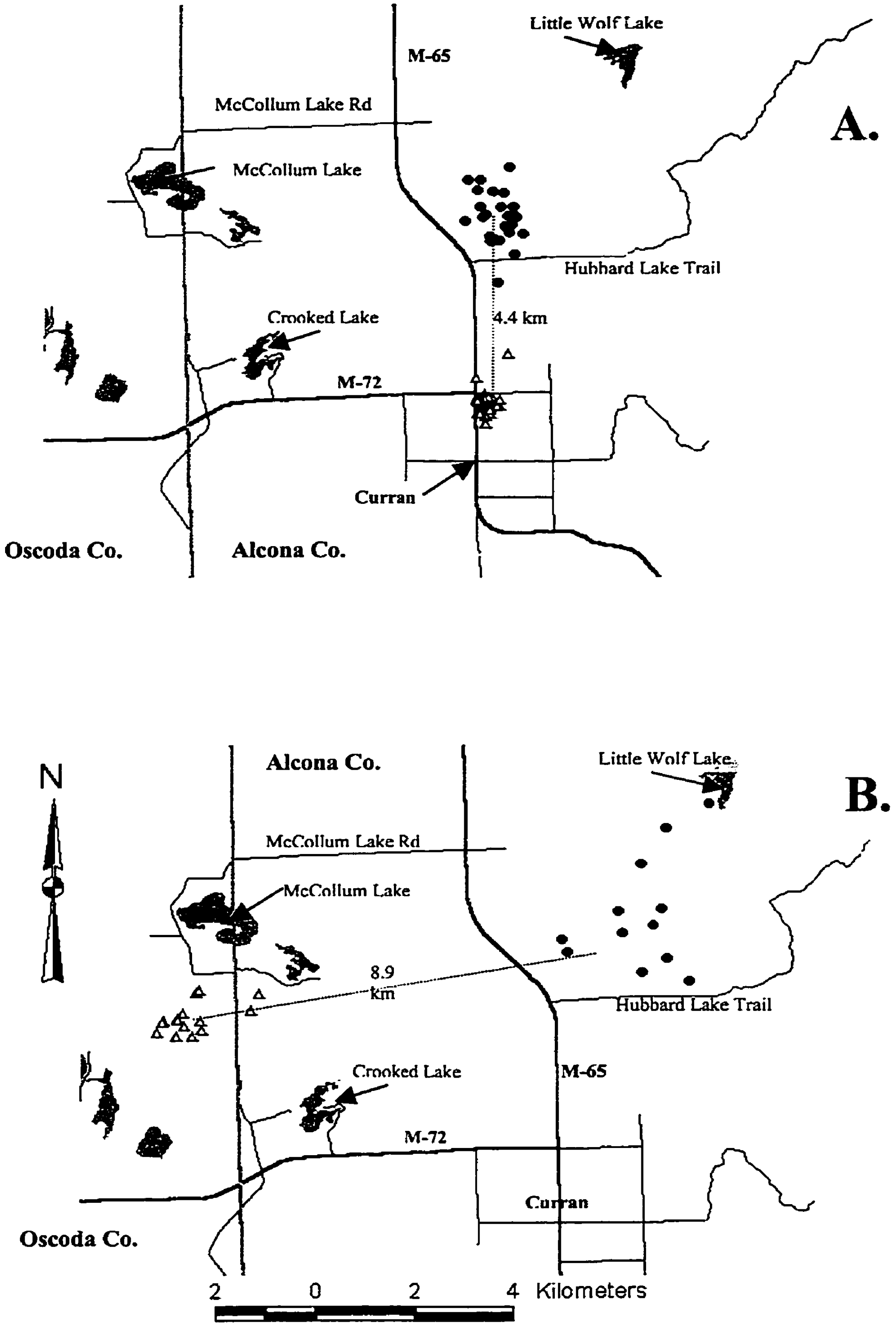




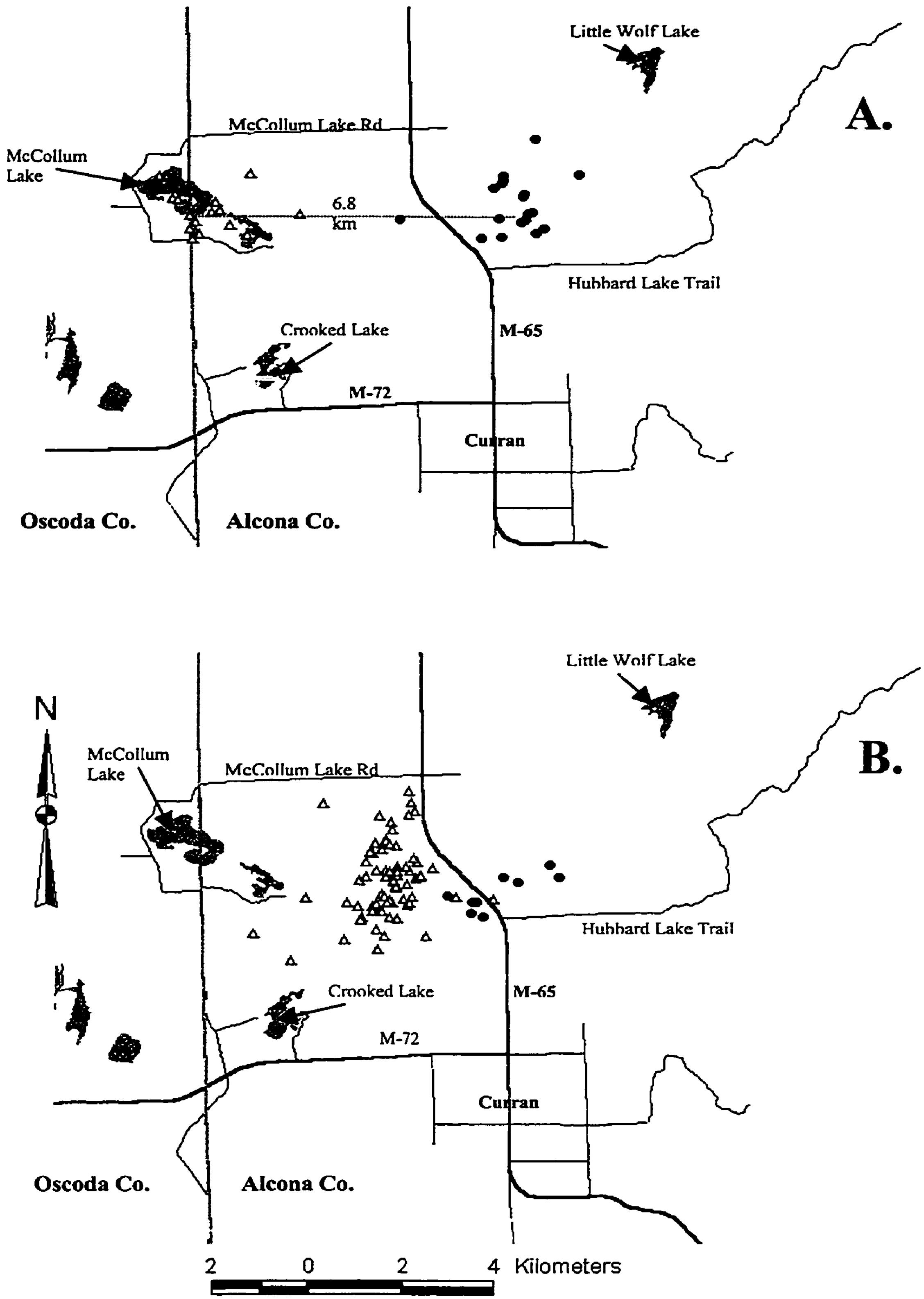
Appendix Figure 40. Point locations for 1.502 (A.) and 1.313 (B.) radio-collared deer.



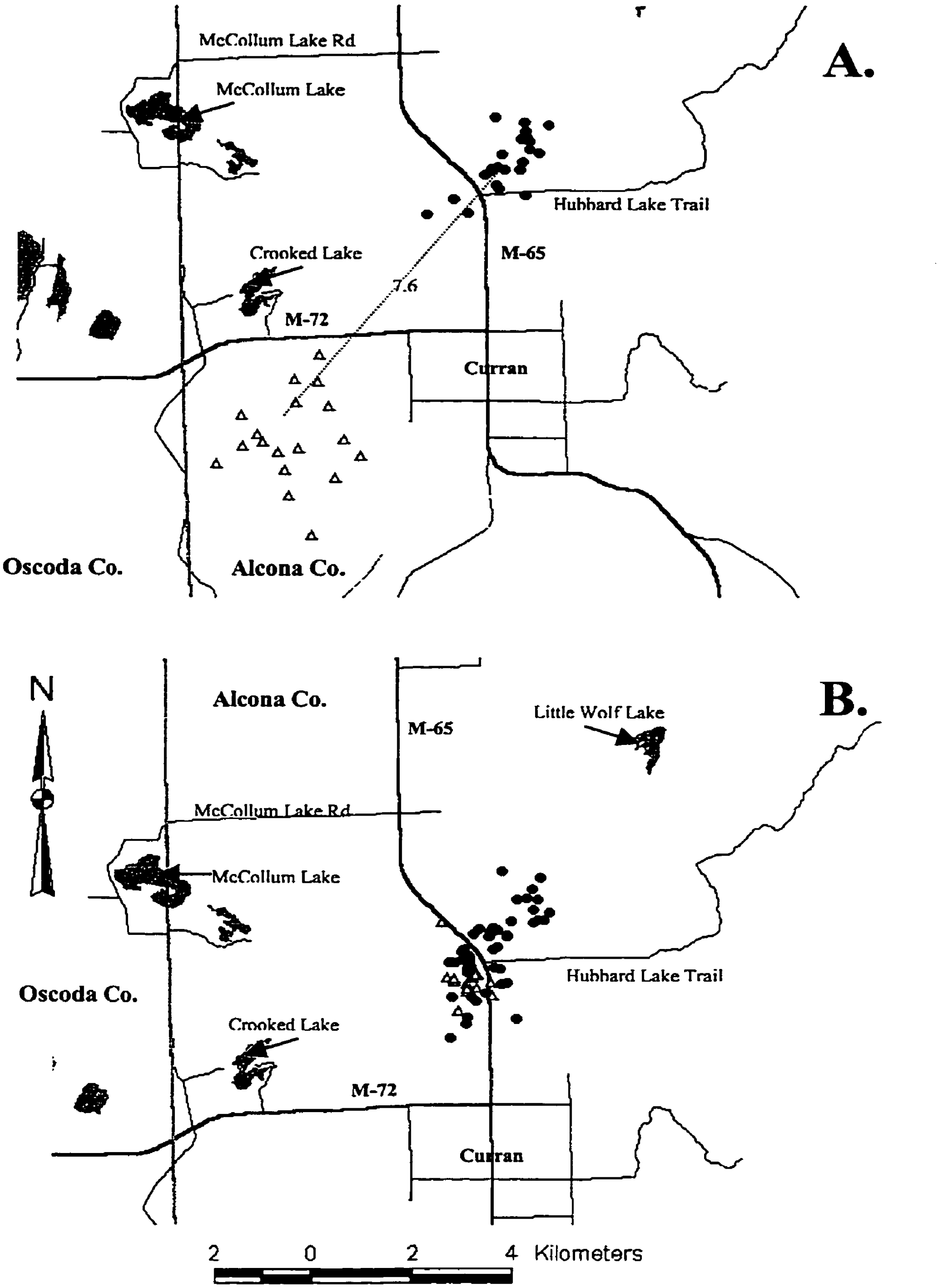
Appendix Figure 41. Point locations for 1.192 (A.) and 1.221 (B.) radio-collared deer.



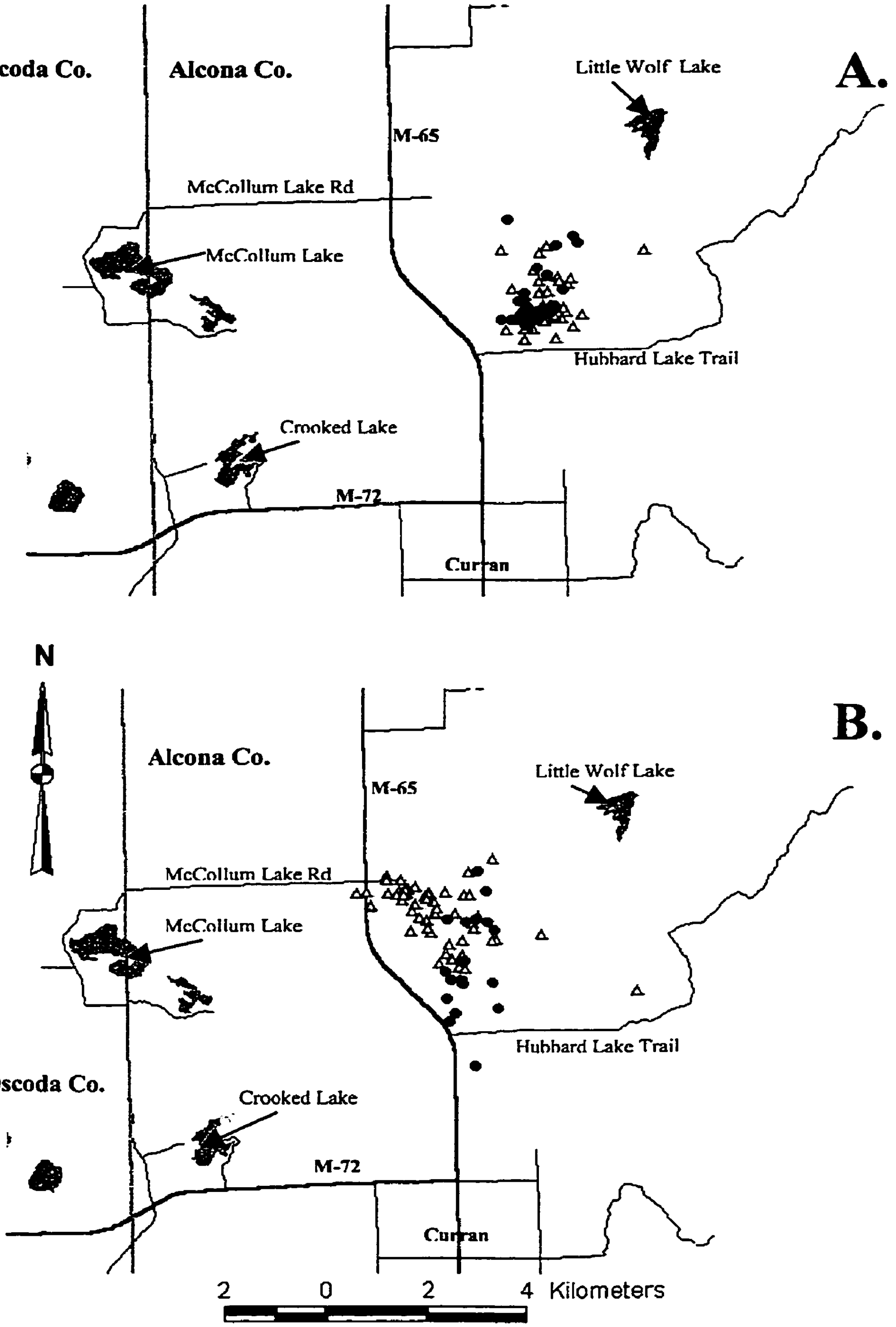
Appendix Figure 42. Point locations for 1.375 (A.) and 1.915 (B.) radio-collared deer.



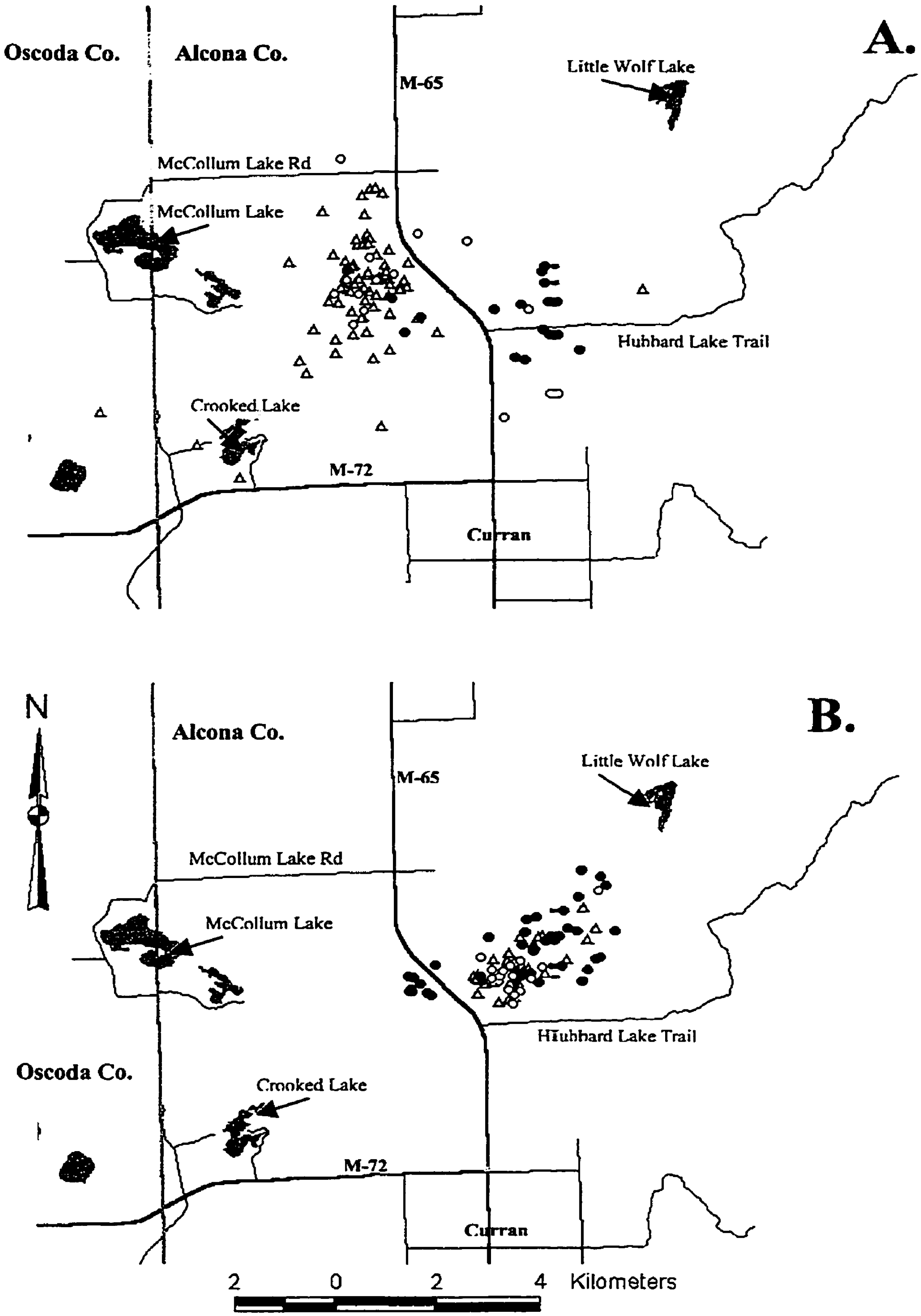
Appendix Figure 43. Point locations for 1.571 (A.) and 1.947 (B.) radio-collared deer.



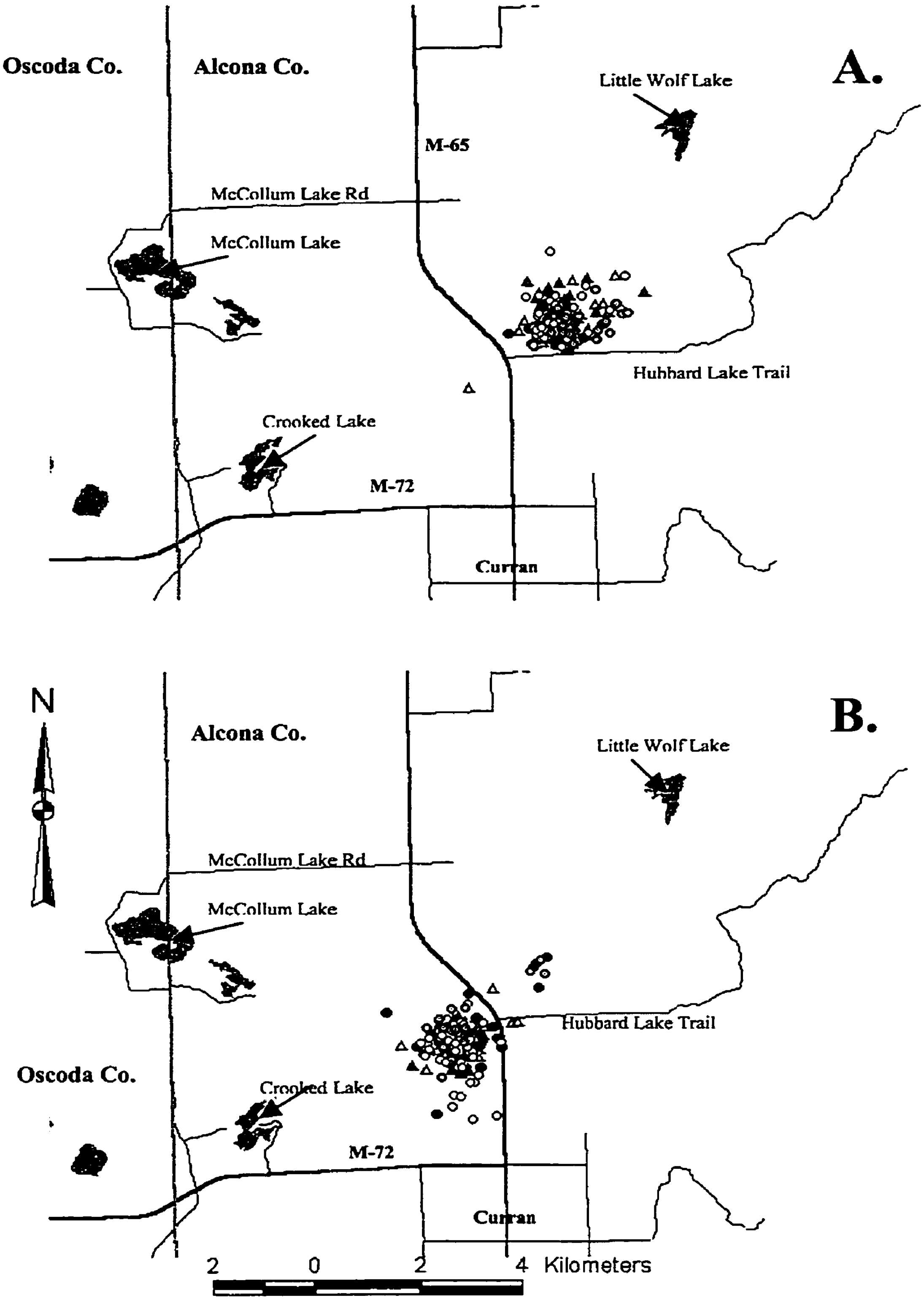
Appendix Figure 44. Point locations for 0.372 (A.) and 1.170 (B.) radio-collared deer.



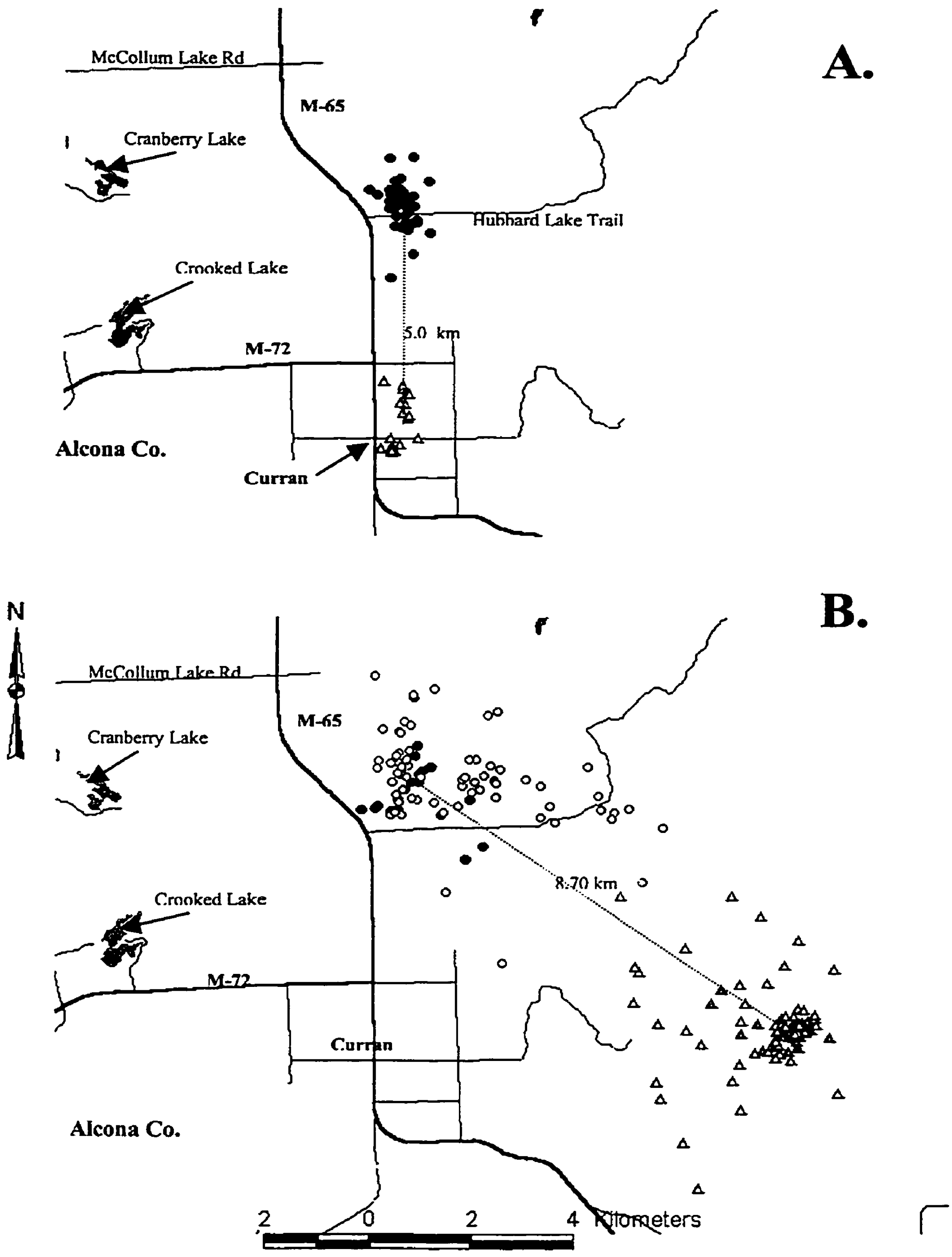
Appendix Figure 45. Point locations for 0.590 (A.) and 0.595 (B.) radio-collared deer.



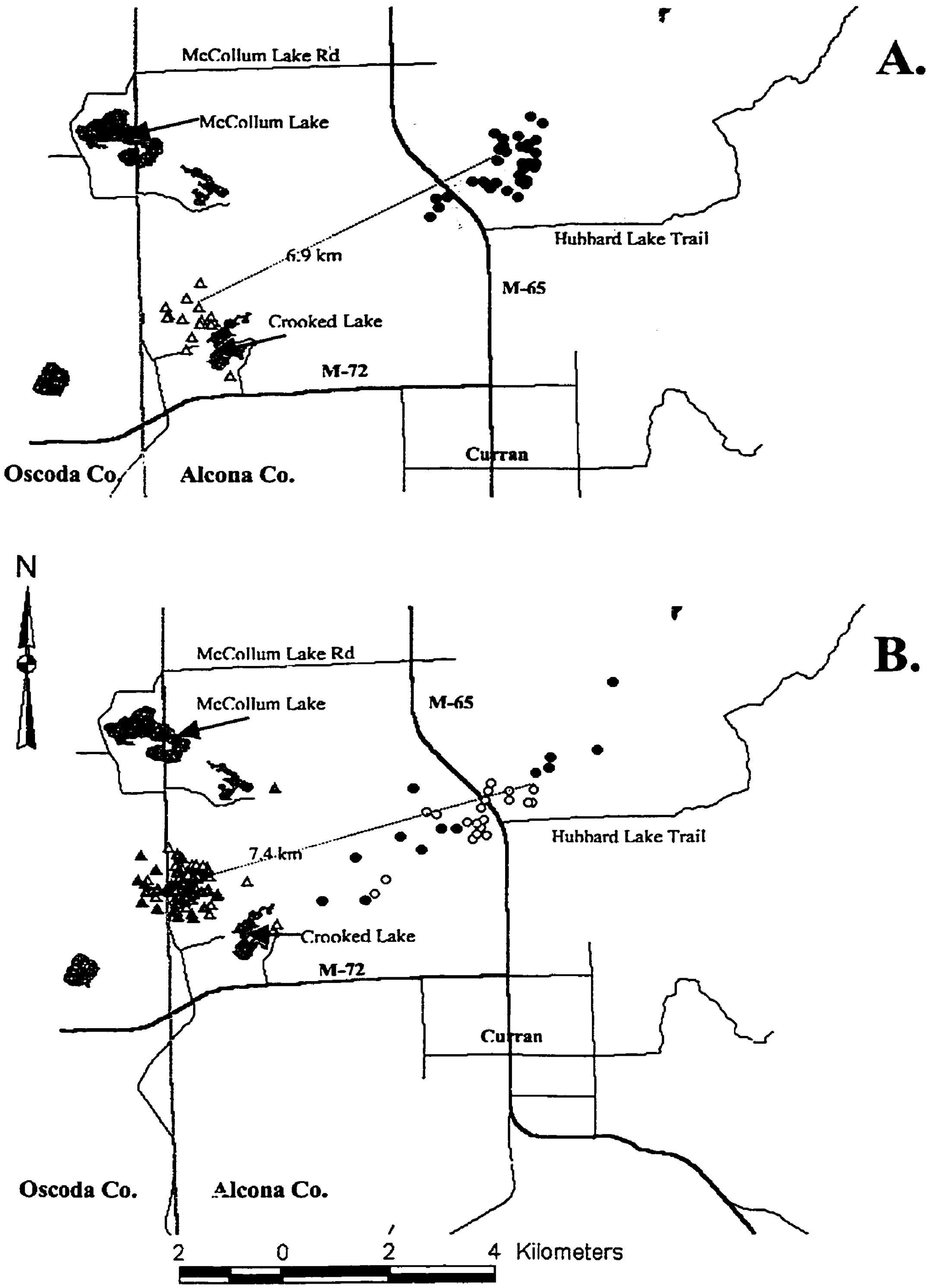
Appendix Figure 46. Point locations for 0.421 (A.) and 0.422 (B.) radio-collared deer.



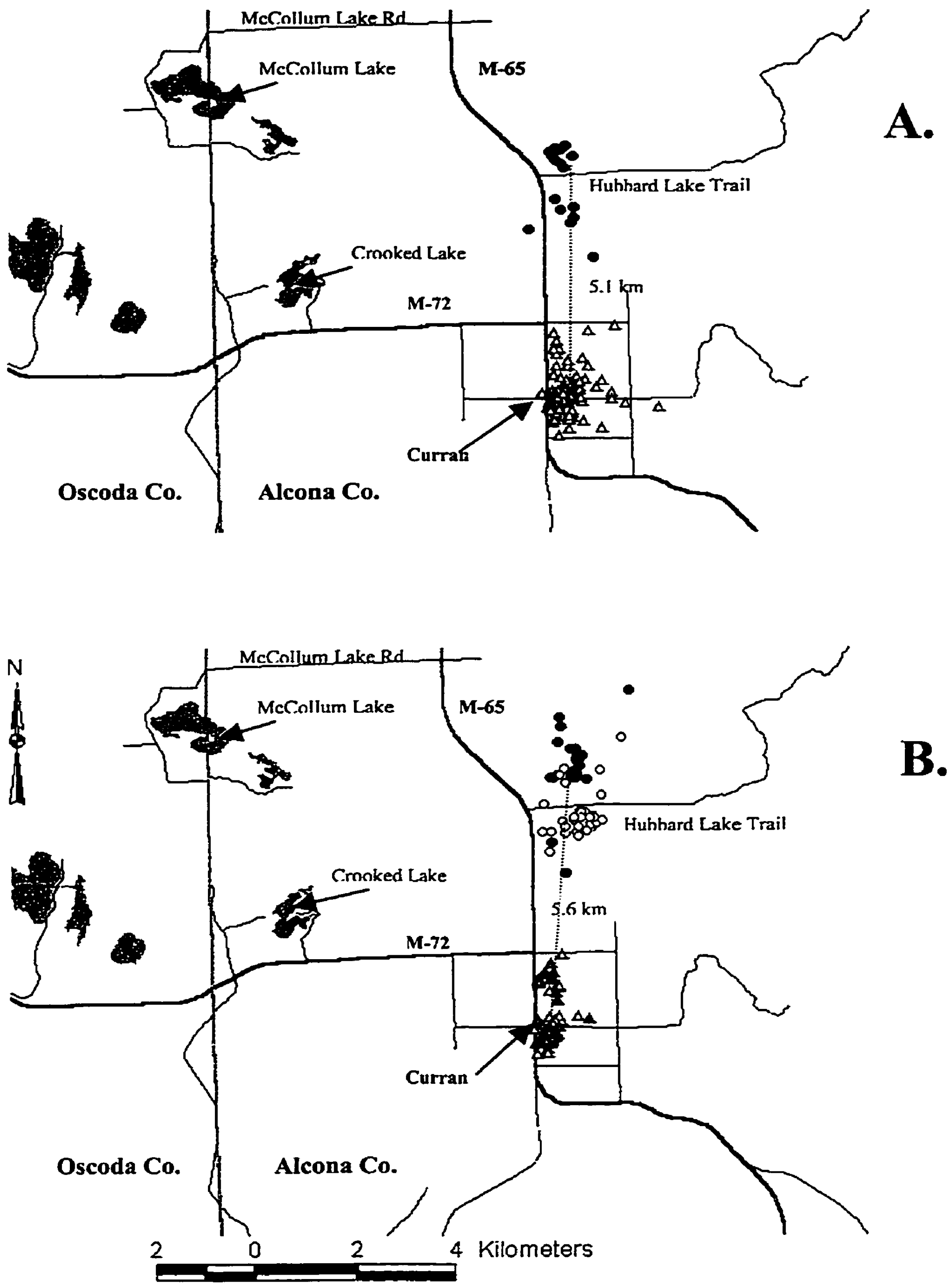
Appendix Figure 47. Point locations for 0.622 (A.) and 0.680 (B.) radio-collared deer.



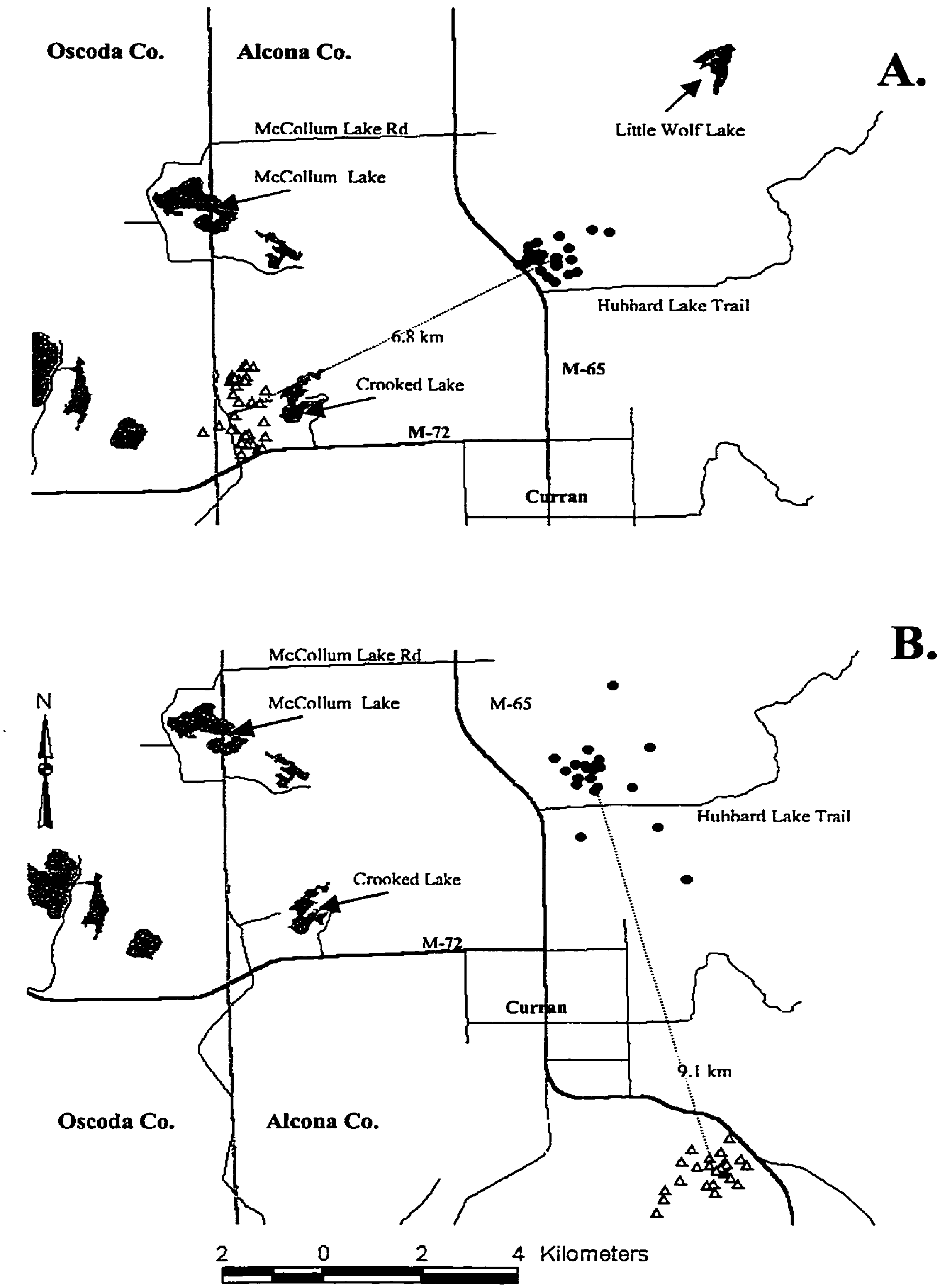
Appendix Figure 48. Point locations for 1.370 (A.) and 0.942 (B.) radio-collared deer.



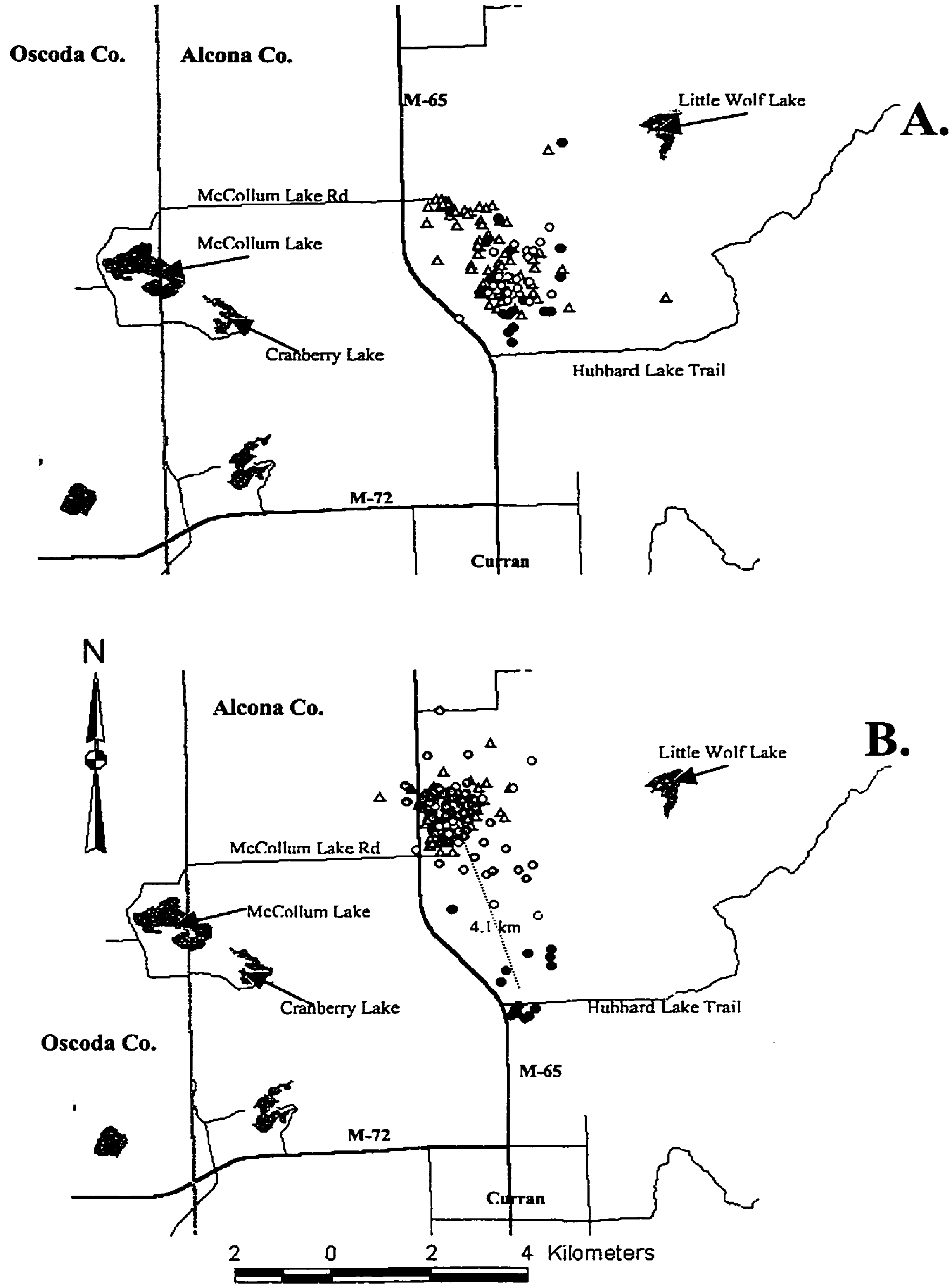
Appendix Figure 49. Point locations for 0.875 (A.) and 1.095 (B.) radio-collared deer.



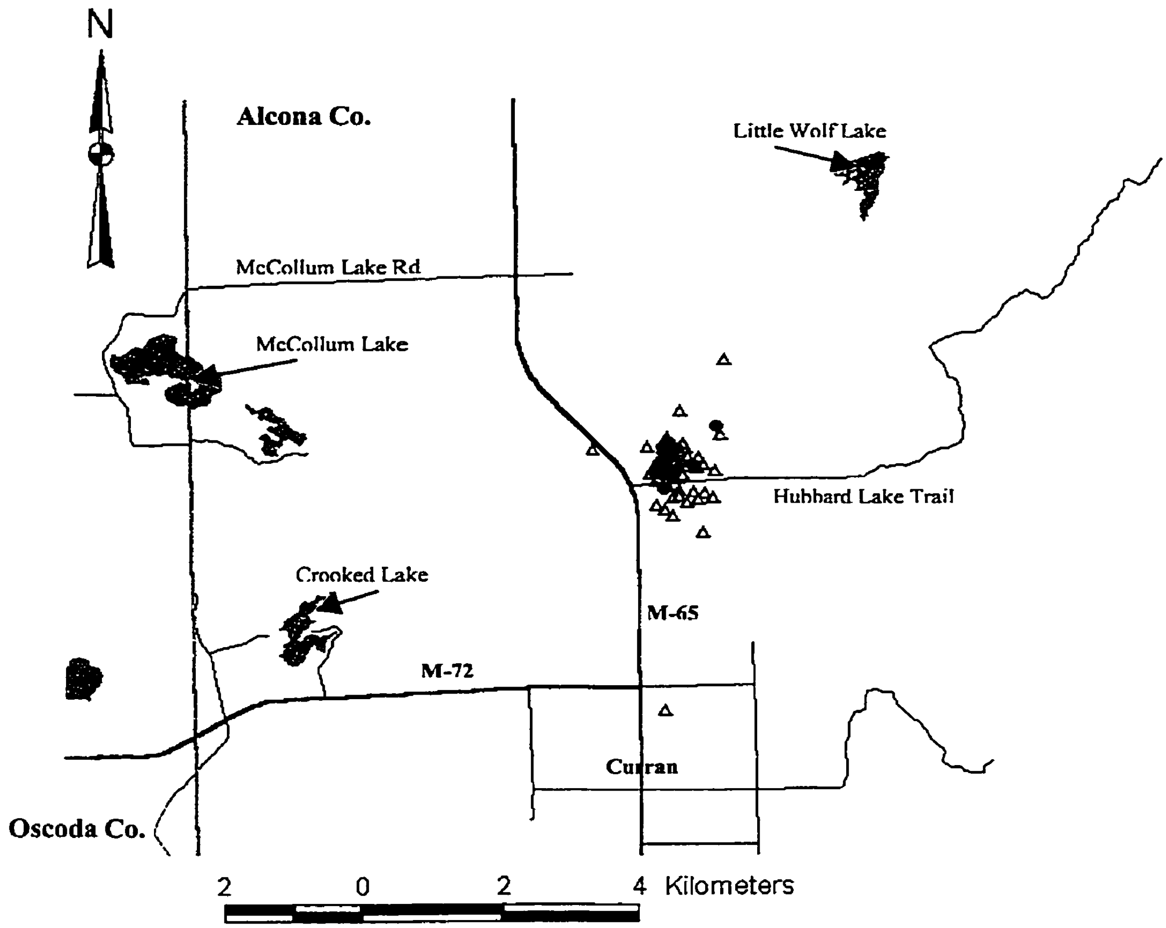
Appendix Figure 50. Point locations for 0.390 (A.) and 1.405 (B.) radio-collared deer.



Appendix Figure 51. Point locations for 1.285 (A.) and 1.171 (B.) radio-collared deer.

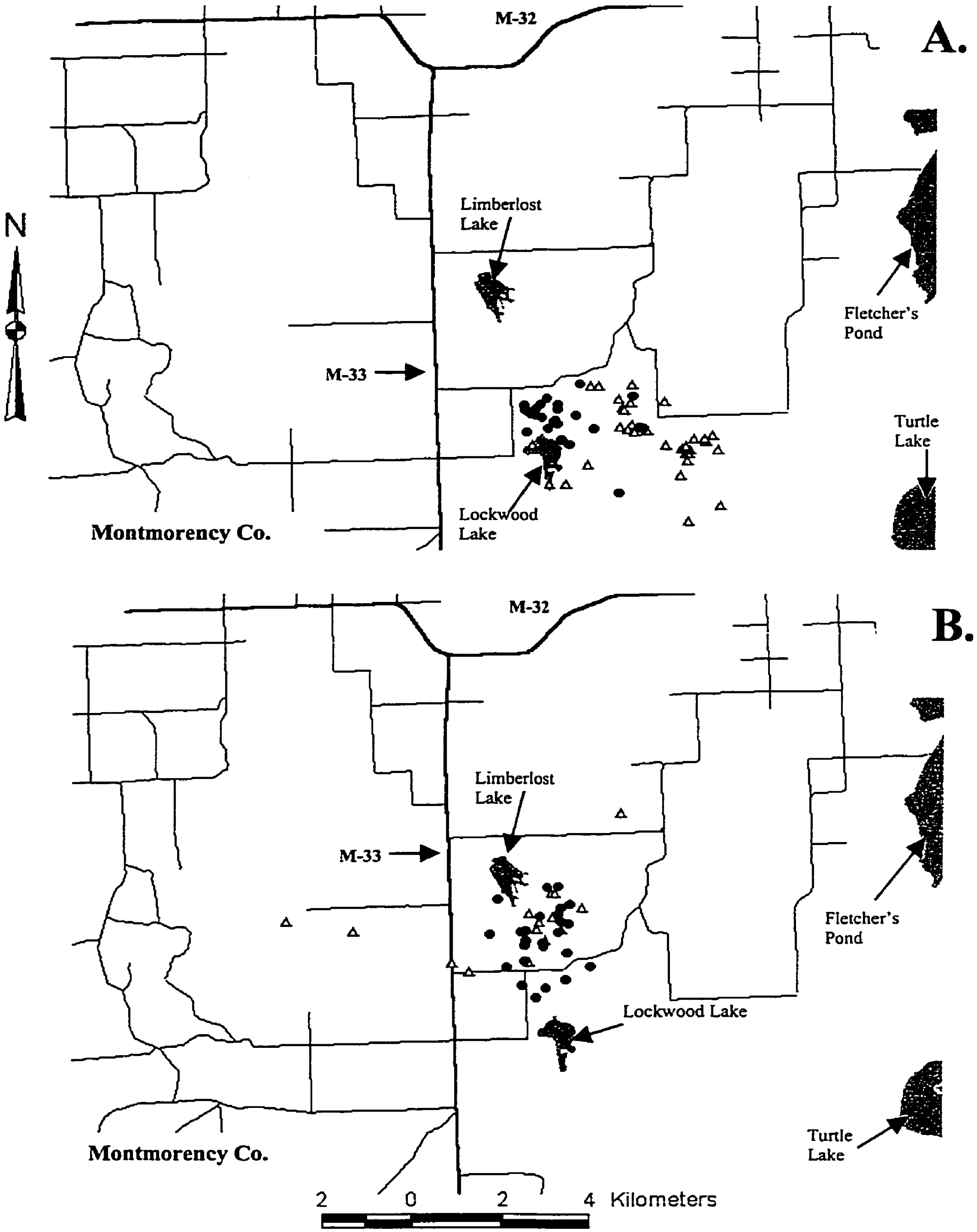


Appendix Figure 52. Point locations for 0.912 (A.) and 1.184 (B.) radio-collared deer.

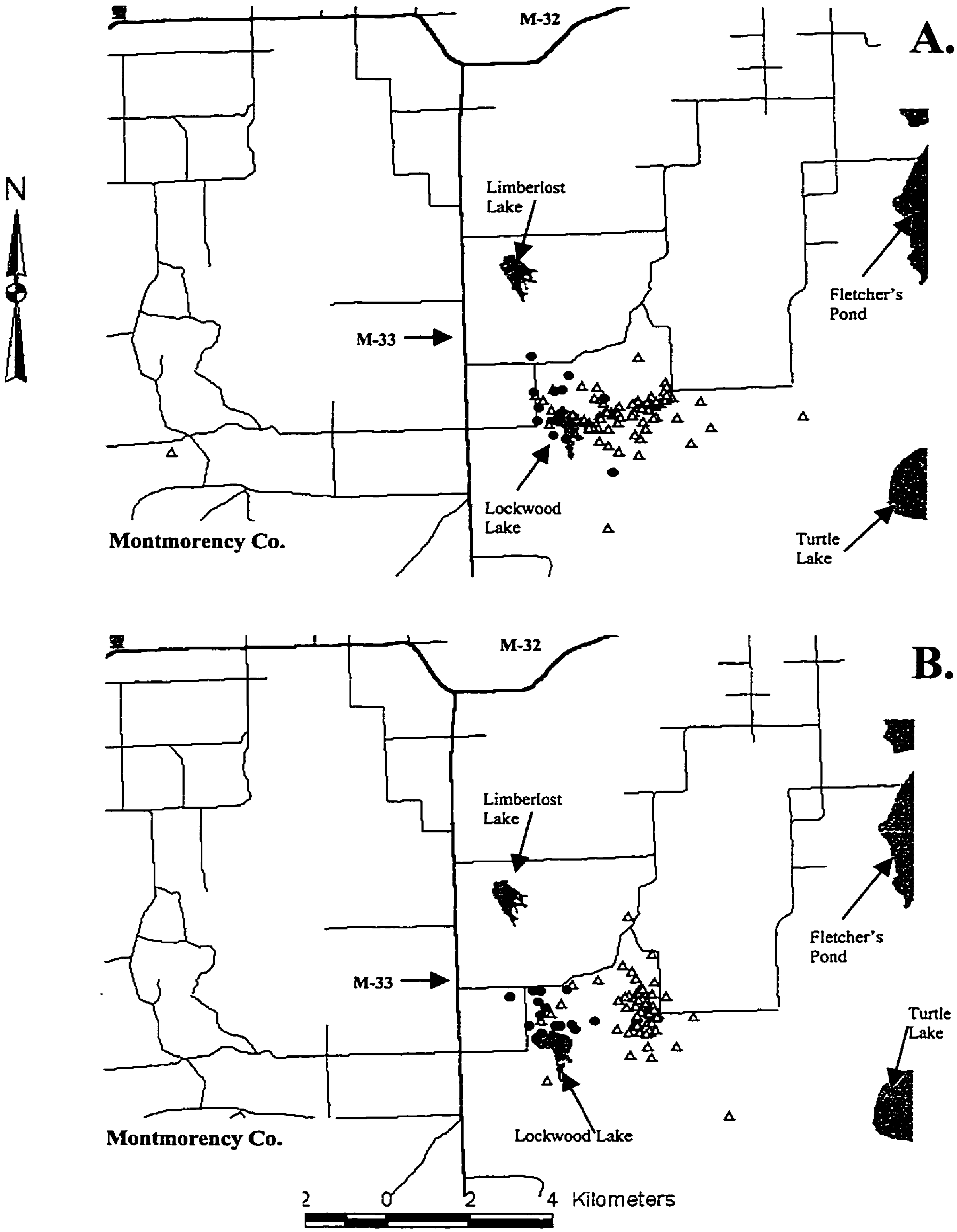


Appendix Figure 53. Point locations for 1.033 a radio-collared deer.

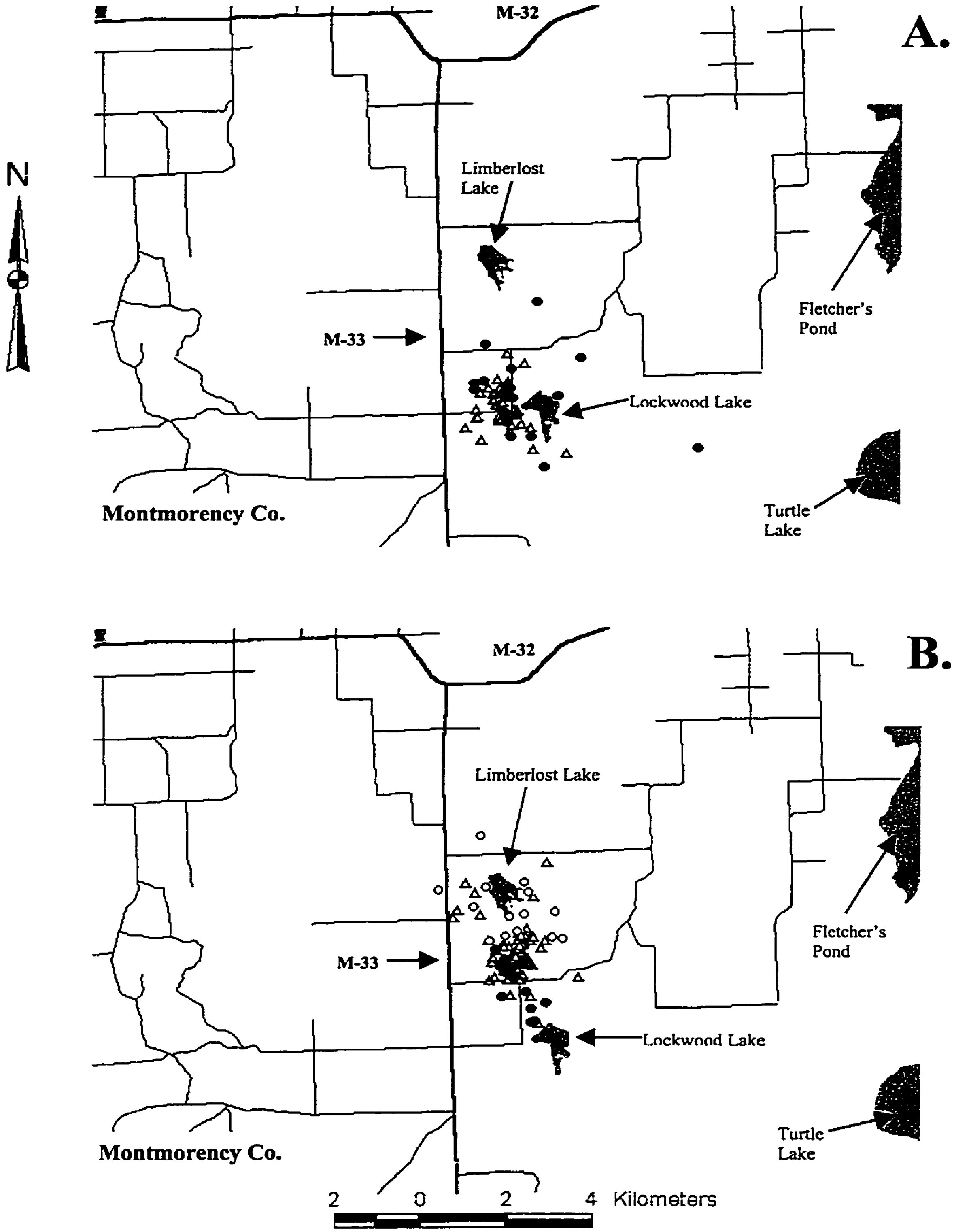
LOCKWOOD LAKE RANCH



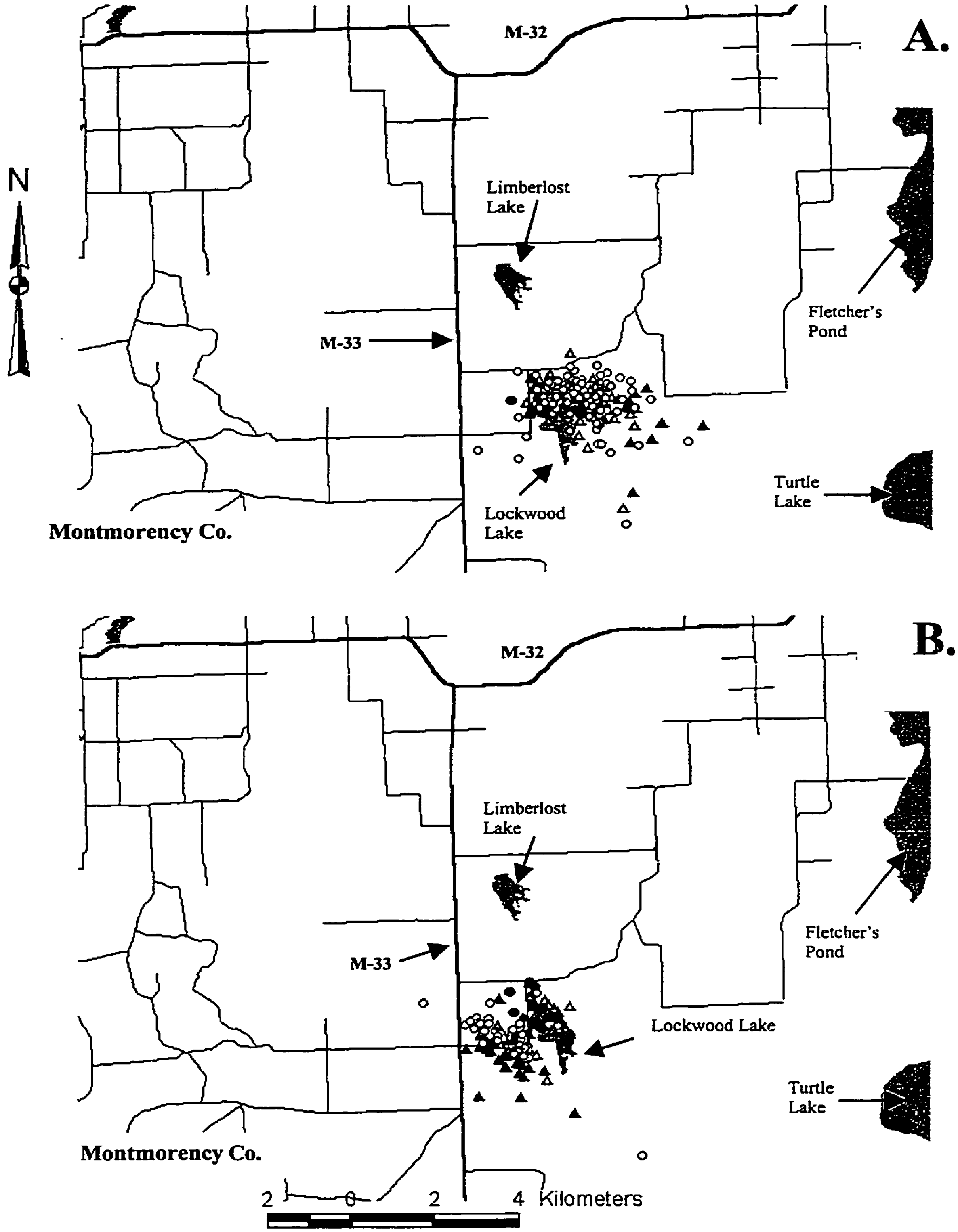
Appendix Figure 54. Point locations for 1.215 (A.) and 1.240 (B.) radio-collared deer.



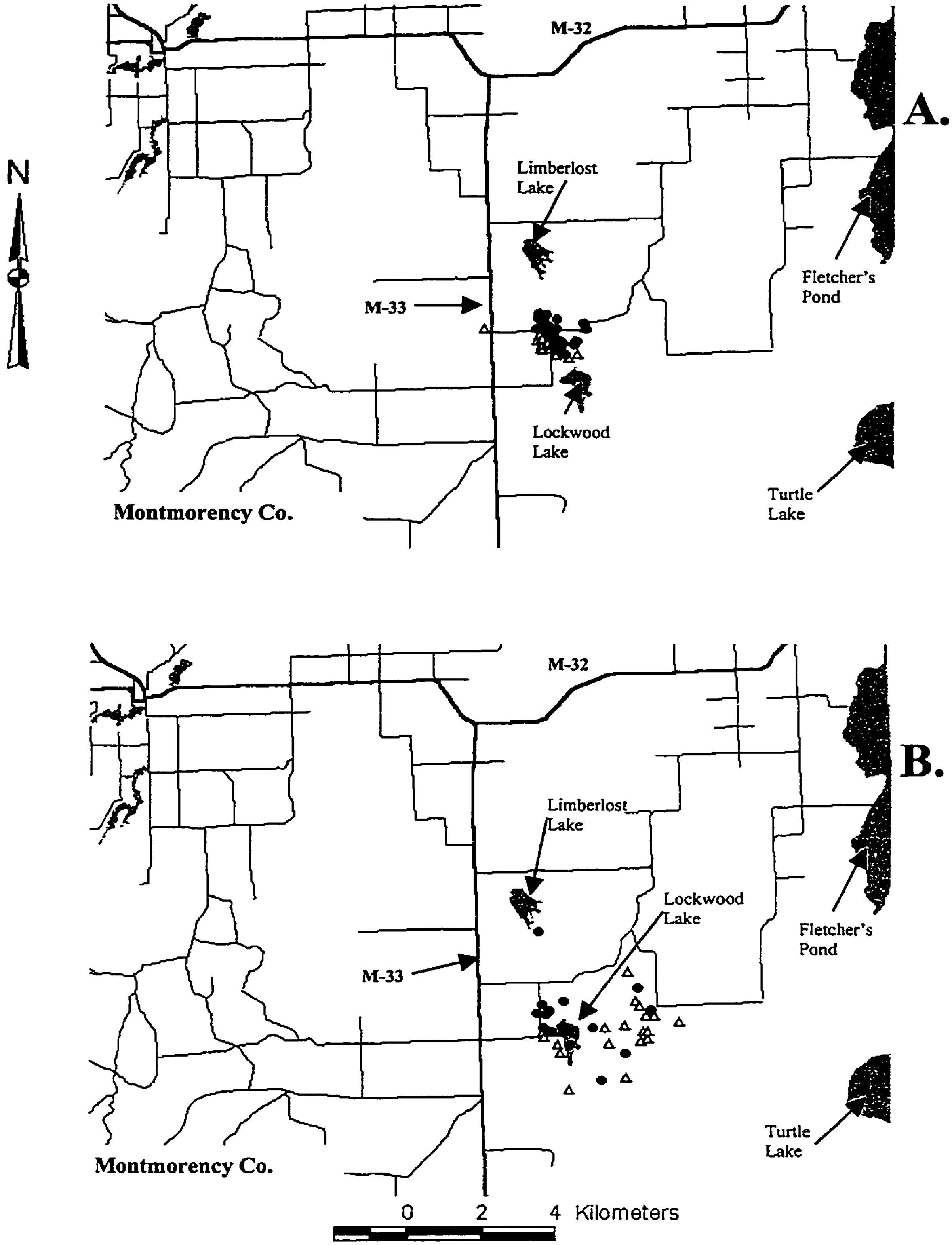
Appendix Figure 55. Point locations for 1.797 (A.) and 1.915 (B.) radio-collared deer.



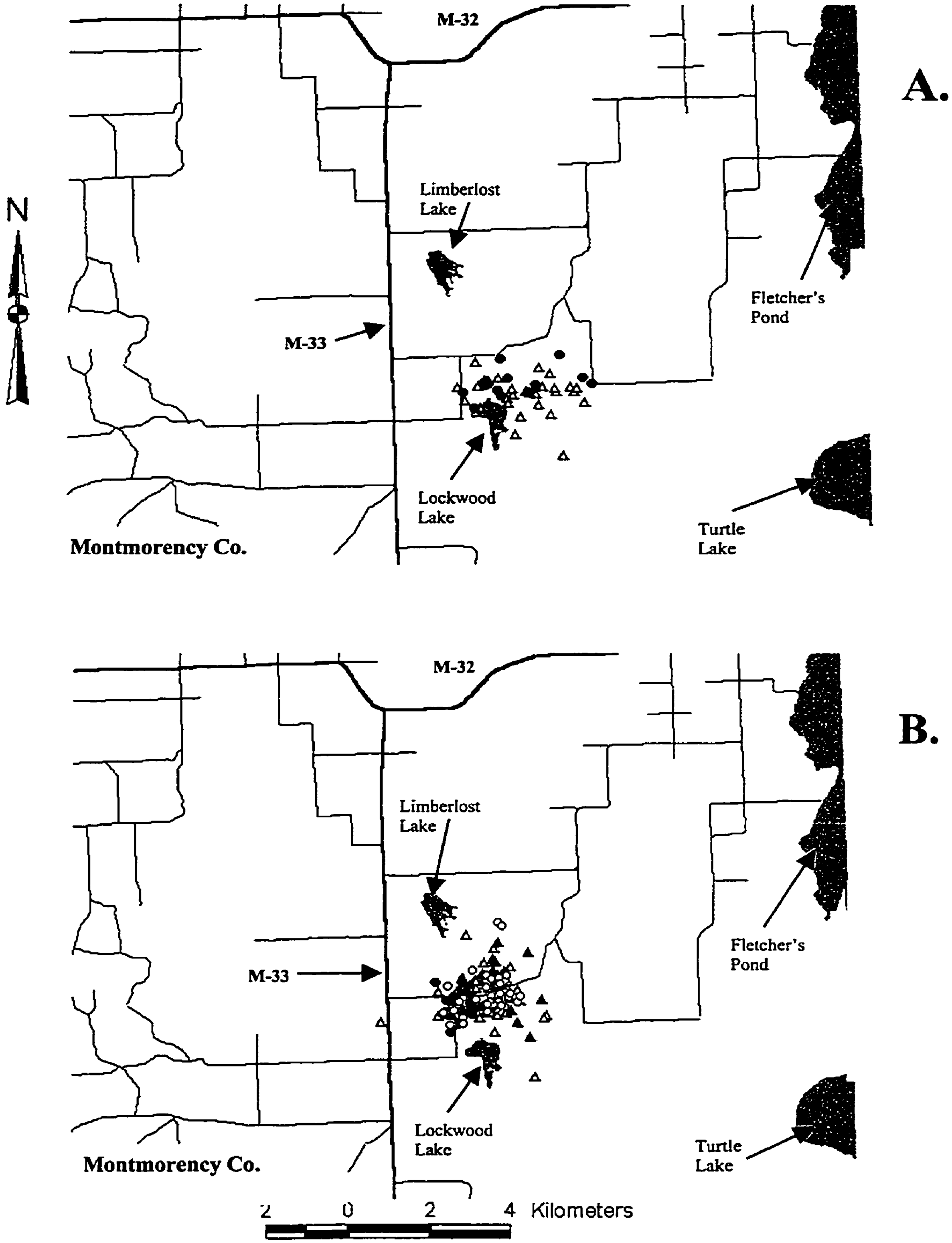
Appendix Figure 56. Point locations for 1.175 (A.) and 1.207 (B.) radio-collared deer.



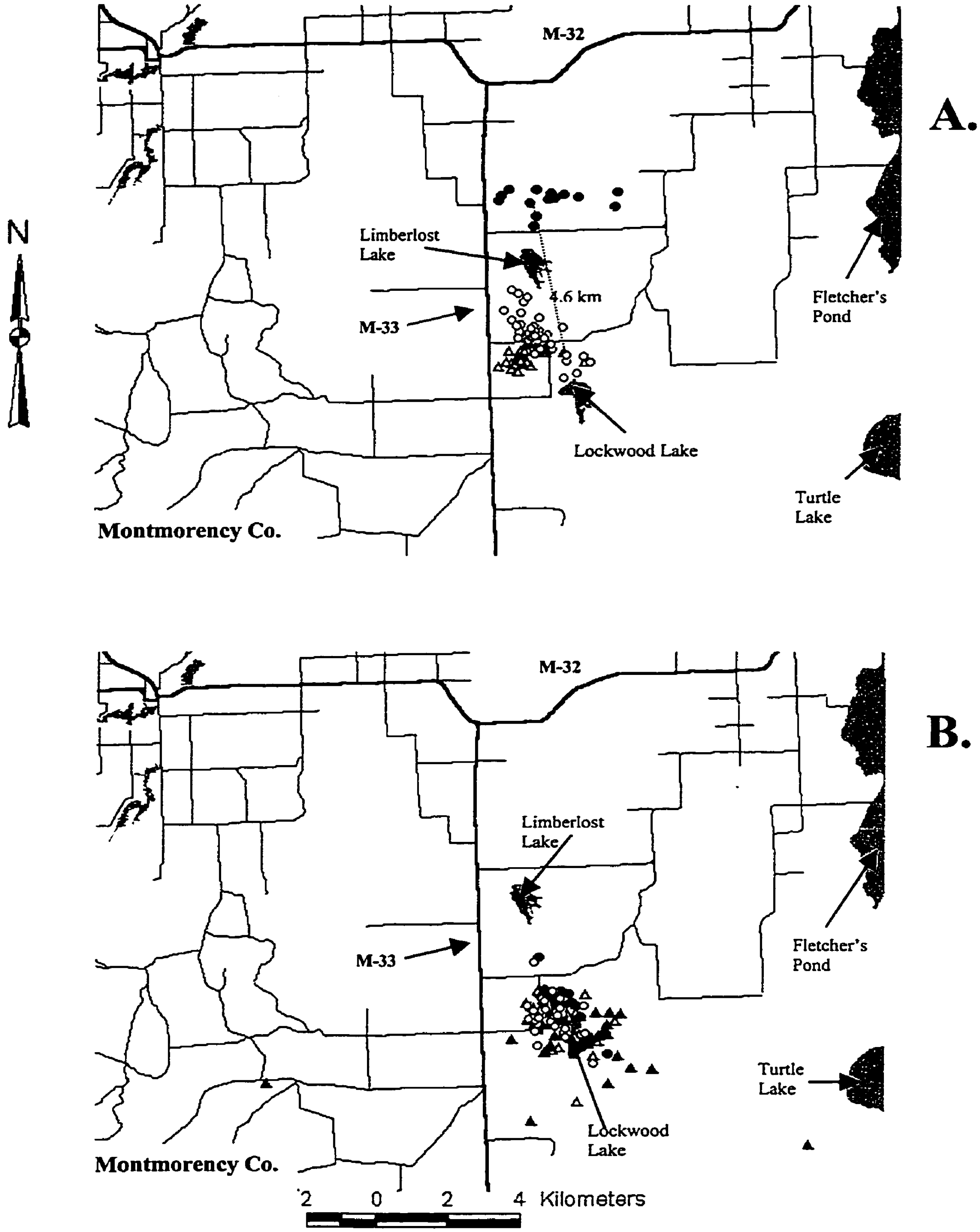
Appendix Figure 57. Point locations for 1.462 (A.) and 1.676 (B.) radio-collared deer.



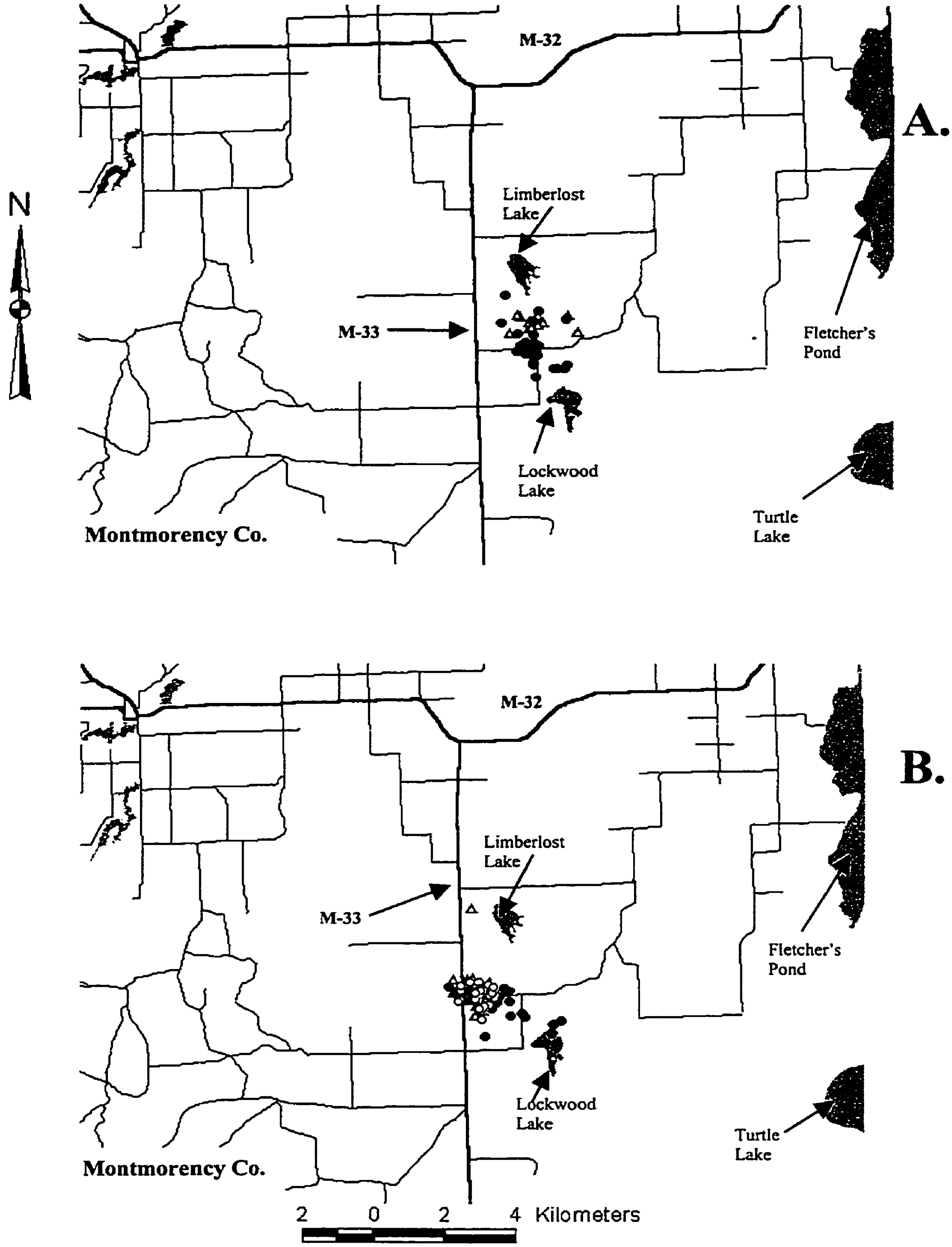
Appendix Figure 58. Point locations for 0.685 (A.) and 0.871 (B.) radio-collared deer.



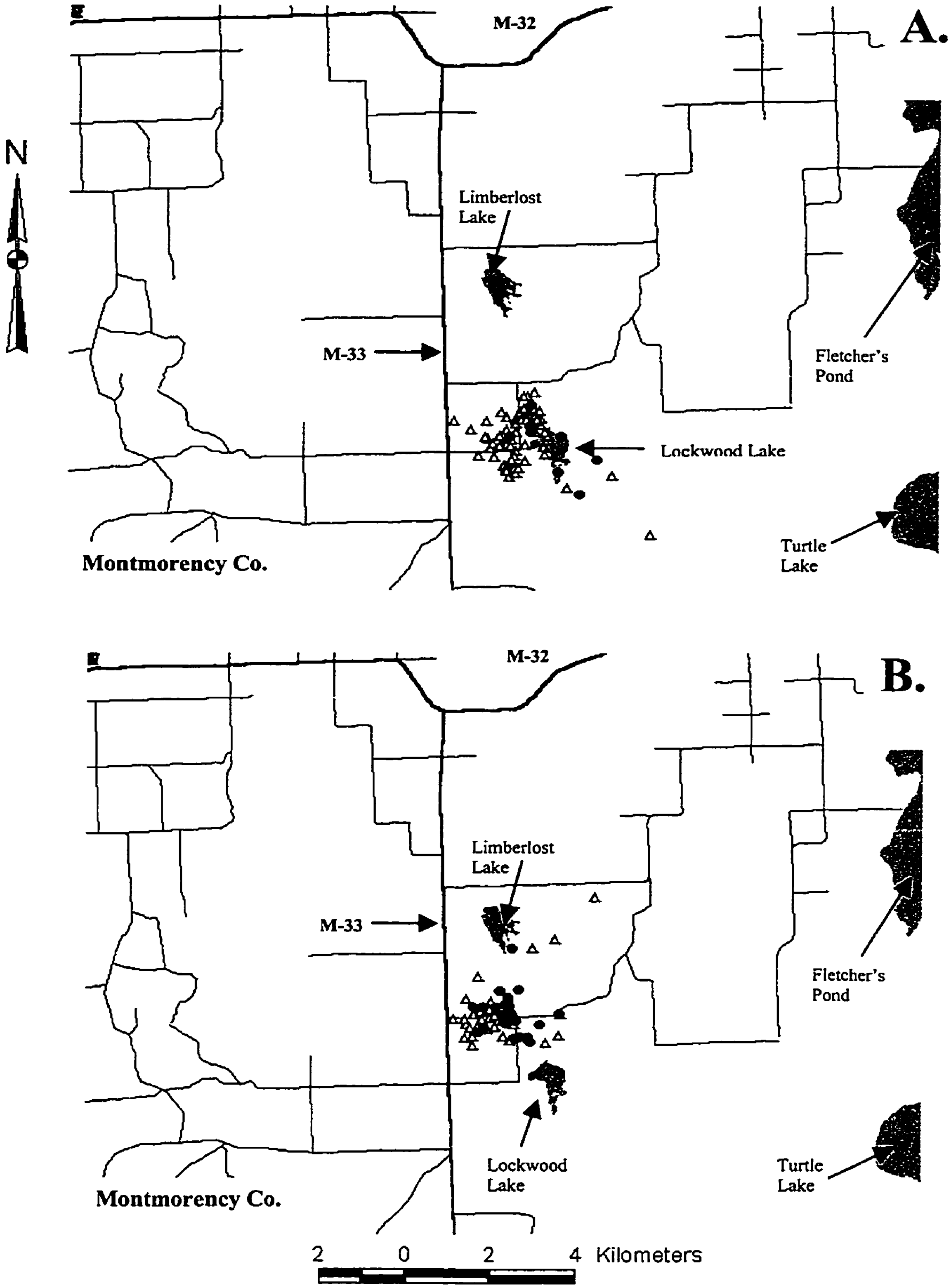
Appendix Figure 59. Point locations for 1.946 (A.) and 1.955 (B.) radio-collared deer.



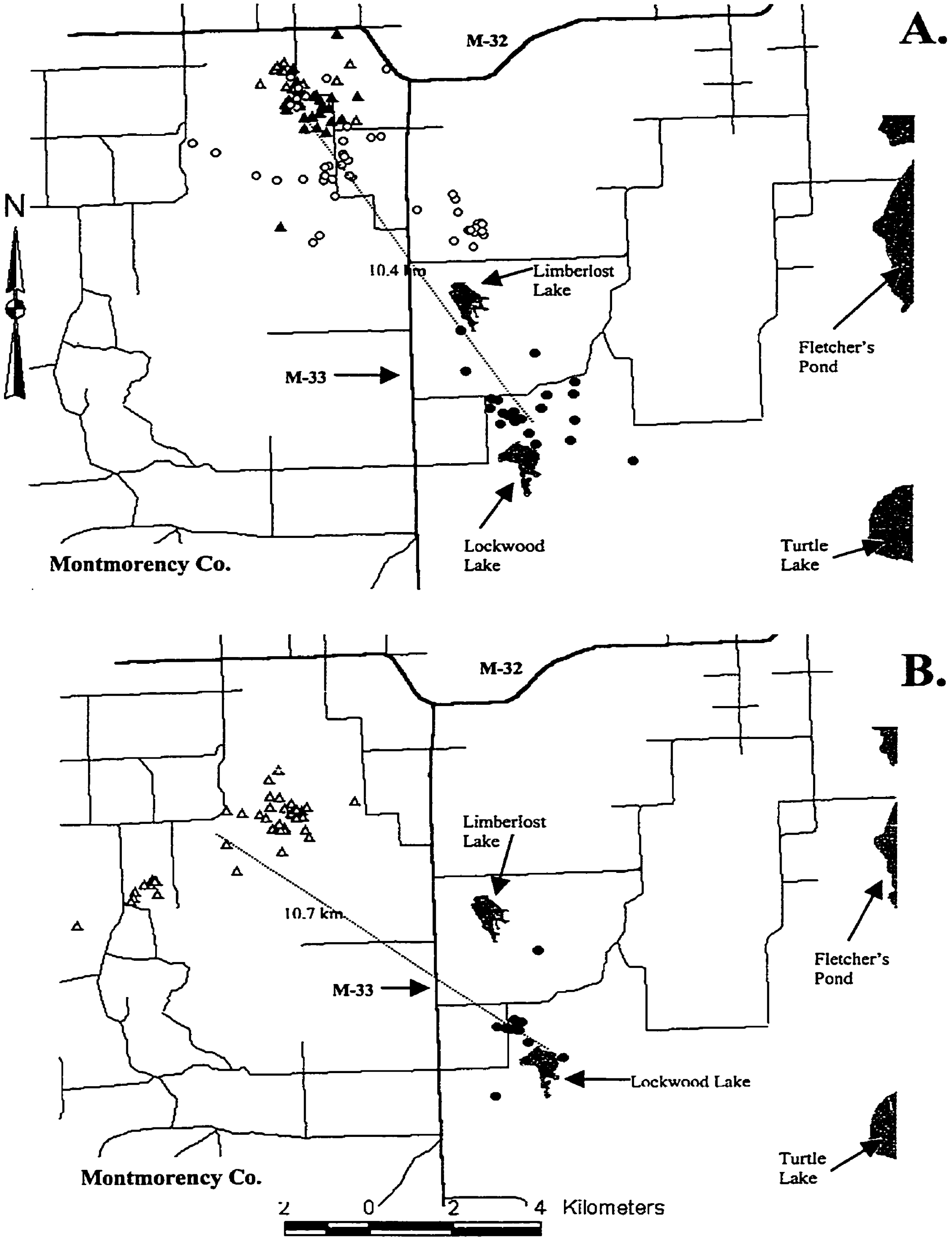
Appendix Figure 60. Point locations for 0.582 (A.) and 0.595 (B.) radio-collared deer.



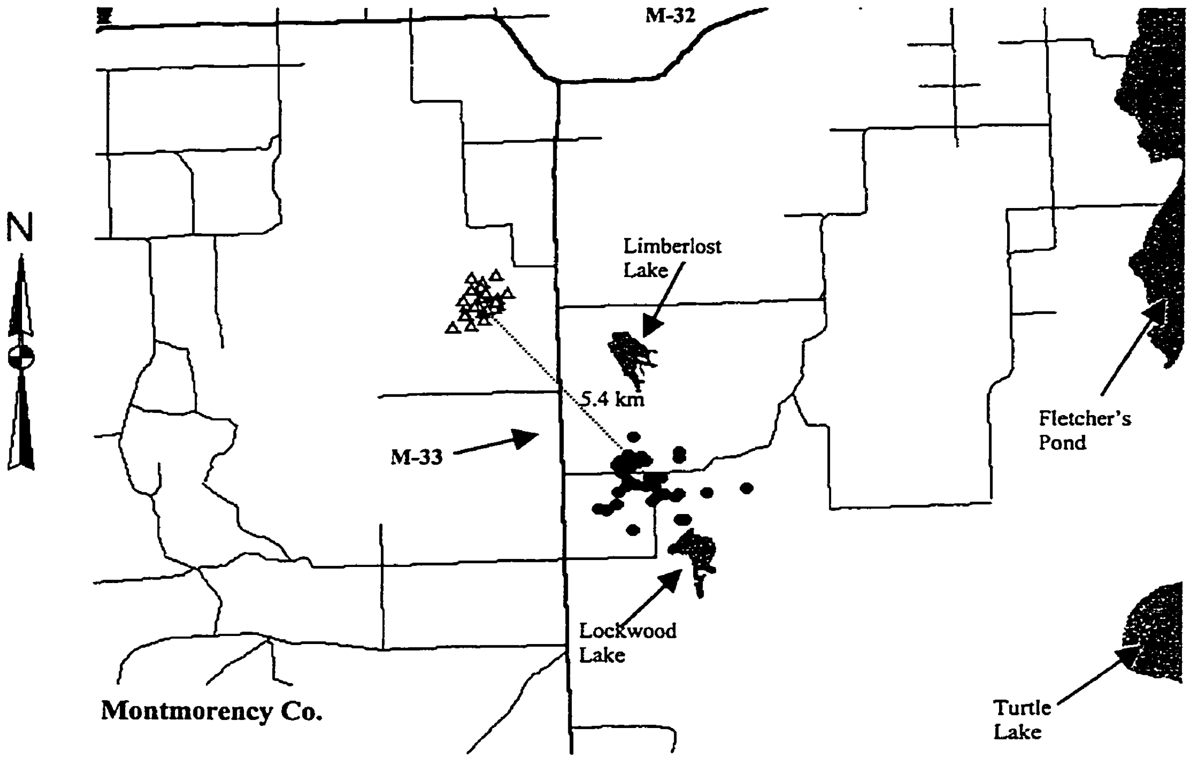
Appendix Figure 61. Point locations for 1.350 (A.) and 1.380 (B.) radio-collared deer.



Appendix Figure 62. Point locations for 0.981 (A.) and 1.090 (B.) radio-collared deer.

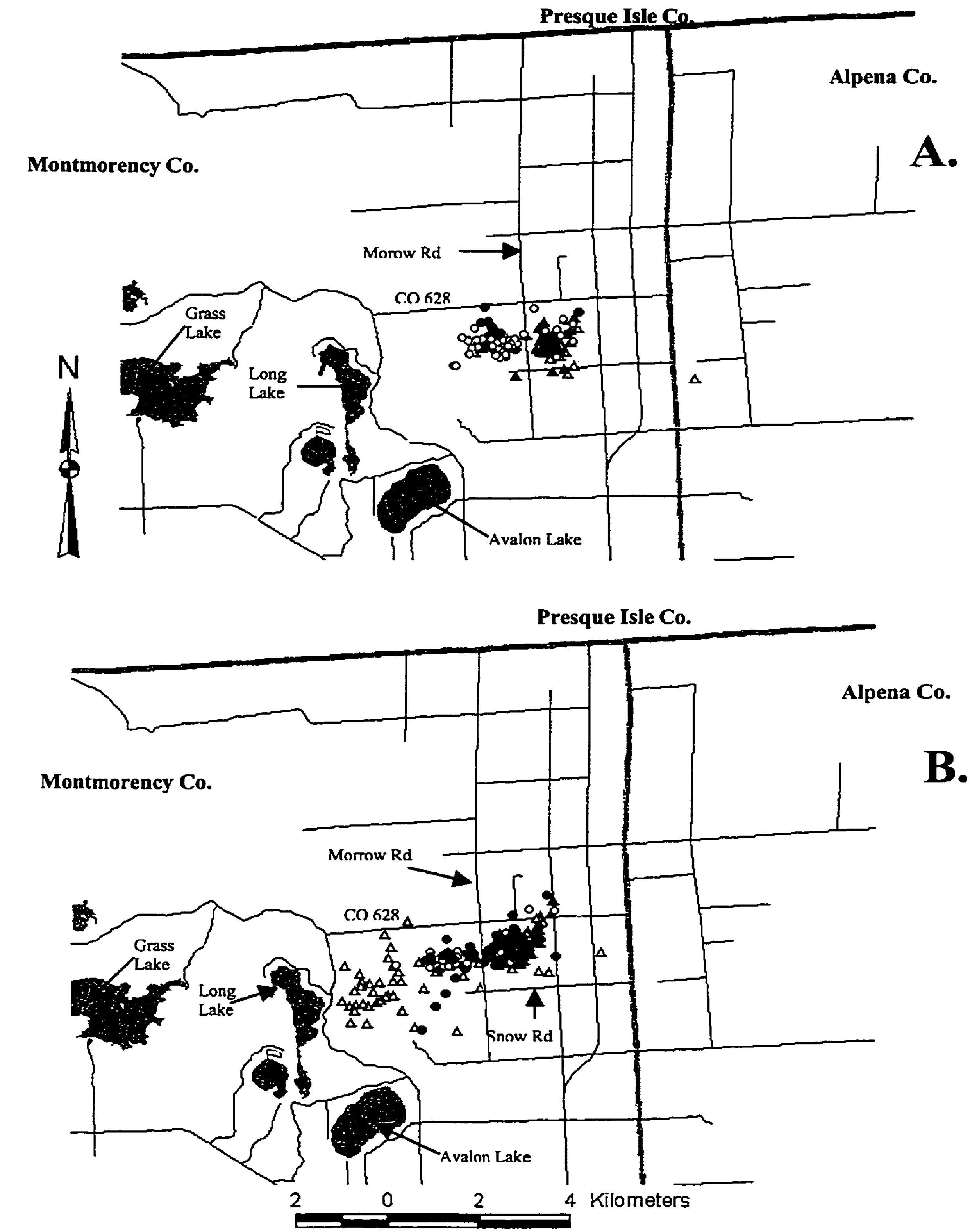


Appendix Figure 63. Point locations for 1.541 (A.) and 1.996 (B.) radio-collared deer.

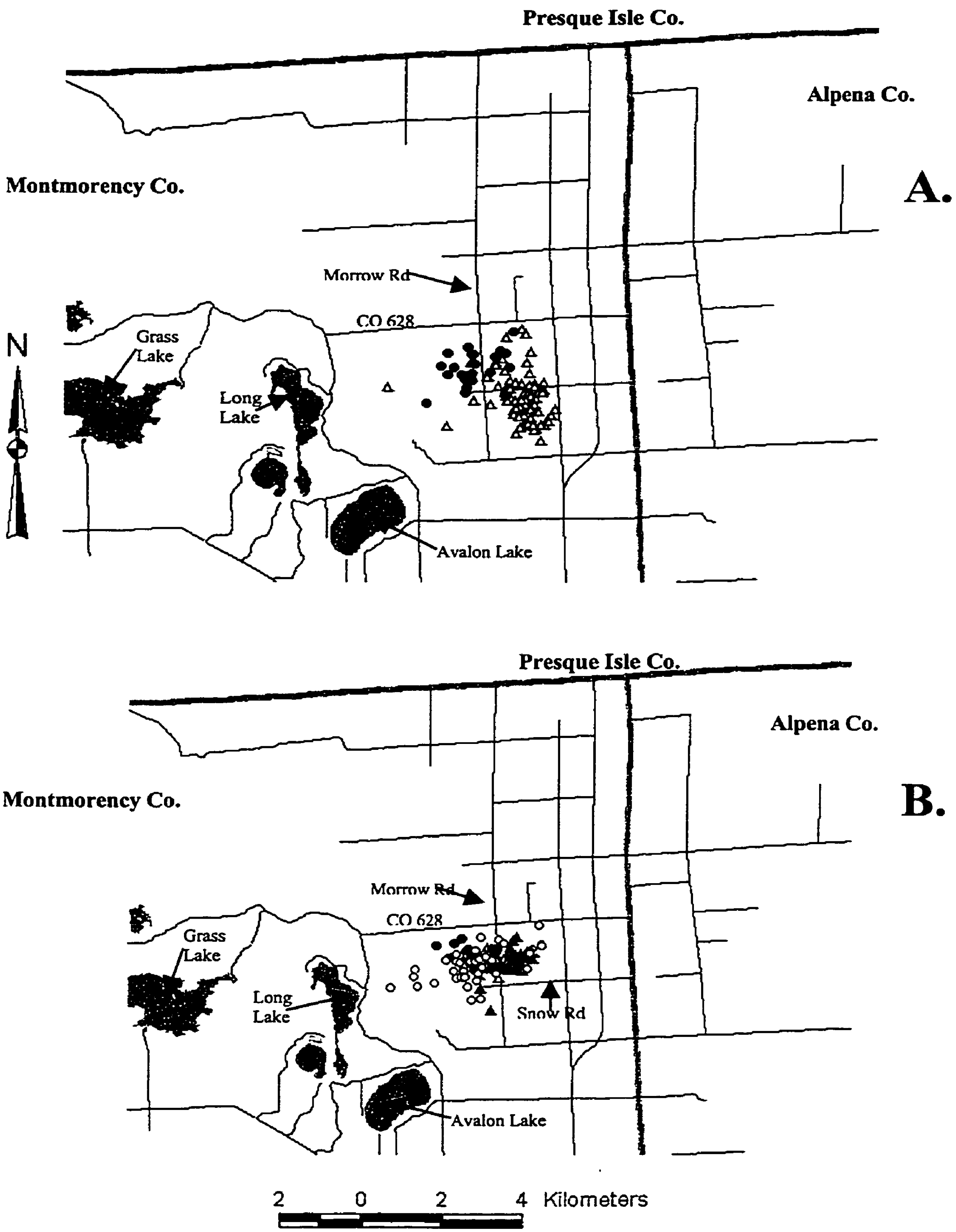


Appendix Figure 64. Point locations for 1.205 a radio-collared deer.

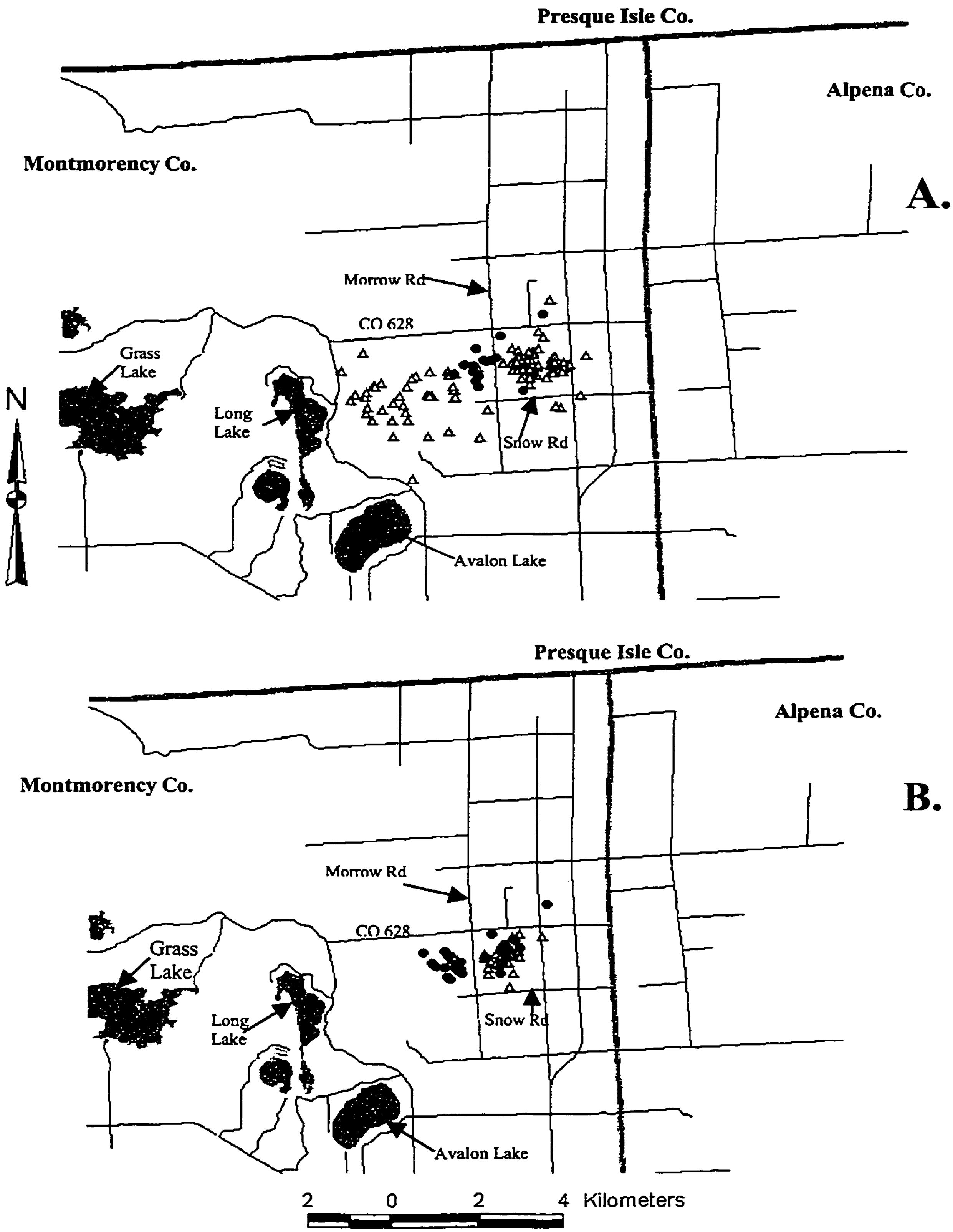
STROHSCHEIN'S FARM



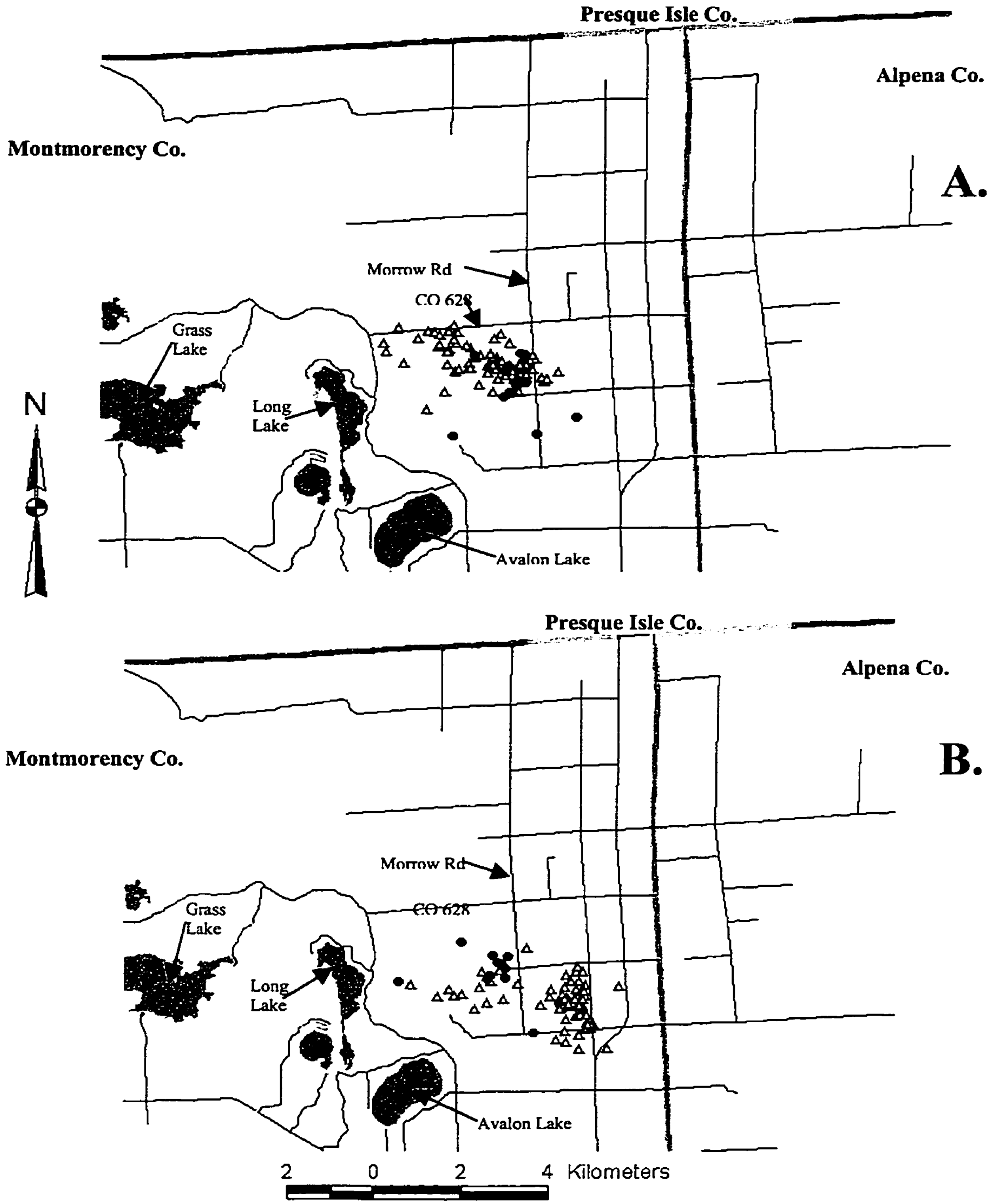
Appendix Figure 65. Point locations 0.390 (A.) and 1.985 (B.) radio-collared deer.



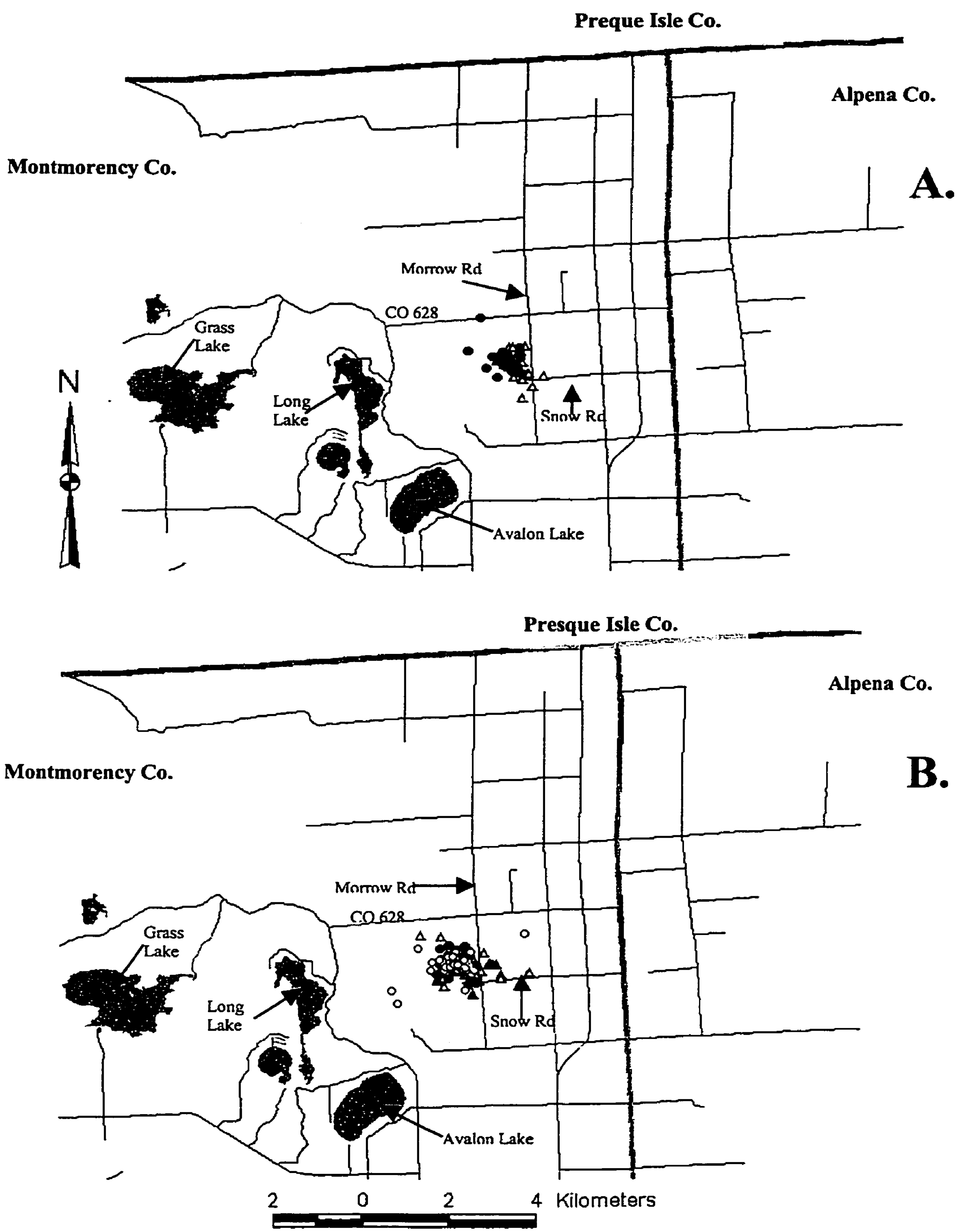
Appendix Figure 66. Point locations for 0.440 (A.) and 0.973 (B.) radio-collared deer.



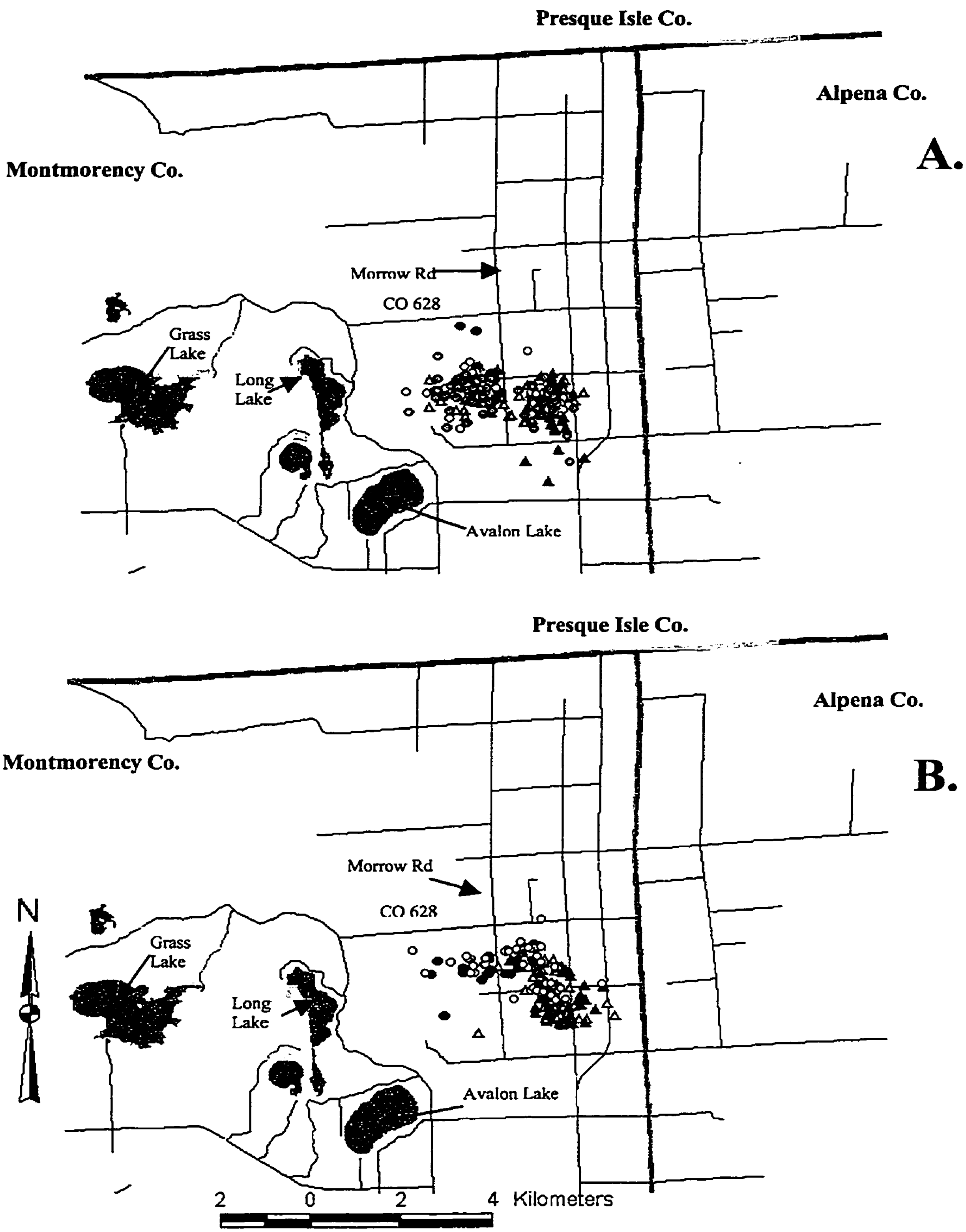
Appendix Figure 67. Point locations for 1.246 (A.) and 1.402 (B.) radio-collared deer.



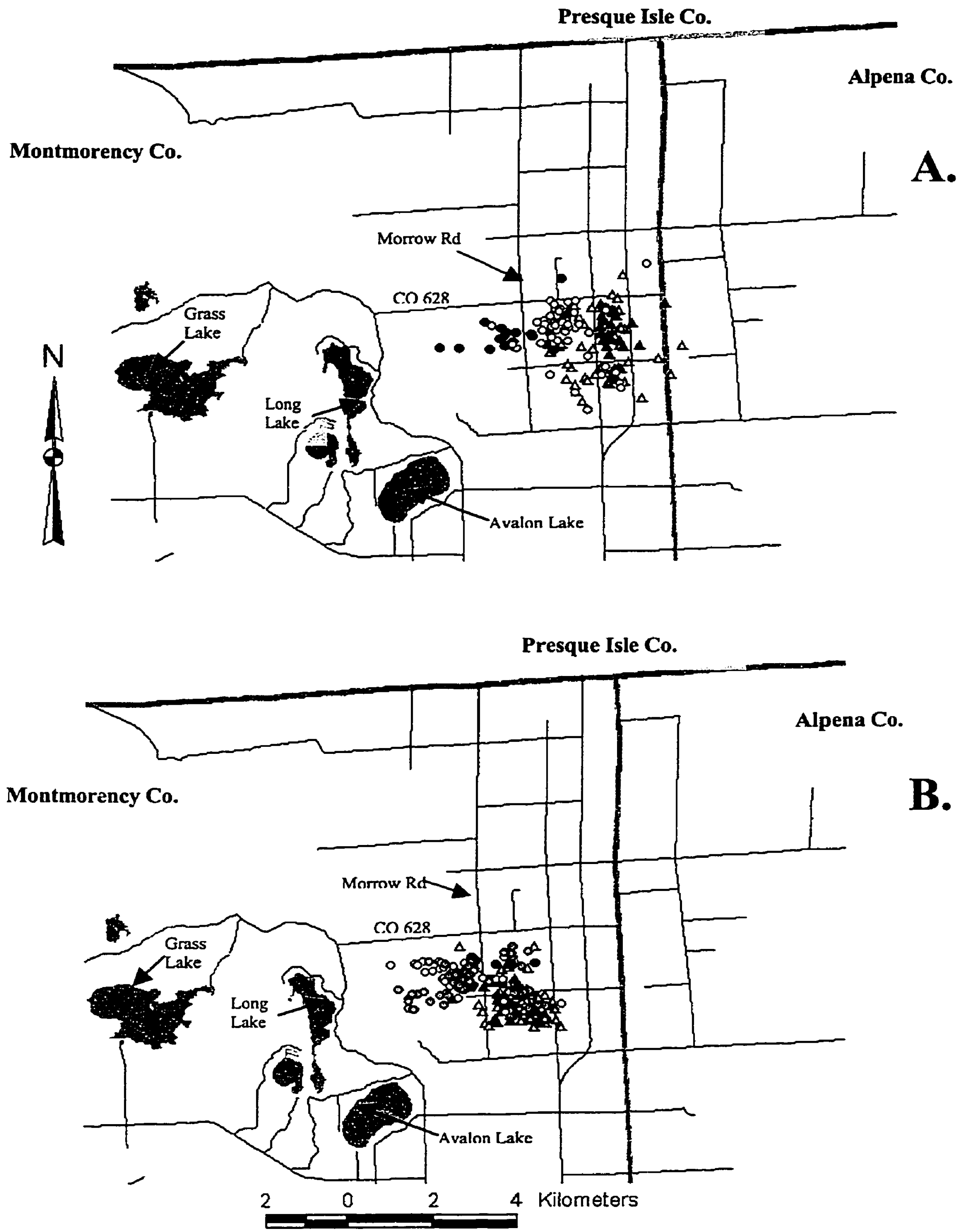
Appendix Figure 68. Point locations for 1.561 (A.) and 1.601 (B.) radio-collared deer.



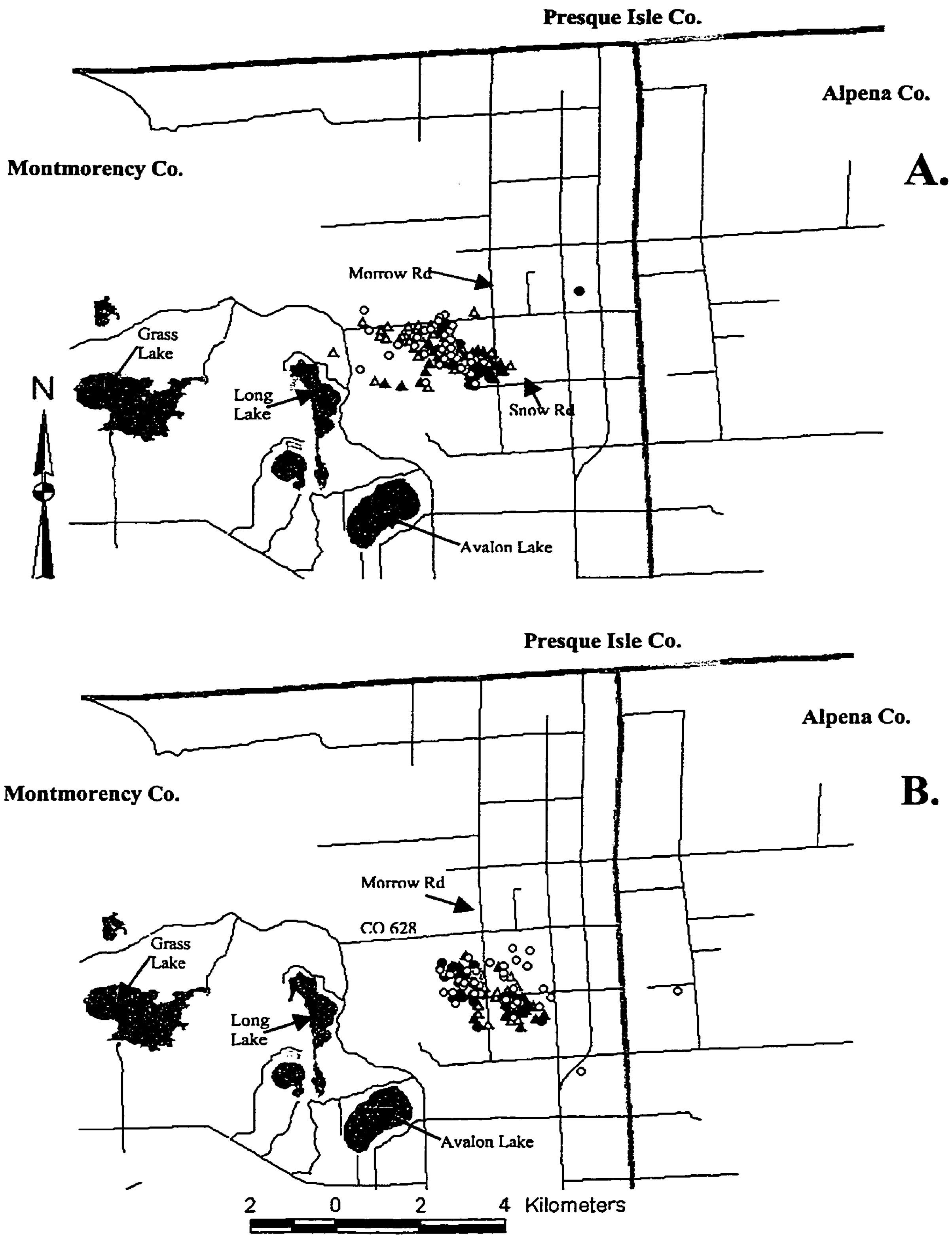
Appendix Figure 69. Point locations for 1.225 (A.) and 1.386 (B.) radio-collared deer.



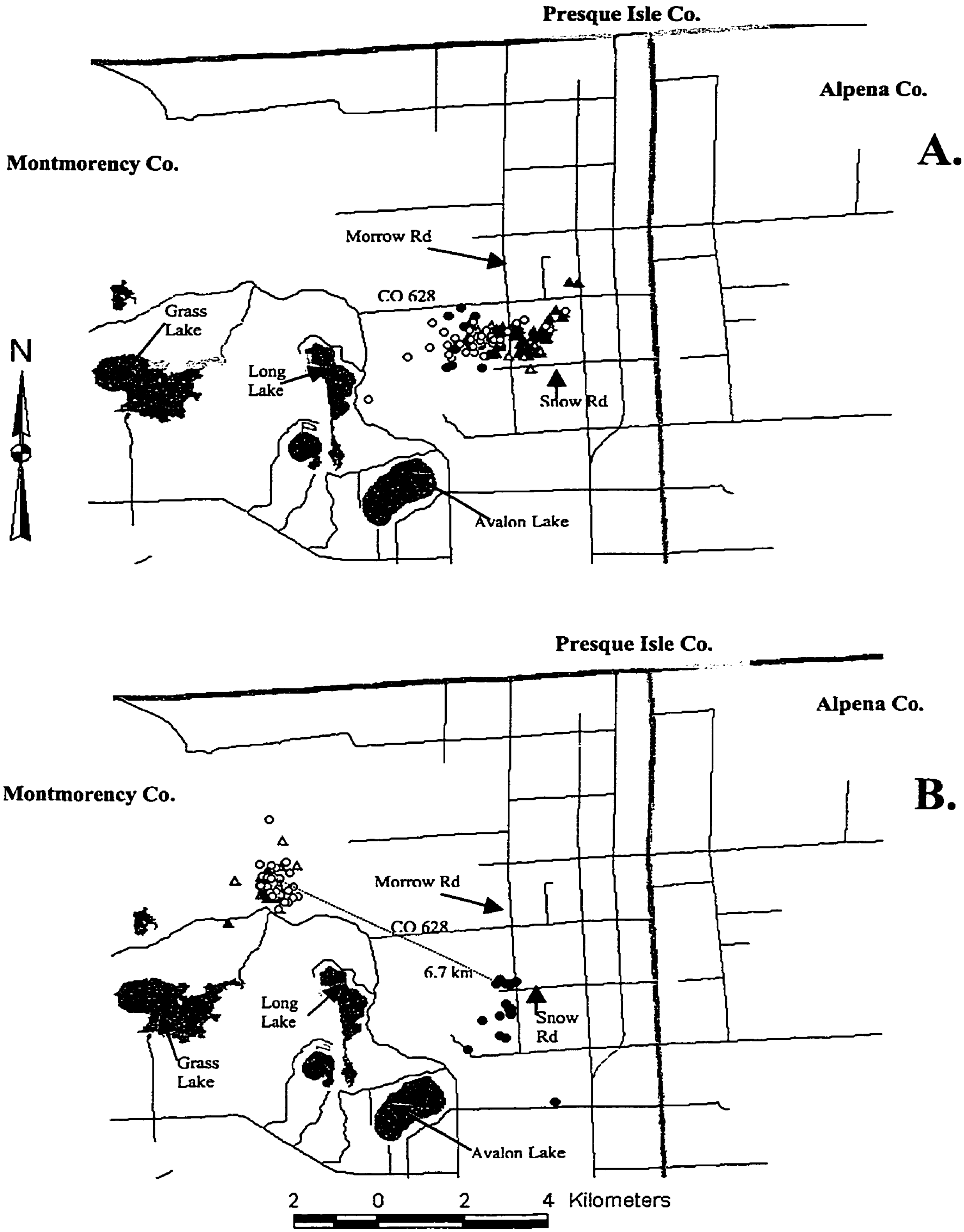
Appendix Figure 70. Point locations for 1.512 (A.) and 0.952 (B.) radio-collared deer.



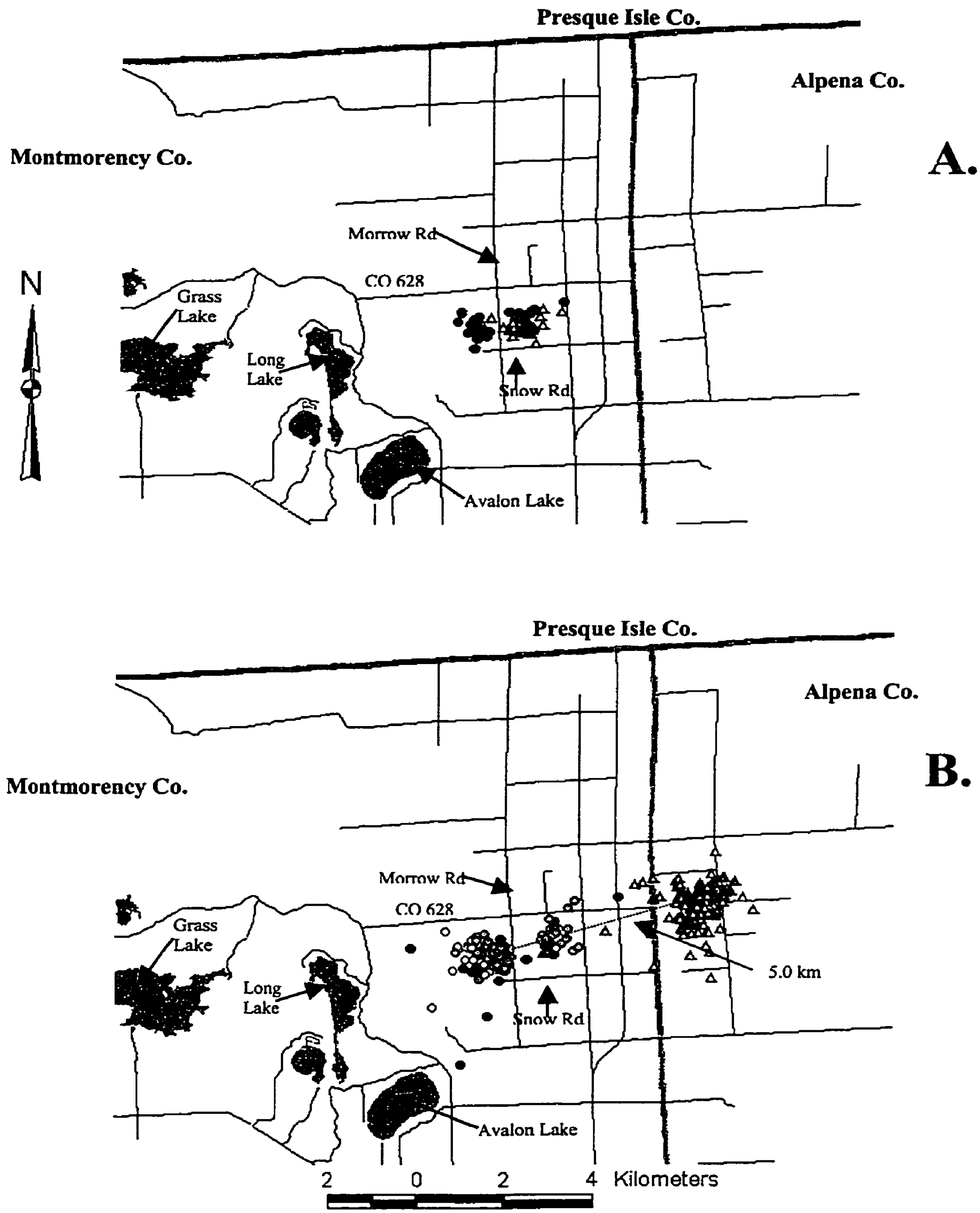
Appendix Figure 71. Point locations for 0.085 (A.) and 0.901 (B.) radio-collared deer.



Appendix Figure 72. Point locations for 1.492 (A.) and 1.582 (B.) radio-collared deer.



Appendix Figure 73. Point locations 1.415 (A.) and 1.425 (B.) radio-collared deer.



Appendix Figure 74. Point locations 0.370 (A.) and 1.888 (B.) radio-collared deer.

LITERATURE CITED

LITERATURE CITED

Beringer, J., L. P. Hansen, W. Wilding, J. Fisher, and S. L. Sheriff. 1996. Factors affecting capture myopathy in white-tailed deer. J. Wildl. Manage. 60(2):373-380.

Byford, J. L. 1970. Movement responses of white-tailed deer to changing food supplies. Proc. Ann. Conf. Southeast Assoc. Game and Fish Comm. 23:63-78.

Clover, M.R. 1954. A portable deer trap and catch-net. Calif. Fish and Game. 40:376-373.

__________. 1956. Single-gate deer trap. Calif. Fish and Game. 42:199-201.

Collins, J.D. 1995. Regional and country status reports. Ireland. Pages 224-237. *In* C.O. Thoen and J.H. Steele eds. *Mycobacterium bovis* infection in animals and humans. Iowa State University Press. Ames, Iowa. 348pp.

Conover, M. R. 1997. Monetary and intangible valuation of deer in the United States. Wildlife Society Bulletin. 25(2):298-305.

Darrow, D.A. 1993. Effects of baiting on deer movement and activity. M.S. Thesis, Mississippi State, Mississippi. 107pp.

Delgiudice, G. D., L. D. Mech, and U. S. Seal. 1990. Effects of winter undernutrition on body composition and physiological profiles of white-tailed deer. J. Wildl. Manage. 54(4)539-550.

Diefenbach, D. R., W. L. Palmer, and W. K. Shope. 1997. Attitudes of Pennsylvania sportsmen towards managing white-tailed deer to protect the ecological integrity of forests. Wildlife Society Bulletin. 25(2):244-251.

Doenier, P. B., G. D. DelGiudice, and M. R. Riggs. 1997. Effects of winter supplemental feeding on browse consumption by white-tailed deer. Wildlife Society Bulletin. 25(2):235-243.

Downing, R. L., B. S. McGinnes, R. L. Petcher, and J. L. Sandt. 1969. Seasonal changes in movements of white-tailed deer. Pages 19-24 in L. K. Halls ed. White-tailed deer in the southern forest habitat. Proc. Symp. Nacogdoches, Texas. U.S. For. Serv., South. For. Exp. Stn., New Orleans, La.

Enarson, D.A., and H.L. Rieder. 1995. The importance of *Mycobacterium bovis* to the tuberculosis epidemic in humans. Pages xix - xxii. *In* C.O. Thoen and J.H. Steele eds. *Mycobacterium bovis* infection in animals and humans. Iowa State University Press. Ames, Iowa. 348pp.

Essey, M. A., and J. S. Vantiem. 1995. Mycobacterium bovis infection in captive cervidae: An eradication program. Pages 145-157. *In* C.O. Thoen and J.H. Steele eds. *Mycobacterium bovis* infection in animals and humans. Iowa State University Press. Ames, Iowa. 348pp.

Frelich, L. E., and K. J. Puettmann. 1999. Pages 499-524 in M. L. Hunter, ed. Maintaining biodiversity in forest ecosystems. Cambridge University Press. Cambridge, United Kingdom.

Grange, J. M. 1995. Human aspects of *Mycobacterium bovis* infection. Pages 29-46. *In* C.O. Thoen and J.H. Steele eds. *Mycobacterium bovis* infection in animals and humans. Iowa State University Press. Ames, Iowa. 348pp.

Gross, J. E., and M. W. Miller. 2001. Chronic wasting disease in mule deer: Disease dynamics and control. J. Wildl. Manage. 65(2):205-215.

Healy, W. M. 1997. Influence of deer on the structure and composition of oak forests in central Massachusetts. Pages 249-266 in W. J. McShea, H. B. Underwood, and J. H. Rappole, ed. The science of overabundance: deer ecology and population management. Smithsonian Inst. Press Washington and London.

Henke, S. E. 1997. Do white-tailed deer react to the dinner bell? An experiment in classical conditioning. Wildlife Society Bulletin. 25(2):291-295.

Hiller, I. 1996. The White-tailed deer. Texas A&M University Press, College Station. 115pp.

Holsman, R. H. 2000. Goodwill hunting? Exploring the role of hunters as ecosystem stewards. Wildlife Society Bulletin. 28(4):808-816.

Holzenbein, S., and G. Schwede. 1989. Activity and movements of female white-tailed deer during the rut. J. Wildl. Manage. 53(1):219-223.

Kammermeyer, K. E., and R. L. Marchinton. 1977. Seasonal change in circadian activity of radio-monitored deer. J. Wildl. Manage. 41(2):315-317.

__________________., and R. Thackston. 1995. Habitat Management and supplemental feeding. Pages 129-154 in K. V. Miller and R. L. Marchinton, ed. Quality Whitetails: The why and how of quality deer management. Stackpole Books. Mechanicsburg, PA.

Karns, P. D. 1980. Winter-the grim reaper. Pages 47-53 in R. L. Hine and S. Nehls, eds. White-tailed deer population management in the north central states, Proc. 1979. Symp. North Central Section, The Wildlife Society, 116p.

Kie, J. G., and R. T. Bowyer. 1999. Sexual segregation in white-tailed deer: Density-dependent changes in use of space, habitat selection, and dietary niche. J. of Mammalogy. 80(3):1004-1020.

Kilpatrick, H. J., S. M. Spohr, and A. J. DeNicola. 1997. Darting urban deer: Techniques and technology. Wildlife Society Bulletin. 25(2):542-546.

Labisky, R. F. 1998. Spatial mobility of breeding female white-tailed deer in a low-density population. J. Wildl. Manage. 62(4):1329-1333.

Lawson, E. J. G., and A. R. Rodgers. 1997. Differences in home-range size computed in commonly used software programs. Wildlife Society Bulletin. 25(3):721-729.

Lewis, T. L. 1990. The effects of supplemental feeding on white-tailed deer in northwestern Wisconsin. M.S. Thesis. University of Wisconsin, Madison. 79pp.

Marchington, R. L., and D. H. Hirth 1984. Behavior. Pages 129-168 in L. K. Halls, ed. White-tailed deer ecology and management. Wildl. Manage. Inst. Stackpole Books. Harrisburg, PA.

Mautz, W. W. 1978. Sledding on the a bushy hillside: The fat cycle in deer. Wildlife Society Bulletin. 6:88-90.

McCabe, R. E., and T. R. McCabe. 1984. Pages 19-72 in L. K. Halls, ed. White-tailed deer ecology and management. Wildl. Manage. Inst. Stackpole Books. Harrisburg, PA.

Meslin, F. X., and O. Cosivi. 1995. The importance of Mycobacterium bovis to the tuberculosis epidemic in humans. Pages xxii - xxv. *In* C.O. Thoen and J.H. Steele eds. *Mycobacterium bovis* infection in animals and humans. Iowa State University Press. Ames, Iowa. 348pp.

Miller, K. V., R. L. Marchinton, and J. J. Ozoga. 1995. Deer Sociobiology. Pages 118-128 in K. V. Miller and R. L. Marchinton, ed. Quality Whitetails: The why and how of quality deer management. Stackpole Books. Mechanicsburg, PA.

___________. 1997. Considering social behavior in the management of overabundant white-tailed deer populations. Wildlife Society Bulletin. 25(2):279-281.

Miller, M. W., M. A. Wild, and E. S. Williams. 1998. Epidemiology of chronic wasting disease in captive Rocky Mountain elk. J. Wildl. Manage. 34(3):532-538.

__________., E. S. Williams, C. W. McCarty, T. R. Spraker, T. J. Kreeger, C. T. Larsen, and E. T. Thorne. 2000. Epizootiology of chronic wasting disease in free-ranging cervids in Colorado and Wyoming. J. Wildl. Manage. 36(4):676-690.

Minnis, D. L., and R. B. Peyton. 1994. Unpublished report: 1993 Michigan Deer Hunting Survey: Deer baiting, for Michigan Department of Natural Resources: Wildlife Division. 18pp.

Moen, A. N. 1978. Seasonal changes in heart rates, activity, metabolism, and forage intake of white-tailed deer. J. Wildl. Manage. 42:715-738.

Montgomery, G. G. 1963. Nocturnal movements and activity rhythms of white-tailed deer. J. Wildl. Manage. 27:422-427.

Mooty, J. J., P. D. Karns, and T. K. Fuller. 1987. Habitat use and seasonal range size of white-tailed deer in northcentral Minnesota. J. Wildl. Mange. 51(3):644-648.

Morris, R. S., and D. U. Pfeiffer. 1995. Directions and issues in bovine tuberculosis epidemiology and control in New Zealand. New Zealand Veterinary Journal 43:256-265.

Nahlik, A. J. 1974. Deer management. David and Charles Publishing. North Pomfret, VT. 250pp.

Nelson, M. E., and L. D. Mech. 1981. Deer social organization and wolf predation in northeastern Minnesota. Wildl. Monogr. 77:53pp.

__________., and __________. 1984. Home-range formation and dispersal of deer in northeastern Minnesota. J. Mammal. 65(4):567-575.

__________., and __________. 1992. Dispersal in female white-tailed deer. J. Mammal. 73(4):891-894.

Nixon, C. M., L. P. Hansen, and P. A. Brewer 1988. Characteristics of winter habitats used by deer in Illinois. J. Wildl. Manage. 52(3):552-555.

O'Hara, P. J. 1995. Regional and country status reports. New Zealand. Pages 332 - 336. *In* C.O. Thoen and J.H. Steele eds. *Mycobacterium bovis* infection in animals and humans. Iowa State University Press. Ames, Iowa. 348pp.

Ozoga, J. J., and L. J. Verme. 1982. Physical and reproductive characteristics of a supplementally-fed white-tailed deer herd. J. Wildl. Manage. 46(2):281-301.

__________. 1996. Seasons of the white-tailed: Book three. Willow Creek Press. Minocqua, WI. 143pp.

Palik, B., and R. T. Engstrom. 1999. Pages 65-94 in M. L. Hunter, ed. Maintaining biodiversity in forest ecosystems. Cambridge University Press. Cambridge, United Kingdom.

Petoskey, M. L. 1980. Convincing the decision makers. Pages. 95-97 in R. L. Hine and S. Nehls, ed. White-tailed deer population management. Proc. 1979 Symp. North Central Section, The Wildlife Society, 116p.

Peyton, B. R. 2000. Wildilfe Management: cropping to manage or managing to crop? Wildlife Society Bulletin. 28(4):774-779.

Porter, W. F. 1997. Ignorance, arrogance, and the process of managing overabundant deer. Wildlife Society Bulletin. 25(2):408-412.

Rees, W. H. G., and K. C. Meldrum. 1995. Regional and country status reports. Great Britain. Pages 250 - 256. *In* C.O. Thoen and J.H. Steele eds. *Mycobacterium bovis* infection in animals and humans. Iowa State University Press. Ames, Iowa. 348pp.

Roseberry, J. L., and A. Woolf. 1998. Habitat-population density relationships for white-tailed deer in Illinois. J. Wildl. Manage. 26(2):252-258.

Saltz, D. 1994. Reporting error measures in radio location by triangulation: A review. J. Wildl. Manage. 58(1):181-184.

Sauer, P. R. 1984. Physical Characteristics. Pages 73 – 90 L. K. Halls, ed. White-tailed deer ecology and management. Wildl. Manage, Inst. Stackpole Books. Harrisburg, PA.

Schmitt, S. M., S. D. Fitzgerald, T. M. Cooley, C. S. Bruning-Fann, L. Sullivan, D, Berry, T. Carlson, R. B. Minnis, J. B. Payeur, and J. Sikarskie. 1997. Bovine tuberculosis in free-ranging white-tailed deer from Michigan. J. Wildl. Diseases. 33(4):749-758.

Schmitz, O. J. 1990. Management implications of foraging theory: Evaluating deer supplemental feeding. J. Wildl. Manage. 54(4):522-531.

____________., and A. R. E. Sinclair 1997. Rethinking the role of deer in the forest ecosystem dynamics. Pages 201-223 W. J. McShea, H. B. Underwood and J. H. Rappole, ed. The Science of overabundance: Deer ecology and population management. Smithsonian Inst. Press. Washington and London.

Seagle, S. W., and S. Liang. 1997. Pages 346-365 in W. J. McShea, H. B. Underwood, and J. H. Rappole, ed. The science of overabundance: Deer ecology and populationmanagement. Smithsonian Inst. Press. Washington and London.

Seaman, D. E., and B. Grifffith. 1998. KERNELHR: a program for estimating animal home ranges. Wildlife Society Bulletin. 26(1):96-100.

___________., J. J. Millspaugh, B. J. Kernohan, G. C. Brundige, K. J. Raedeke, and R. Gitzen. 1999. Effects of sample size on kernel home range estimates. J. Wildl. Manage.63(2):739-747.

Semeyn, R. D. 1963. An investigation of the influence of weather on the movements of white-tailed deer in winter. M.S. Thesis, Michigan State Univ., East Lansing. 72pp.

Severinghaus, C. A. 1949. Tooth development and wear as criteria of age in white-tailed deer. J. Wildl. Mange. 13:195-216.

Sitar, K. L. 1996. Seasonal movements, habitat use patterns, and population dynamics of white-tailed deer (*Odocoileus virginianus*) in an agricultural region of northern lower Michigan. M.S. Thesis, Michigan State Univ., East Lansing. 130pp.

Smith, B. L. 2001. Winter feeding of elk in western North America. J. Wildl. Manage. 65(2):173-190.

Spraker, T. R., M. W. Miller, E. S. Williams, D. M. Getzy, W. J. Adrian, G. G. Schoonveld, R. A. Spowart, K. I. O'Rourke, J. M. Miller, and P. A. Merz. 1997. Spongiform encephalopathy in free-ranging mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus verginianus*) and Rocky Mountain elk (*Cervus elaphus nelsoni*) in northcentral Colorado. J. Wildl. Manage. 33(1):1-6.

Staines, B. W. 1974. A review of factors affecting deer dispersion and their relevance to management. Mammal. Rev. 4(3):79-91.

Steel, R. G. D., and J. H. Torrie. 1980. Principles and procedures of statistics: A biometrical approach. McGraw-Hill Book Company. New York, N.Y.

Thoen, C. O., and B. R. Bloom. 1995. Pathogenesis of *Mycobacterium bovis*. Pages 3-14. *In* C.O. Thoen and J.H. Steele eds. *Mycobacterium bovis* infection in animals and humans. Iowa State University Press. Ames, Iowa. 348pp.

__________., R. Schliesser, and B. Kormendy. 1995. Tuberculosis in captive wild animals. Pages 93-104. *In* C.O. Thoen and J.H. Steele eds. *Mycobacterium bovis* infection in animals and humans. Iowa State University Press. Ames, Iowa. 348pp.

Thomas, J. W., J. G. Teer, and E. A. Walker. 1964. Mobility and home range of white-tailed deer on the Edwards Plateau in Texas. J. Wild. Manage 28(3):463-472.

Thorne, E. T., M. S. Boyce, P. Nicoletti, and T. J. Kreeger. 1997. Brucellosis, bision, elk, and cattle in the greater Yellowstone area: defining the problem, exploring solutions. Greater Yellowstone interagency brucellosis committee and Wyoming Game and Fish Dpeartment, Cheyenne, USA.

Tierson, W. C., G. F. Mattfeld, R. W. Sage Jr., and D. F. Behrend 1985. Seasonal movements and home ranges of white-tailed deer in the Adirondacks. J. Wildl. Manage. 49(3):760-769.

Tilghman, N. G. 1989. Impacts of white-tailed deer on forest regeneration in northwestern Pennsylvania. J. Wildl. Manage. 53(3):524-532.

Trumbull, V. L., E. J. Zielinski, and E. C. Aharrah. 1989. The impact of deer browsing on the Allegheny forest type. North Journal of Applied Forestry 6: 162-165.

Van Deelen, T. R. 1995. Seasonal migrations and mortality of white-tailed deer in Michigan's upper peninsula. Ph.D. Thesis. Michigan State University, East Lansing. 158pp.

______________., H. Campa, III, M. Hamady, and J. B. Haufler. 1998. Mirgation and seasonal range dynamics of deer using adjacent deeryards in northern Michigan. J. Wildl. Manage. 62(1):205-213.

_______________., ___________, J. B. Haufler, and P. D. Thompson. 1997. Mortality patterns of white-tailed deer in Michigan's Upper Peninsula. J. Wildl. Manage. 61(3):903-910.

Vercauteren, K. C., and S. E. Hygnstrom. 1998. Effects of agriculture activities and hunting on home ranges of female white-tailed deer. J. Wildl. Manage. 62(1):280-285.

Verme, L. J., and J. F. Johnston. 1986. Regeneration of northern white cedar deeryards in upper Michigan. J. Wildl. Manage. 50(2):307-313.

__________., and J. J. Ozoga. 1971. Influence of winter weather on white-tailed deer in Upper Michigan. Pages 16-28. In A. O. Haugen, ed. Proc. Snow and ice Symp. Iowa State Univ., Ames.

Wae, N. A., H. L. Stribling, and M. K. Causey. 1997. Cost efficiency of forage plantings for white-tailed deer. J. Wildl. Manage. 25(4):803-808.

Wilson, M. L., and J. E. Childs. 1997. Vertebrate abundance and the epidemiology of zoonotic diseases. Pages 224-248 in W. J. McShea, H. B. Underwood, and J. H. Rappole, ed. The science of overabundance: Deer ecology and population management. Smithsonian Inst. Press. Washington and London.

Winterstein, S. R., H. Campa, III, and K. F. Millenbah. 1995. Status and potential of Michigan natural resources: Wildlife. Michigan Agricultural Experiment Station Special Report No. 75. 38pp.

Wipple, D. L., and M. V. Palmer. 2000. Survival of *Mycobacterium bovis* on feeds. Page 17 in C. Reed and J. Clifford, eds. Conference on Bovine Tuberculosis, Proc. 2000. Lansing, Michigan. 40pp.

Worton, B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. J. of Ecology. 70(1):164-168.