FINAL REPORT

A LIFE HISTORY STUDY OF TURKEY VULTURES ALONG THE ROOT RIVER VALLEY IN FILLMORE COUNTY, MINNESOTA

by

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15 April 1986

ACKNOWLEDGMENTS

I wish to thank the following people for their assistance: J. Tenney, J. Deden, M. Gilbert, J. Flemming, M. Mossman, D. Johnson, M. Gernes, A. Weaver, C. Dorff, J. Horihan, D. Book, V. Perkins, and E. Knutson, Additional thanks are due Kark Rendering. George Friederich Scholarship funds made my graduate studies possible. Special thanks are due Al Grewe for his support. Grants offered by the Minnesota Nongame Program made this project possible and are greatfully acknowledged. Special thanks to Lee Pfannmuller for her interest and support.

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INTRODUCTION

The Turkey Vulture (*Cathartes aura*) is the only member of Cathartidae to occur in Minnesota. Their numbers, though still fair, are not as large as they once were (Roberts 1932, Green and Janssen 1975, Johnson 1982). Little information regarding population size, nest and roost location and usage, roost site habitat requirements, and foraging ranges for Minnesota Turkey Vultures is extant. Localized populations of vultures throughout the state suggest that certain habitat types are preferred. A summer population of approximately 100 Turkey Vultures, and the occurrence of 4 communal roosts, in north central Fillmore county suggest that this area is attractive to vultures. Roberts (1932) suggested that Turkey Vultures nested in SE Minnesota, and Gardner (1974) described three nests in the Root River Valley of Fillmore county. Investigation into the life history of the Turkey Vulture, particularly in this area, would establish much needed baseline data on the species. A study area was chosen within the Root River

valley area of Fillmore county, Minnesota in an attempt to determine the following objectives:

1. To locate all nest and roost sites within the Root River Valley of Fillmore county, Minnesota.
2. To determine habitat requirements associated with roost sites.
3. To estimate the foraging ranges of vultures roosting in the study area.
4. To describe nest sites and nestling development in the study area.
5. To determine roost usage within the study area.

STUDY AREA

The 34,500 ha Root River Valley Study Area (RRVSA) was located in north central Fillmore county, Minnesota (Figure 1). Fillmore county has 140,000 ha of cultivated land, 35,000 ha of forested land, and 46,000 ha of pasture and open land (Spadaccini 1985). Average yearly precipitation and average yearly temperature for Rochester, Minnesota, 22 km NW of the study area, is 71.8 cm/year and 6.4 °C respectively (National Weather Service, Rochester, MN pers. comm.). The average growing season is 142 days. Within the RRVSA, forests occur mainly along the Root River and its tributaries were bluffs of limestone, ddolomite, and sandstone rock formations are common. Above the forested valleys, agricultural land predominates. The mix of forested and agricultural areas represents good vulture habitat (Coleman 1985). Vultures within the RRVSA have access to wild and domestic carrion types, as well as potential roosting and nesting sites.

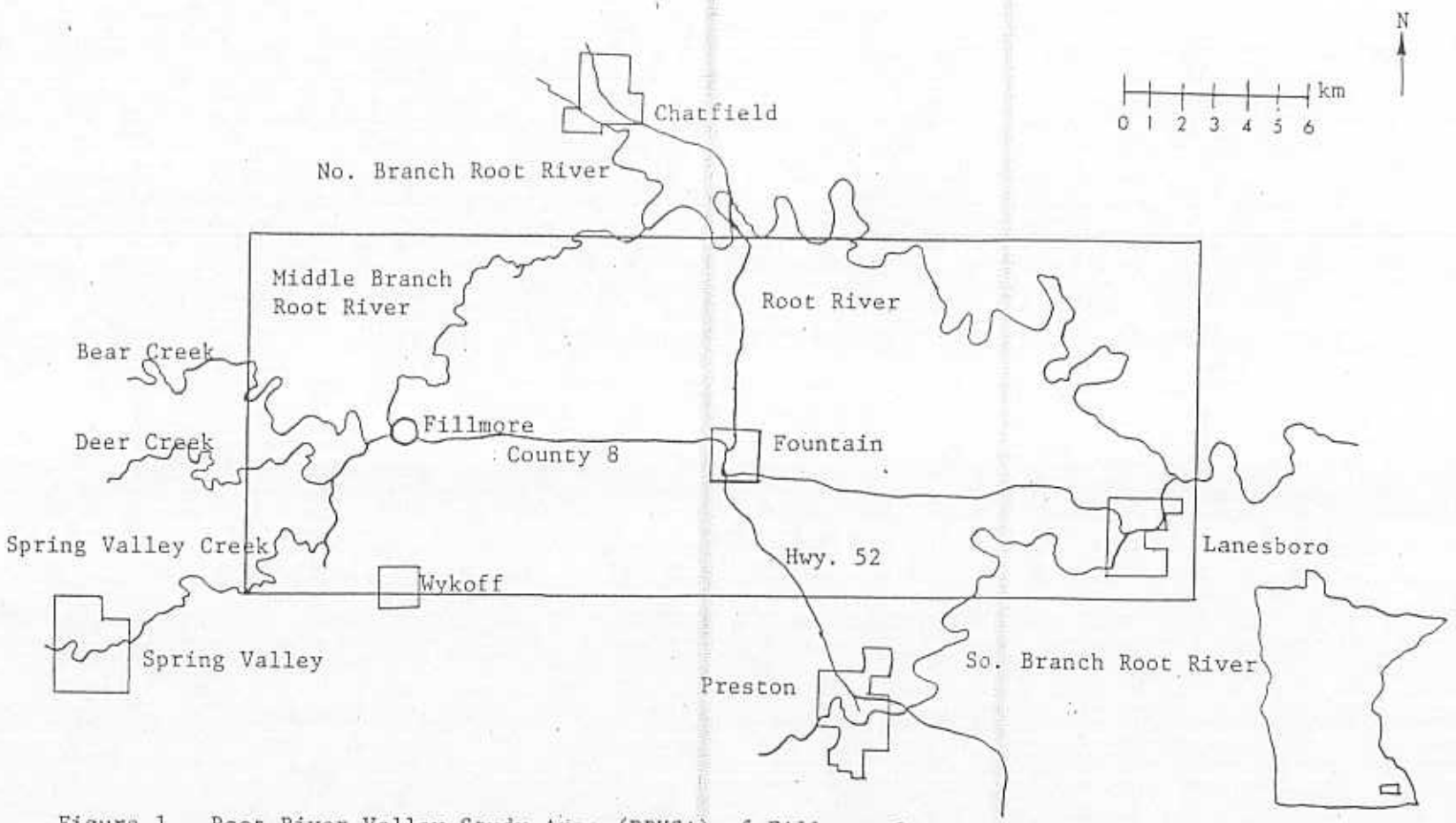

Figure 1. Root River Valley Study Area (RRVSA) of Fillmore County, Minnesota.

METHODS

Trap Sites and Trapping

In an attempt to place patagial markers and radio transmitters on free ranging Turkey Vultures, 6 trap sites were established within the RRVSA (Figure 2). To facilitate trap placement, areas chosen were level to gently sloping, open and grassy. Bait consisted of road killed wild animals collected under a Minnesota Department of Natural Resources Special Permit and dead domestic livestock obtained at an area rendering plant. Capture techniques included a noose carpet and a rocket net. The noose carpet, a modified bal chatri, was constructed on a 1.2 m X 1.2 m piece of 0.63 cm hardware cloth with 500 ten pound monofilament nooses attached. An area in the center of the noose carpet was left free of nooses for bait placement. A rocket net was used late in the 1984 field season and exclusively in the 1985 field season. Vegetation that may have interfered with rocket net performance was cleared in all cases prior to trap and bait placement. Trap sites were established and baited no less than 2 weeks prior to capture attempts in an effort to establish habitual and consistent visits by area

vultures. Fresh carcasses were deposited every second or third day, depending on vulture feeding rates and bait decay. 8 variables were measured on all vultures captured at RRVSA trap sites (Table 1).

Tagging

It has been demonstrated that U.S. Fish and Wildlife Service leg bands cause restrictions to the legs of Turkey Vultures due to fecal material accumulation, leading to foot and leg loss (Henckel 1976). Patagial markers have proven to be a safe and effective method for marking Cathartid vultures (Wallace et al. 1980, Sweeney et al. 1986). All captured vultures were fitted with vinyl wrap-around patagial streamers following Sweeney (1984). Streamer lobes, one on each side of the wing, measured 15 cm X 9 cm. The yellow markers were secured to one or both wings using 1 in cattle ear tag buttons. Both the securing button and the patagial streamer were printed with a black alpha-numeric code, M01 through M99. Care was taken to avoid flight muscles and tendons when attaching tags.

Nest Searches

Prior to 1984, 19 Turkey Vulture nest records

were recorded for Minnesota including Hennepin, Traverse, Nicollet, Becker, Jackson, Clearwater, Beltrami, St. Louis, Fillmore, Mahnomen, Aitkin, and Wabasha counties (Johnson 1983). Of these, 3 (16%) were located within the RRVSA (Gardner 1976, Paul Gardner, Per. Comm.).

Potential nest habitat was located using 1:24,000 topographic maps, road, and foot surveys. Search effort was concentrated in forested areas where rock outcrops were located, and in areas where historical records or local residents indicated possible vulture nests. When a potential nest cavity was found, such as a cave or hollow tree, a careful search was made for vulture droppings and/or feathers in and around the site. Physical characteristics relative to each active nest site were recorded (Table 2). Subsequent visits to active nests allowed observations of nestling development and behavior (Table 3). To avoid interference with nestling wing feather development, all young vultures captured at nest sites, with one exception, were fitted with patagial streamers just prior to fledging.

Radio Telemetry and Foraging Ranges

5 battery powered and 2 solar powered radio

transmitters were purchased from Cedar Creek Bioelectronics Laboratory in June 1985. Transmitters were of a back package design and secured with TEFLON ribbon. The battery powered transmitters were cylindrical with a length of 10.5 cm and a diameter of 2 cm and contained two 3V PANASONIC lithium batteries. Average weight was 65 g. and life expectancy was estimated at 12 to 15 months. The solar powered transmitters were rectangular, with dimensions 5 cm X 1.8 cm X 1.5 cm. Average weight was 44 g and and life expectancy was unlimited. 1 solar powered and 4 battery powered transmitters were fitted to vultures by 14 July 1985. Each radio tagged vulture carried at least 1 patagial steamer. Individual vultures were tracked at random, but any 1 vulture was not followed again until all other radio tagged vultures had been tracked. Tracking was facilitated with a car top mounted 4 element antenna. Permanent fix stations were established and recorded on 1:24,000 topographic maps. Locations of foraging vultures were recorded as visual fixes or as radio fixes with 2 or radio bearings from established fix stations. All locations were plotted on a 5 m X 2.5 m map board containing 20 1:24,000 topographic maps or on

1:250,000 topographic maps. Minimum foraging ranges were determined by constructing a convex polygon for each radio tagged vulture by connecting all external loci (Mohr 1947, Hayne 1949, Odum and Kuenzler 1972). Area inside of each polygon was determined using a dot grid (Avery 1962, 1967).

Roost Sites

Turkey Vulture night roosts have been described by several authors (Davis 1974, Stewart 1978, Rabenold 1983, Wright 1984). Except for limited discussion by Roberts (1932), the location and quantitative description of Minnesota vulture roosts have not been published. The search for active roosts began in the spring of 1984 and continued throughout the study. Roosts were discovered by speaking with area residents and wildlife personnel familiar with the study area and by direct observation of vultures. Roosts were periodically observed in the morning and evening in an attempt to count leaving or arriving vultures.

In an attempt to discover consistent physical features associated with Turkey Vulture roosts within the RRVSA, certain data were collected. Roost vegetation variables were recorded when visiting roosts on foot. Additional variables were determined

using 1:24,000 topographic maps. In all cases, trees were not measured as roost trees unless more than 25% of the ground beneath the tree canopy was white with vulture droppings (Wright 1984). Point-centered quarter analysis was conducted by establishing 100 m transect lines, centered near the main roost tree in each roost (Cottam and Curtis 1953, Cox 1985). The small size of the evening roosts discovered in the RRVSA made it possible to determine the main roost tree by observations of vultures arriving at roosts, or through relative amounts of vulture excreta beneath the trees of a roost. Samples were taken at 10 m intervals along the transect line and living trees with a diameter at breast height (DBH) $\geq$ 4 cm were accepted for analysis. 14 descriptive habitat variables were determined and used to summarize the habitat associated with roosts (Table 4).

In addition, 0.04 ha circular plots were established, centered at each roost tree (James and Shugart 1970, Wright 1984). 9 variables within each plot were recorded (Table 5). 9 additional variables were recorded at each roost site (Table 6). From these measurements, 13 quantitative habitat variables relative to Turkey Vulture evening roosts

were determined and used to summarize the habitat associated with roosts (Table 7) (James and Shugart 1970).

Table 1. Turkey vulture morphometric variables measured at RRVSA trap sites in 1985.

Variable	Description
Length of wing cord (flat)	Length (cm) measured from the wrist joint to the tip of the longest primary.
Length of tarsus	Length (mm) of the tarsometatarsus.
Weight	Weight (g) as recorded with a 3 Kg tubular spring scale.
Condition estimate	Determined by feeling pectoral muscle fullness relative to keel (good, fair, poor).
Facial warts	Presence or absence of facial warts, thier location and abundance.
Head color	Red or grey.
Beak color	Amount (%) of darkness compared to normally all white beak of adults.
Age	Young or adult as determined by head and beak color (Friedman 1950).
Molt progress	Remiges examined for feather loss, blood quills, etc.
Other marks or abnormalities	Lateral brood patches, injuries, etc.

Table 2. Physical characteristics recorded at active nest sites in Minnesota in 1984 and 1985.

Characteristic	Description
Nest type	Cave, hollow log, abandoned building, etc.
Location	Legal description of active nest location
Aspect	Direction (compass azimuth) of main entrance.
Entrance dimensions	Height and width (m) of nest entrance
Cavity dimensions	Height, width, and depth (m) of nest cavity.
Mutes or feathers in nest	Presence or absence of vulture excreta and/or adult feathers in nest cavity.
Number of eggs or young	Number of eggs or young in nest on date discovered.
Age of young	Age as determined by adult feather development (Ritter 1983). Helpful in determining laying dates and hatching dates, if not known.
Success	Fate of eggs or young, fledging date.

Table 3. Turkey vulture nestling development variables measured at active nest sites in Minnesota in 1984 and 1985.

Variables	Description
Head color	Head color of nestlings (black, dark grey, light grey).
Beak color	Amount (%) of darkness compared to normally all white beak of adults.
Length of wing cord (flat)	Length (cm) measured from the wrist joint to the tip of the longest developing primary.
Length of tarsus	Length (mm) of the tarsometatarsus.
Weight	Weight (g) as recorded with a 3 Kg tubular spring scale.
Feather development	Appearance and extent of adult feather development (rectrices, remiges, upper and lower wing coverts, and body contour feathers).
Age	Age as determined by adult feather development (Ritter 1983). Estimated at each visit.
Behavior	Behavior exhibited by young (vocalizations, vomitting, defacation, biting, etc.).

Table 4. Descriptive habitat variables as determined with point-centered quarter analysis (Cottam et al. 1953, Cox 1985). 100 meter transect lines were centered at the main roost tree in each roost as determined by relative abundance of fecal material. Only trees with DBH $\geq$ 4 cm were included.

Variable	Description
Total DBH	Diameter at breast height measurements (cm) summed for each species (Avery 1967).
Total basal area	Basal area summed for each species.
Average dominance values	Total basal area values for each species divided by the number of individuals of the species.
Mean point to plant distance	Mean distances from sampling points (m) to the nearest 4 trees in each quarter summed for each species.
Mean area per plant period	Total point to plant distances summed for all trees and divided by total number of trees sampled and then squared (m^2).
Total density of all species	Unit area (10,000 square meters per hectare) divided by the mean area per plant period. Indicates individuals per hectare.
Average Dominance value	Basal area values for each species summed and divided by the number of individuals of the species.

Table 4.--continued.

Variable	Description
Relative density	Individuals of a species divided by total individuals of all species, then multiplied by 100.
Density	Relative density of a species divided by 100, then multiplied by total density of all species.
Dominance	Density of a species multiplied by average dominance values for the species.
Relative dominance	Dominance for a species divided by total dominance for all species, then multiplied by 100.
Frequency	Number of sample points at which species occurred divided by total number of points sampled.
Relative frequency	Frequency value for a species divided by total frequency values for all species, then multiplied by 100.
Importance value	Relative density + relative dominance + relative frequency.

Table 5. Variables measured within 0.04 ha circular plots centered at turkey vulture roost trees located within the RRVSA. Only trees with DBH $\geq$ 4 cm were included.

Variables	Description
Number of trees	Total number of trees within each plot.
Number of tree species	Total number of tree species represented within each plot.
Tree DBH	Diameter at breast height measurements (cm) for all trees within each plot taken with tree diameter tape.
Tree height	Height of all trees (m) within each plot measured with a SPIEGEL RELASKOP.
Basal area	Basal area values were averaged for each species and for total trees present.
Canopy coverage	Canopy coverage (%) based on 56 spherical densiometer readings taken along eight main compass bearings from each roost tree (modified from James and Shugart 1970).
Understory stem density	Density (stems/ha) of shoulder height, non-overstory, woody stems along two perpendicular 22.5 m transects in each 0.04 ha plot (James and Shugart 1970).
Slope	Maximum ground slope (degrees) in each 0.04 ha plot (Wright 1984).

Table 5.--continued.

Variable	Description
Relative roost tree height	Height of roost tree divided by average of four tallest non-roost trees within each 0.04 ha plot.

Table 6. Additional variables measured at each roost site within the RRVSA.

Variable	Description
Roost tree lowest limb height	Height to lowest limb on each roost tree measured with SPIEGEL RELASKOP.
Crown diameter	Diameter of roost tree crown using tape line and stick (Andresen and McCormick 1962)
Perpendicular crown diameter	Diameter of roost tree crown along a tape line perpendicular to crown diameter tape line.
Distance to nearest roost tree	Distance (m) from roost tree to nearest roost tree using a 100 m tape.
Distance to nearest clearing and type	Distance (m) from roost site to nearest clearing using a 1:24,000 topographic map.
Distance to nearest water and type	Distance (m) from roost site to nearest water using a 1:24,000 topographic map.
Distance to nearest human activity area and type	Distance (m) from roost site to nearest human activity area using a 1:24,000 topographic map.
Elevation 1	Elevation at roost site using a 1:24,000 topographic map.
Elevation 2	Elevation at roost site minus lowest elevation within 500 meters using a 1:24,000 topographic map.

Table 7. Quantitative habitat variables relative to turkey vulture evening roosts as measured within 0.04 ha circular plots centerd at each roost tree within the RRVSA (James and Shugart 1970).

Variable	Description
Trees by diameter size class	All trees recorded placed into one of eight diameter size classes by species.
Trees/ha by diameter size class	Number of trees/ha in each diameter size class.
Trees/ha by species	Number of trees of a species/ha.
Relative density by diameter size class	Trees/ha by size class divided by total trees/ha, then multiplied by 100.
Relative density by species	Trees/ha by species divided by total trees/ha, then multiplied by 100.
Basal area by diameter size class	Total basal area for a species in each diameter size class.
Basal area by species	Total basal area for a species.
Basal area/ha	Total basal area of a size class/ha.
Relative basal area	Total basal area of a size class divided by total basal area of all size classes, then multiplied by 100.

Table 7.--continued.

Variable	Description
Relative dominance	Total basal area for a species divided by total basal area for all species, then multiplied by 100.
Frequency	Number of circular plots (% of total) in which a species occurred.
Relative Frequency	Frequency for a species divided by total frequency of all species, then multiplied by 100.
Importance Value	Relative density + relative dominance + relative frequency.

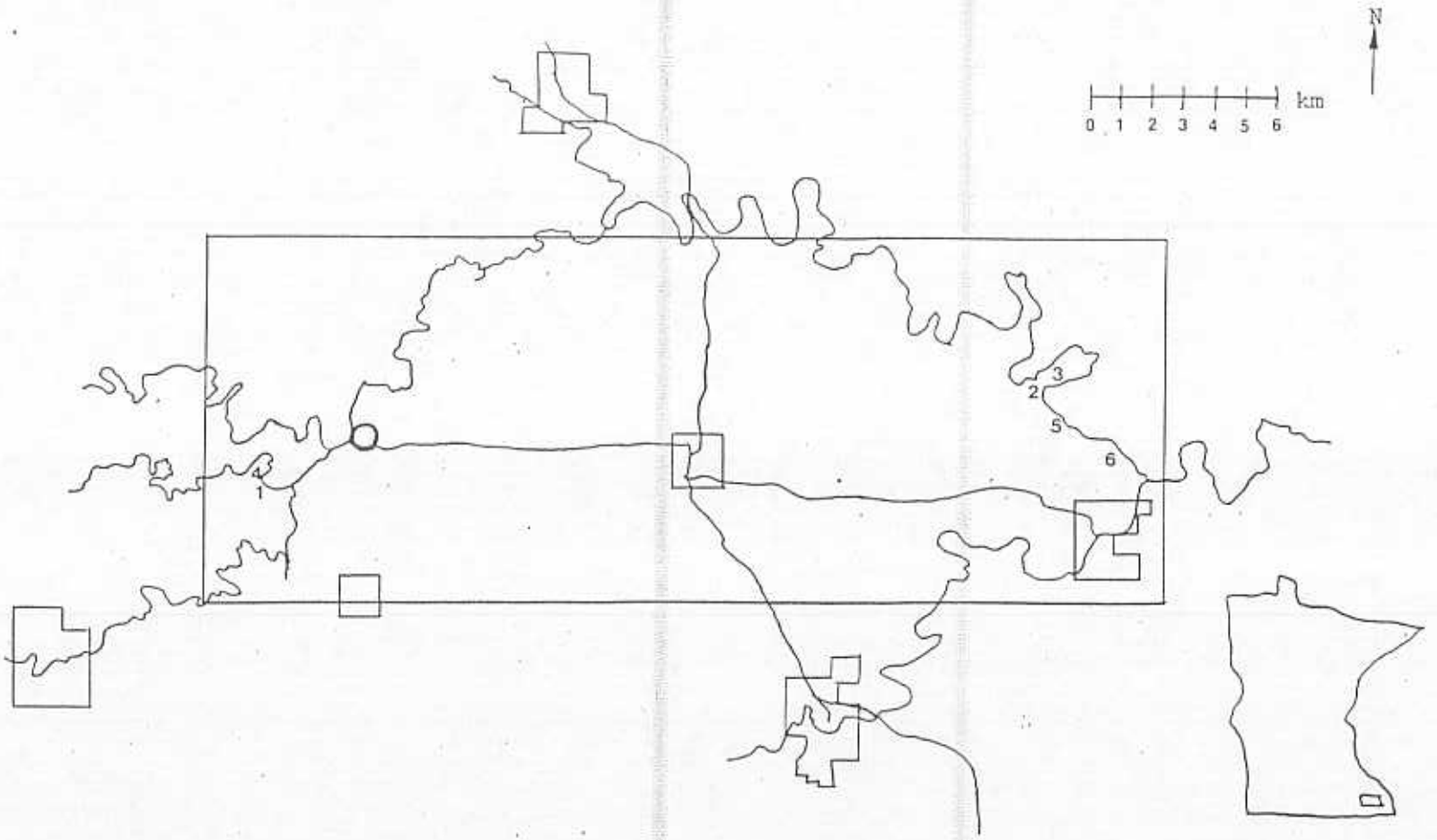

Figure 2. Location of 6 trap sites used within the RRVSA in 1984 - 1985.

RESULTS

Trap Sites and Trapping

Turkey Vultures were captured at 3 of the 6 trap sites used during the study. Successful sites afforded feeding vultures an unobstructed view in at least 2 directions and had no less than 1 large dead tree nearby allowing perched vultures to view the carcasses. The noose carpet was used 12 different days in July and August 1984 at bait site 1. On 16 occasions Turkey Vultures arrived to feed while the noose carpet was in place. In all cases, vultures walked around the trap, seemingly hesitant to step on the trap's hardware cloth foundation. At no time did a vulture become entangled in the noose carpet. All bait site capture attempts from August 1984 to September 1985 were made at sites 4, 5, and 6, and accomplished using a rocket net. The rocket net was fired 5 times resulting in the capture of 14 vultures, an average of 2.8 vultures per capture attempt (Table 8). Morphometric characteristics relative to each trapped vulture were measured (Table 9). Wing cord, tarsus length, and weight measurements of vultures captured

at trap sites averaged 513 mm (± 13.1 SE), 70 mm (± 2.5 SE), and 1956 g (± 179 SE) respectively. Beak color for adult Turkey Vultures averaged 10% dark. Pectoral muscle fullness in all but 2 individuals was good. M18, the 1 juvenile Turkey Vulture captured at a trap site, demonstrated wing cord and weight measurements of 521 mm and 2450 g respectively. This was larger than the adult average wing cord and weight measurements of 512 mm (± 13.6 SE) and 1918 g (± 119 SE) respectively.

Tagging

Vinyl streamers were attached to at least 1 wing on 18 of the 19 Turkey Vultures captured during the study. 1 adult vulture captured at trap site 4 on 14 July 1985 was previously tagged near Baraboo, Wisconsin and carried a blue-green patagial streamer on its left wing with the alpha-numeric U30. Visability of the tags was good. The alpha-numeric code on the tag of a perched vulture could be read at distances up to 1250 m using a 15-60 X 60 mm spotting scope. All vultures appeared to adjust quickly to the streamers and no differences were detected when observing the simultaneous flight of tagged and

untagged vultures.

Sightings of tagged vultures occurred periodically during the study. M01 and M02, 2 nestlings tagged on the Red Lake Wildlife Management Area in 1984, were later observed soaring near their nest site (Johnson 1985). M01 was sighted near Fayetteville, Iowa on or near 16 November 1984 (Figure 9). M02 was discovered alive but unable to fly on a farm south of Cresco, Iowa on 16 November 1984 and was euthanized (Figure 3). M03 and M04, 2 nestlings tagged in the RRVSA in 1984, were later observed soaring near their nest site. M05, tagged on 15 June 1985, was later observed on 30 July 1985 in a pasture with 14 other Turkey Vultures 3.2 km from where it was captured. M08, tagged on 23 June 1985, was later observed at communal roost 2 on 22 July 1985, 3.1 km from where it was captured. M12, tagged on 14 July 1985, was resighted on 23 July, 20 August, and 1 September 1985 (Figure 4). M12 was the only vulture observed near both major roosting areas located in the RRVSA.

Nesting

The RRVSA was searched for active Turkey Vulture

nests from 29 May 1984 to 6 July 1984 and from 26 May 1985 to 22 July 1985 (Figure 5). 31 potential nest sites were discovered (Table 10). 15 of the caves (79%) and 3 of the overhangs (60%) discovered contained mammal scats and/or hair, the majority of which was Raccoon or Groundhog. The occupation of potential nest cavities by these mammals may, in part, account for the small number of active nests discovered. Alternatively, the digging activity of these mammals may create additional cavities suitable for Turkey Vulture nesting.

Of the 31 potential nest sites discovered, 1 was active in 1984. That active nest was located in a cave at the base of a limestone outcrop overlooking the Root River in Pilot Mound twp., Fillmore county. The cave's single entrance measured 1.2 m in width by 0.23 m in height. The aspect of the cave entrance was 145^{o}, the slope was aproximately 45^{o}, and the canopy coverage was > 80%. The nest cavity was located 1.8 m back from the cave entrance and measured 0.7 m wide by 0.5 m deep. No foreign nest material was evident and the cave floor was dry. 2 downy nestlings were present upon discovery on 16 July 1984. Developmental progress was checked and measurements were taken on 3

occasions (Table 11). Feather development exhibited by the chicks when discovered indicated their age to be 32-35 days and that the eggs were probably deposited between 3 May 1984 and 13 May 1984, assuming a 30 to 40 day incubation period (Jackson 1983). Both nestlings were fitted with patagial streamers, M03 and M04, on 15 August 1984 after flight feathers, upper wing coverts, and under wing coverts were well developed.

2 additional nests were discovered in Minnesota during the study. The first was located in Minnie twp., Beltrami county and contained 2 downy nestlings when discovered on 5 July 1984 (Johnson 1985, David Johnson, per. comm.). The 2 Nestlings were fitted with patagial streamers, M01 and M02, on 8 August 1984. Feather development exhibited by the young indicated their age to be 40 days and that the eggs were deposited between 19 May 1984 and 29 May 1984.

The second nest discovered outside the RRVSA was located in a large hollow tree 4.2 km SW of Kellogg, Wabasha county. The tree, a dead American Elm, was located on the edge of a grassy meadow and was surrounded by a Prickly Ash and raspberry shrub layer. The opening to the nest cavity was located 2.03 m

above the ground and measured 1.52 m high by 0.82 m wide. The actual nest site was 1.42 m below the opening, 0.62 m above ground level. The inside diameter of the nest cavity was 71 cm and the outside diameter (DBH) was 129.2 cm. 2 nestlings were in the nest cavity on 14 August 1985. One nestling was sufficiently volant and escaped capture as the nest was approached. The remaining nestling, M14, was captured and morphological characteristics were recorded (Table 12). Feather development when captured suggested that the eggs were deposited between 4 May 1985 and 14 May 1985.

Foraging Ranges

Of 5 Turkey Vultures fitted with radio transmitters, 4 were successfully tracked. M10 escaped from its radio transmitter several days after attachment by biting through the TEFLON ribbon harness. Turkey Vultures were tracked for 142 hours from 26 June 1985 to 6 September 1985. 112 fix stations were established, located in Fillmore, Houston, and Winona counties in Minnesota, and Allamakee and Winneshiek counties in Iowa. 330 fixes, including 43 radio and 287 visual, were used to determine the maximum foraging ranges utilized by the

4 radio tagged vultures. Foraging ranges for M06, M07, M09, and M11 were determined using 105, 85, 69, and 71 fixes respectively. All radio tagged Turkey Vultures were captured near, and regularly used, roost 2, which was considered their central hub of activity. 40 to 50 vultures often departed from roost 2 simultaneously. Small groups of birds would then disperse to forage and feed. M06 was never observed farther then 14.5 km from roost 2 and foraged within a 12,840 ha area, the smallest foraging range of the radio marked vultures (Figure 6). M09 foraged within a 18,580 ha area and always remained within 26.7 km of roost 2 (Figure 7). M07 foraged more extensively then any of the other radio marked vultures, travelling 82.4 km on 15 July 1985 when it was followed to the Upper Iowa River near Hanover, Allamakee county, Iowa. It foraged within a 122,750 ha area and often did not return to roost 2 for several days (Figure 8). M11 also foraged extensively utilizing an area of 47,140 ha while never travelling farther the 35.2 km from roost 2 (Figure 9). The average foraging range was 50,330 ha.

M12, though never radio tagged, was observed on 3 occasions after it was fitted with patagial

streamers. When connected, those observation points suggest a foraging range of no less then 5,622 ha (Figure 10).

Roosting

4 permanent evening roosts were discovered within the RRVSA (Figure 11). Roost 1 was located on top of a NW facing slope along the Root River. The 2 White Pines used for roosting had an average DBH and average crown height of 91.7 cm and 23.2 m respectively. Turkey Vultures were first observed using roost 1 on 16 May 1984 and again on 9 April 1985. In 1984 and 1985, roost 1 was used nightly by Turkey Vultures until leaf-out was complete in May (Figure 12). From that time, until fall migration, area vultures, instead, used roost 2, 1.2 km to the N (Figures 13 and 14). Roost 2 was located near the top of an E facing slope also along the Root River. The 3 Cottonwood trees used for roosting had an average DBH and average crown height of 46.3 cm and 27.1 m respectively. Roost 3, 25 km W, SW of roosts 1 and 2, was located at the top of a S facing slope along Deer Creek. A stand of Cottonwood trees was used sporadically for the entire season in 1984, and from March to the end of April in 1985 (Figure 15). Roost 4, located in a small

N, NE facing coulee 2.5 km NE of roost 3, was used on 3 occasions in 1984, and from June to August in 1985 (Figure 16). The single, dead American Elm used for roosting had a DBH and crown height of 53.6 cm and 21 m respectively.

All roost areas, except roost 4, were within 200 m of running water (Table 13). The single tree used at roost 4 was within 10 m of a drainage bed, dry most of the year. All roost areas were within 220 m of an opening; a hay field for roost 1, grassy meadow for roost 2, and corn fields for roosts 3 and 4 (Table 13). All roost areas were at least 500 m from a human activity area; a single home for roost 3, farm homes and buildings for roosts 1, 2, and 4 (Table 13). Distance to nearest water, distance to nearest opening, and distance to nearest human activity areas averaged 320 m (± 309 SE), 119 m (± 72 SE), and 662 m (± 198 SE) respectively. No data relative to roost trees were collected at roost 3 due to inconsistent use of specific trees by roosting vultures. Unless stated, future references to "roosts" exclude roost 3.

At 2 of 3 roosts, tree species used for roosting had larger relative dominance values than other tree species sampled, based on point-centered quarter
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calculations (Tables 14, 15, and 16). Only at roost 1 did the tree species used for roosting have the largest importance value (Tables 14, 15, and 16). Total density at all 3 roosts averaged 1176 trees/ha (± 100 SE).

All roost trees had large, stout, horizontal branches used for perching. Accumulations of broken limbs beneath roost trees was common. Large DBH, crown height, and canopy coverage values were typical of roost trees (Table 17). For roosts 1 and 2, distances from a roost tree to the nearest other roost tree averaged 10.5 m (± 6.2 SE). Elevation at roost areas, and elevation of roost areas less the lowest elevation within 500 m, including roost 3, averaged 338 m (± 42.8 SE) and 42 m (± 25.7 SE) respectively.

200 non-roost trees, including 13 species, were measured within 6 0.04 ha circular plots. Non-roost trees/plot ranged from 21 to 48 and averaged 34 (± 9 SE). Due to small distances between some roost trees, several plots overlapped and 42 trees (21%) were recorded in more than 1 plot. Duplicate measurements of non-roost trees were omitted from the following analysis. DBH, basal area, and crown height of non-roost trees within the 6 plots averaged 20.4 cm

(± 12.9 SE), 474 cm (± 563 SE), and 11.7 m (± 2.8 SE) respectively (N = 158), (Table 18).

All trees within the 6 plots were grouped into 8 diameter size classes by species (Table 19). 110 (67%) of the trees measured were within the first 2 diameter size classes (4 to 16 cm DBH), (Table 19). Of those, Ironwood and Sugar Maple accounted for 42% (N = 46) and 32% (N = 35) respectively (Table 19). 11 trees, 6.7% of all trees within the 6 plots, were >46 cm DBH, 5 of which were roost trees (Table 19). An additional 5 trees were Red Oaks, none of which were used for roosting (Table 19). 683 trees/ha was estimated from the 6 0.04 ha plots, 58% of the figure determined above based on point-centered quarter calculations. The 3 roost tree species account for 45.7% of the relative dominance values (Table 19). Importance values for the roost species were 35.2, 31.6, and 19.3 for American Elm, Cottonwood, and White Pine respectively, giving a combined total of 86.1 (Table 19). For non-roost trees, Red oak had the highest relative dominance value (30.2%) and the highest importance value (56.2) of all tree species sampled (Table 19).

Table 8. Turkey Vultures captured at bait sites within the RRVSA in 1985.

Alpha-numeric code	Wings Tagged	Age	Bait Site
M05	Both	A	5
M06*	L	A	5
M07*	R	A	5
M08	Both	A	5
M09*	L	A	5
M10*	R	A	5
M11*	Both	A	5
M12	Both	A	5
M13	Both	A	5
U30	L	A	5
M15	Both	A	4
M16	Both	A	4
M17	Both	A	4
M18	Both	HY	6

* Indicates vultures fitted with radio transmitters.

Table 9. Turkey Vulture morphometric characteristics collected at trap sites within the RRVSA in 1985.

Alpha-numeric Code	Wing Cord (mm)	Tarsus (mm)	Weight (g)	Condition	Warts	Head Color	Beak Color (% dark)
M05	520	69	2030	Good	E, N	Red	50
M06	537	73	2175	Good	H, E, N	Red	0
M07	499	68	1725	Good	H, E, N	Red	0
M08	500	73	1860	Good	H, E, N	Red	0
M09	532	70	1900	Good	H, E, N	Red	0
M10	506	67	1905	Good	H, E, N	Red	0
M11	503	74	1905	Good	H, E, N	Red	10
M12	510	68	1980	Good	H, E, N	Red	0
M13	489	66	1710	Good	E	Red	40
M15	522	72	1945	Fair	E	Red	10
M16	502	67	1880	Good	H, E	Red	0
M17	522	68	1885	Good	H, E, N	Red	0
M18	521	69	2450	Good	None	Grey	90
U30*	518	71	2040	Fair	H, E, N	Red	15

* = previously tagged near Baraboo, Wisconsin
H = head
E = eyes
N = neck

Table 10. Potential nest sites discovered within the RRVSA during nest searches in 1984 and 1985.

Potential Nest Type	Number	% of Total
Cave	19	61
Overhang	5	16
Abandoned Building	3	10
Hollow Log	3	10
Hollow Tree	1	3
	31	100

Table 11. Development of turkey vulture nestlings discovered in the RRVSA in 1984.

	7-16-84		8-3-84		8-15-84	
	M03	M04	M03	M04	M03	M04
Weight (g)	1540	1625	@	2045	1940	2115
Tarsus (mm)	64	66	@	73	78	76
Wing Cord (mm)	200	206	@	#	445	435
Beak Color (% dark)	95	95	@	95	95	95
Condition (keel)	good	good	@	good	good	good
Warts (facial)	none	none	@	none	none	none
Head Color	black-grey		black-grey		grey	
Age*	32-35 days		46 days		53-60 days	

* determined by adult feather development (Ritter 1983)

@ unable to retrieve vulture from cave

measurement not taken

Table 12. Morphological characteristics of Wabasha County nestling, 14 August 1985.

Wing Cord (mm)	Tarsus (mm)	Weight (g)	Condition (keel)	Warts	Head Color	Beak Color (% dark)
451	59	1655	Fair	None	Grey	100

Table 13. Variables relative to evening roost areas within the RRVSA.

	Roost 1	Roost 2	Roost 3	Roost 4
Distance to nearst water	80	200	150	850
Distance to nearest clearing	30	220	300	150
Distance to nearest human activity area	1000	600	500	550
Aspect	330°	65°	170°	22°
Elevation 1 (m)	299	293	375	387
Elevation 2 (m)	24	12	58	76

Table 14. Point-centered quarter analysis of roost number 1.

	No. of Trees	Total Point to Plant Distance	Total DBH	Total Basal Area	Average Dominance Values	Density
American Elm	16	46.4	243	3609	226	512
Ironwood	11	25.2	74	459	42	352
White Pine	3	11.3	222	14573	4858	96
Blue Beech	3	4.1	21	120	40	96
Hackberry	2	7.0	28	337	168	64
Bur Oak	1	3.3	4	15	15	32
Box Elder	1	3.7	7	37	37	32
Black Walnut	1	3.3	16	199	199	32
Red Oak	1	6.6	9	57	57	32
Big Tooth Aspen	1	1.0	9	66	66	32
Total	40	111.9	633	19472		1280

Table 14.--continued.

	Rel. Density	Dominance	Rel. Dominance	Frequency	Rel. Frequency	Importance Value
American Elm	40.0	115712	18.6	.7	28.0	86.5
Ironwood	27.5	14784	2.4	.5	20.0	49.9
White Pine	7.5	466368	74.8	.3	12.0	94.4
Blue Beech	7.5	3840	0.6	.3	12.0	20.1
Hackberry	5.0	10752	1.7	.2	8.0	14.7
Bur Oak	2.5	480	0.1	.1	4.0	6.6
Box Elder	2.5	1184	0.2	.1	4.0	6.7
Black Walnut	2.5	6368	1.0	.1	4.0	7.5
Red Oak	2.5	1824	0.3	.1	4.0	6.8
Big Tooth Aspen	2.5	2112	0.3	.1	4.0	6.8
Total	100%	623424	100%	2.5	100%	300

Table 15. Point-centered quarter analysis of roost number 2.

	No. of Trees	Total Point to Plant Distance	Total DBH	Total Basal Area	Average Dominance Values	Density
Sugar Maple	20	67.5	306	5407	270	603
Ironwood	11	28.6	66	348	32	332
Red Oak	4	8.4	207	8452	2113	121
White Oak	2	4.9	55	1190	595	60
Cottonwood	2	3.5	90	3217	1609	60
Basswood	1	2.2	9	66	66	30
Total	40	115.1	733	18680		1206

Table 15.--continued.

	Rel. Density	Dominance	Rel. Dominance	Frequency	Rel. Frequency	Importance Value
Sugar Maple	50.0	162810	28.9	.9	36.0	114.9
Ironwood	27.5	10624	1.9	.7	28.0	57.4
Red Oak	10.0	255673	45.4	.4	16.0	71.2
White Oak	5.0	35700	6.4	.2	8.0	19.4
Cottonwood	5.0	96540	17.1	.2	8.0	30.2
Basswood	2.5	1980	0.3	.1	4.0	6.9
Total	100%	563327	100%	2.5	100%	300

Table 16. Point-centered quarter analysis of roost number 4.

	No. of Trees	Total Point to Plant Distance	Total DBH	Total Basal Area	Average Dominance Values	Density
Ironwood	25	73.9	203	1534	61	651
Red Oak	10	32.8	252	5700	570	260
American Elm	2	2.3	82	2908	1454	52
Sugar Maple	2	9.4	27	321	160	52
Black Walnut	1	5.6	12	113	113	26
Total	40	124.0	576	10576		1041

Table 16.--continued.

	Rel. Density	Dominance	Rel. Dominance	Frequency	Rel. Frequency	Importance Value
Ironwood	62.5	39711	14.5	.9	45.0	122.0
Red Oak	25.0	148200	53.9	.6	30.0	108.9
American Elm	5.0	75608	27.5	.2	10.0	42.5
Sugar Maple	5.0	8320	3.0	.2	10.0	18.0
Black Walnut	2.5	2938	1.1	.1	5.0	8.6
Total	100%	274777	100%	2.0	100%	300

Table 17. Variables relative to roost trees within the RRVSA.

	Roost 1		Roost 2			Roost 4	Mean (Standard Error)
	A	B	A	B	C	A	
DBH (cm)	101.9	81.6	48.2	42.3	48.5	53.6	62.7 (21.6)
Basal Area (cm^2)	8155	5230	1825	1405	1847	2256	3453 (2454)
Crown Height (m)	27.0	22.5	24.5	28.2	29.5	21.0	25.4 (3.0)
Height to lowest limb (cm)	4.0	5.0	15.5	16.2	18.5	8.5	11.3 (5.7)
Crown Diameter (m) (CD)	12.9	11.9	7.6	6.3	8.9	7.9	9.2 (2.4)
Perpendicular Crown Diameter (m) (PCD)	15.2	14.4	10.4	8.4	8.9	10.2	11.2 (2.6)
CD x PCD	196	171	79	53	79	81	111 (53)
Canopy Coverage (%)	85.7	82.4	88.5	85.3	86.3	59.7	81.3 (7.8)
Relative Roost Height	1.9	1.6	2.0	1.9	2.9	2.0	2.0 (0.4)
Slope	8°	8°	40°	45°	12°	4°	19.5° (16.5°)

Table 18. Non-roost trees located within 0.04 hectare circular plots centered at 6 roost trees within the RRVSA. Figures represent averages of all values recorded per species.

Species (number)	DBH (cm)	Basal Area (cm^2)	Crown height (m)
Ironwood (48)	7.4	50	9.7
Sugar Maple (45)	11.2	129	7.3
American Elm (23)	15.6	244	9.9
Red Oak (16)	34.8	1198	15.7
Basswood (8)	20.2	383	15.4
Box Elder (5)	17.6	279	10.0
Hackberry (4)	13.5	166	14.0
Black Walnut (3)	11.1	113	15.0
White Oak (2)	28.8	656	15.0
Cottonwood (1)	25.7	519	9.0
White Pine (1)	52.0	2124	10.2
Blue Beech (1)	9.9	77	10.0
Green Ash (1)	16.9	224	11.0
Total	264.7	6162	152.2

n.

s in all circles by size class (cm) E 28	F 28.1-34	G 34.1-40	H 40.1-46	>46	Total	trees / hectare	Relative density (%)	Basal Area (cm^2) of trees in all circles by diameter size class (cm) A	B	C	D	E	F	G	H	Total	Relative Dominance (%)	Circles in which species occurs	Frequency	Relative frequency	Importan Value
					48	200	29.4	1405	568	441	--	--	--	--	--	2414	3.8	4	67	10.8	44.0
1					45	188	27.6	1129	961	1192	1724	784	--	--	--	5790	9.1	4	67	10.8	47.5
4				1	24	100	14.7	375	441	1451	426	2909	--	--	2256	7858	12.4	3	50	8.1	35.2
	3		3	5	16	67	9.8	177	--	--	402	--	3465	4378	10721	19143	30.2	6	100	16.2	56.2
2					8	33	4.9	96	201	687	577	1506	--	--	--	3067	4.8	4	67	10.8	20.5
					5	21	3.1	--	350	--	1044	--	--	--	--	1394	2.2	2	33	5.3	10.6
			1	2	4	17	2.4	--	--	--	519	--	--	1405	3672	5596	8.8	3	50	8.1	19.3
					4	17	2.4	22	113	530	--	--	--	--	--	665	1.1	3	50	8.1	11.6
				3	3	12	1.8	--	--	--	--	--	--	--	15509	15509	24.5	2	33	5.3	31.6
					3	12	1.8	20	319	--	--	--	--	--	--	339	0.5	3	50	8.1	10.4
1					2	8	1.2	--	--	--	577	735	--	--	--	1312	2.1	1	17	2.8	6.1
					1	4	0.6	77	--	--	--	--	--	--	--	77	0.1	1	17	2.8	3.5
					1	4	0.6	--	224	--	--	--	--	--	--	224	0.4	1	17	2.8	3.8
8	3	4	11	164	683	100	Total	3301	3177	4301	5269	5934	3465	5783	32158	63388	100	37	618	100	300
33	12	17	46	683	Basal Area / Hectare by diameter size class			13755	13239	17922	21956	24727	14438	24098	134002						
4.9	1.8	2.4	6.7	100	Relative basal area by diameter size class			5.2	5.0	6.8	8.3	9.4	5.5	9.1	50.7						

Figure 3. Location of Red Lake Wildlife Management Area nest and locations in Iowa where M01 and M02 were sighted, 1984.

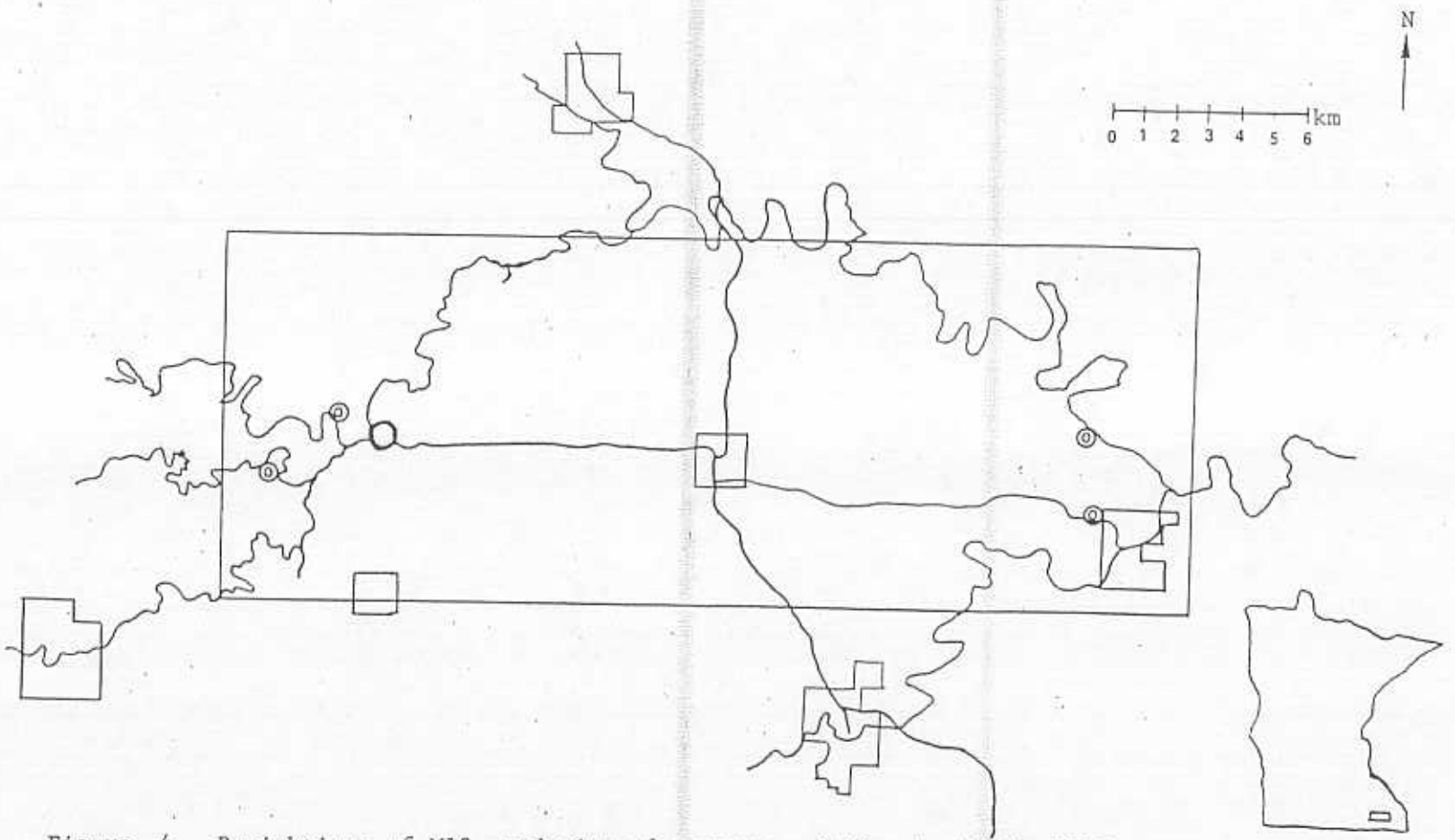

Figure 4. Resightings of M12, and site of capture, within the RRVSA, 1985.

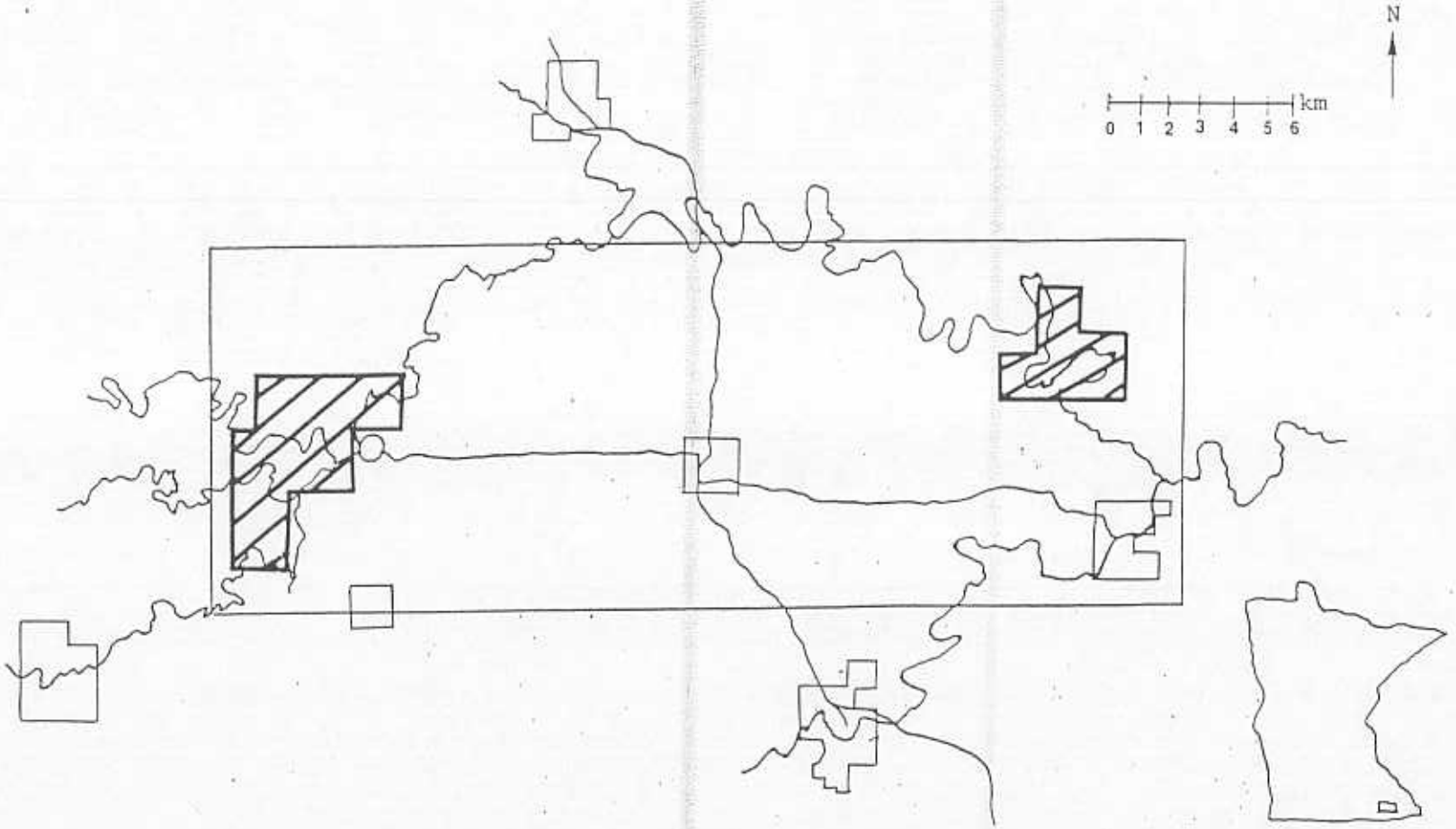

Figure 5. Areas searched for Turkey Vulture nests within the RRVSA, 1984 - 1985.

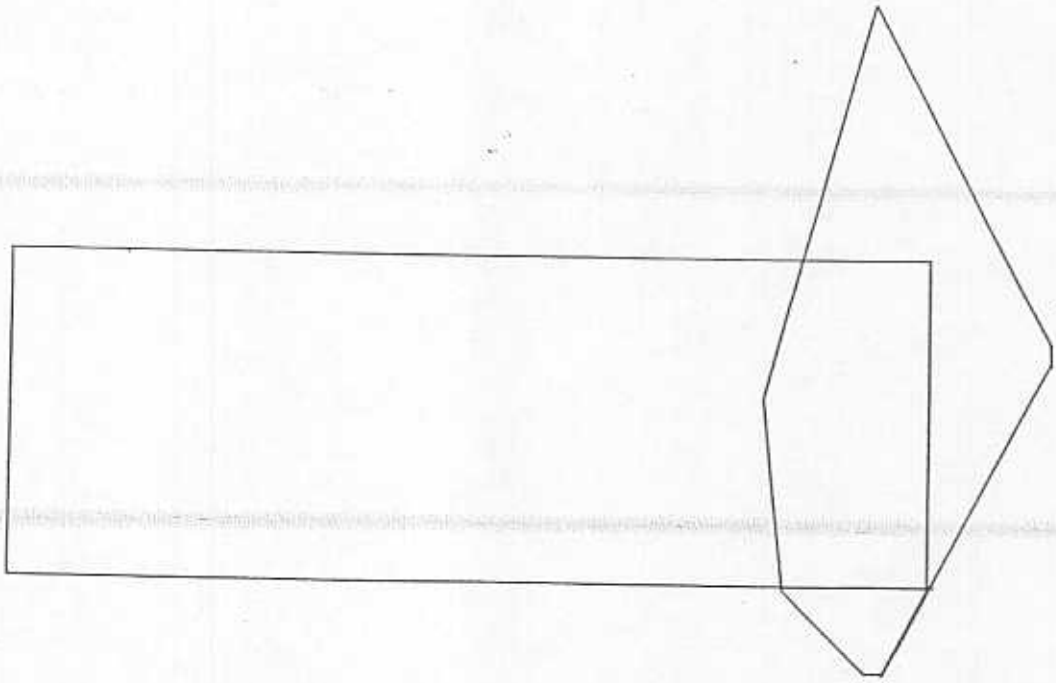

Figure 6. 12,840 ha foraging range of M06, and RRVSA.

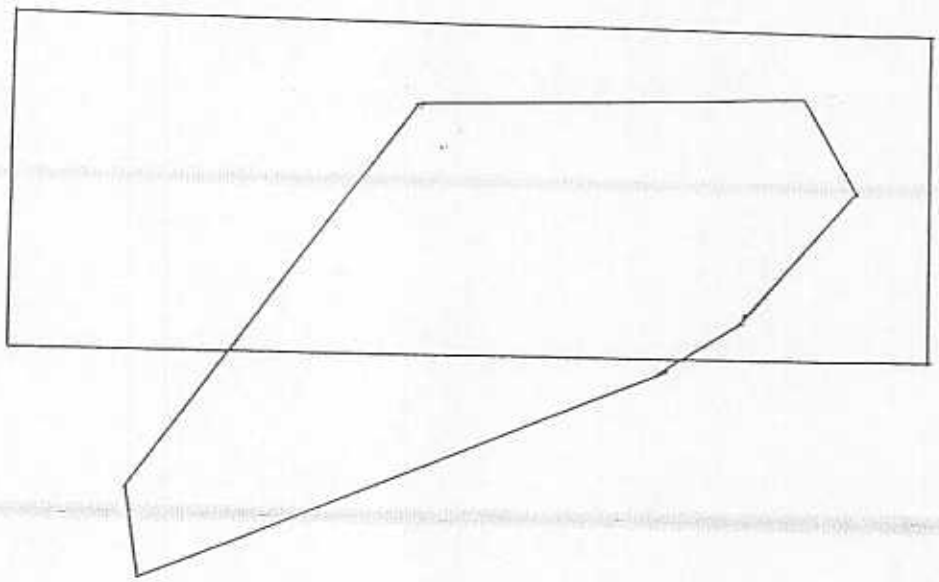

Figure 7. 18,580 ha foraging range of M09, and RRVSA.

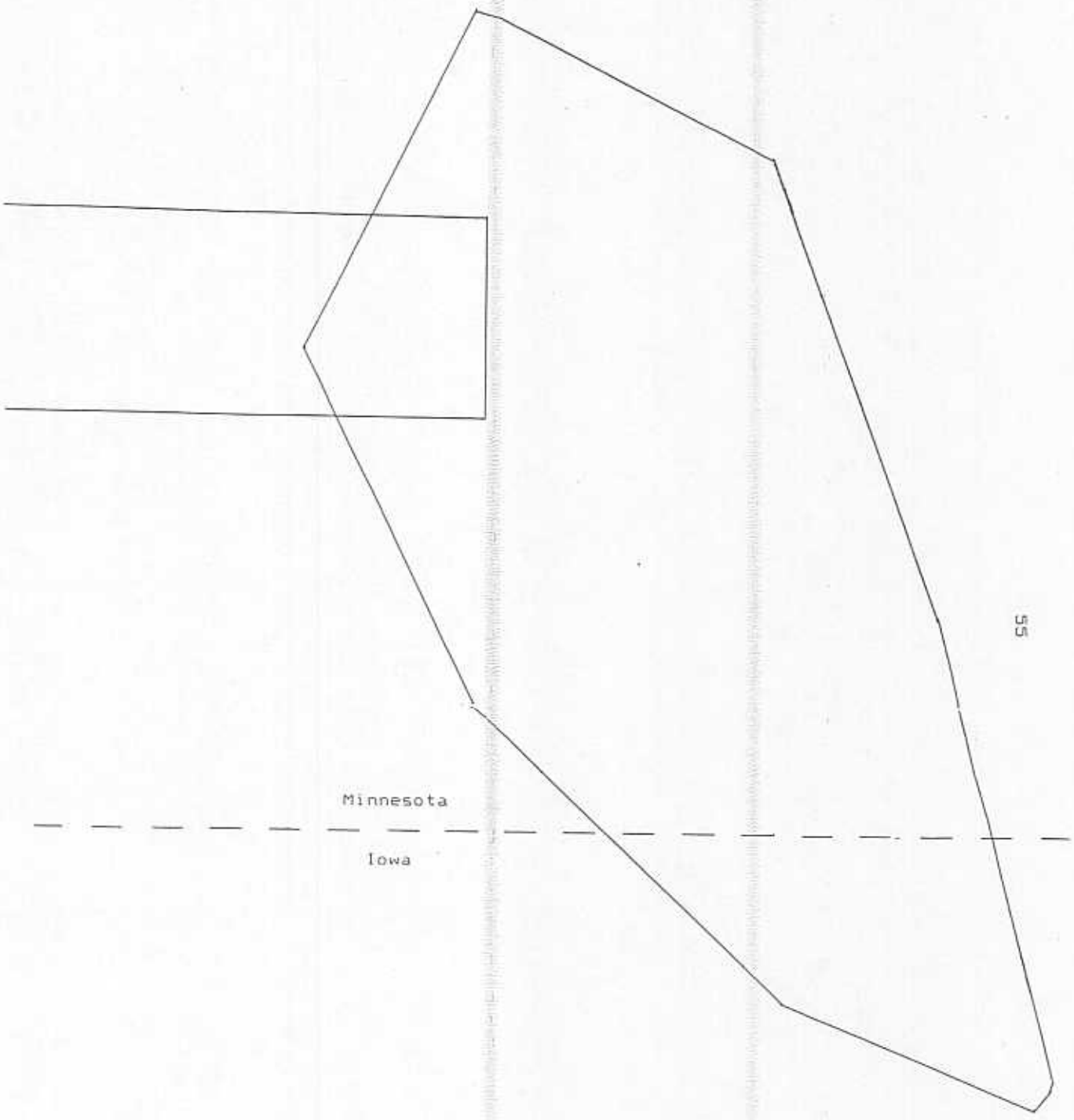

Figure 8. 122,750 ha foraging range of M07, and RRVSA.

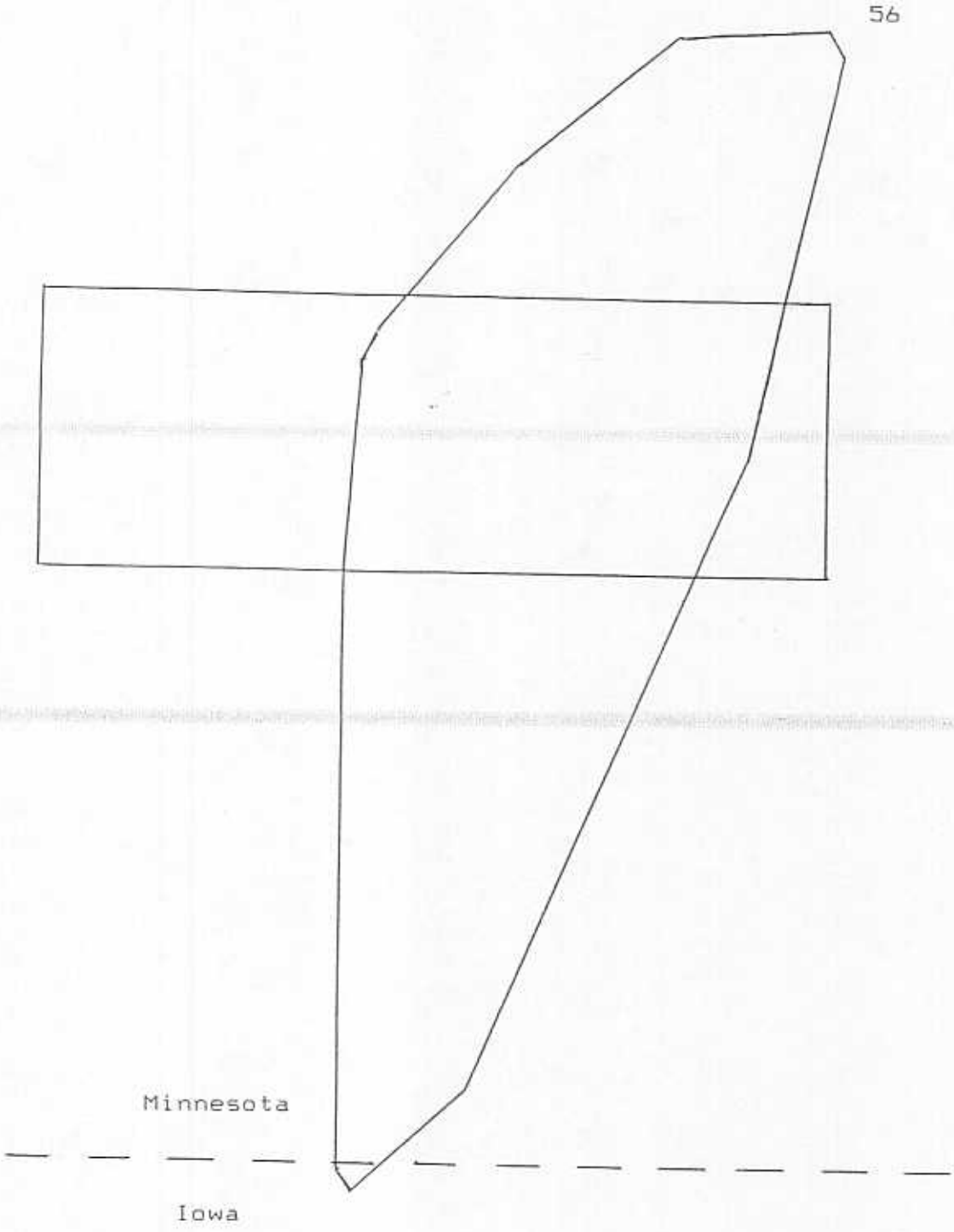

Figure 9. 47,140 ha foraging range of M11, and RRVSA.

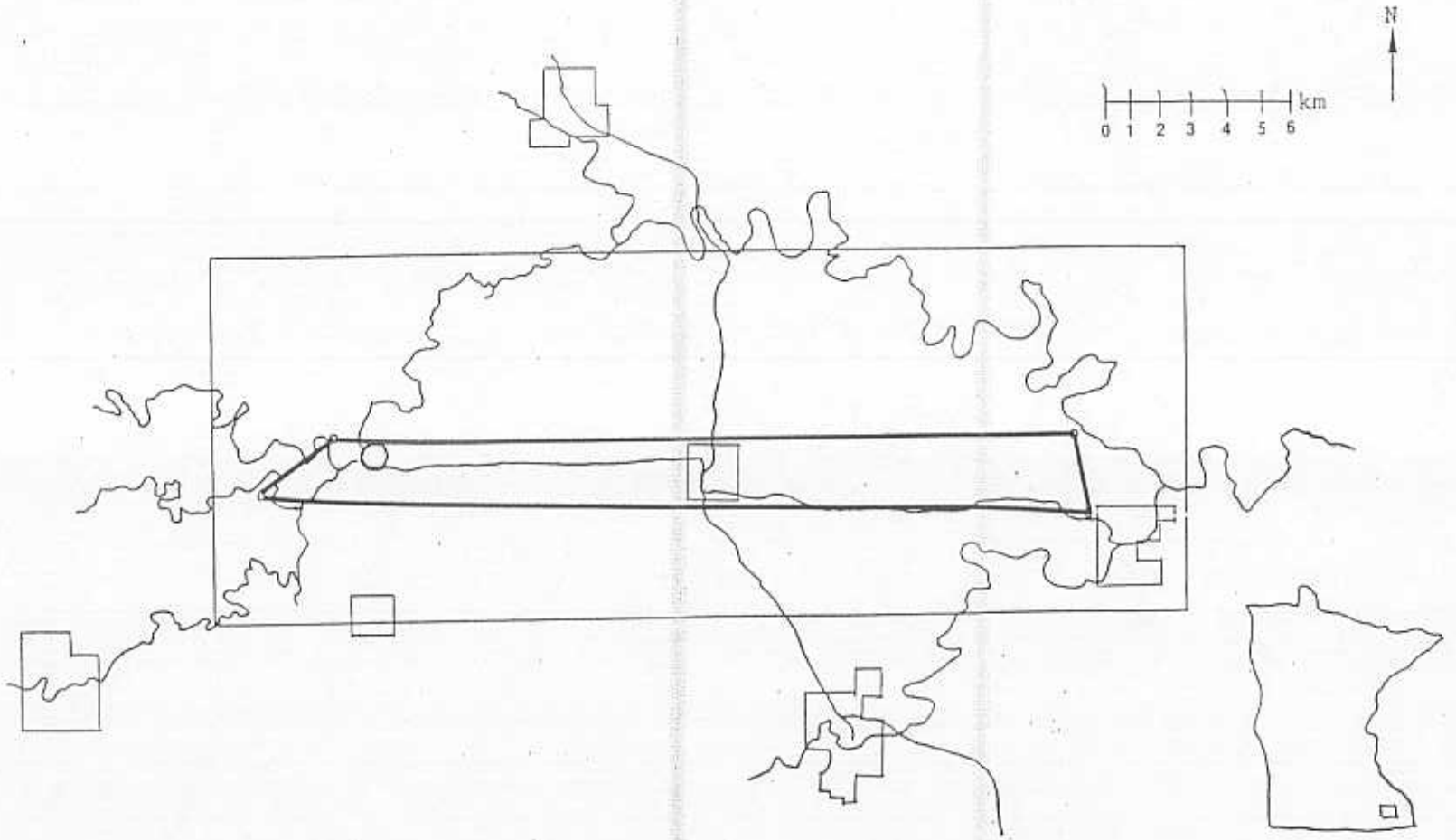

Figure 10. Minimum foraging area for M12 based on capture location and 3 resightings, 1985.

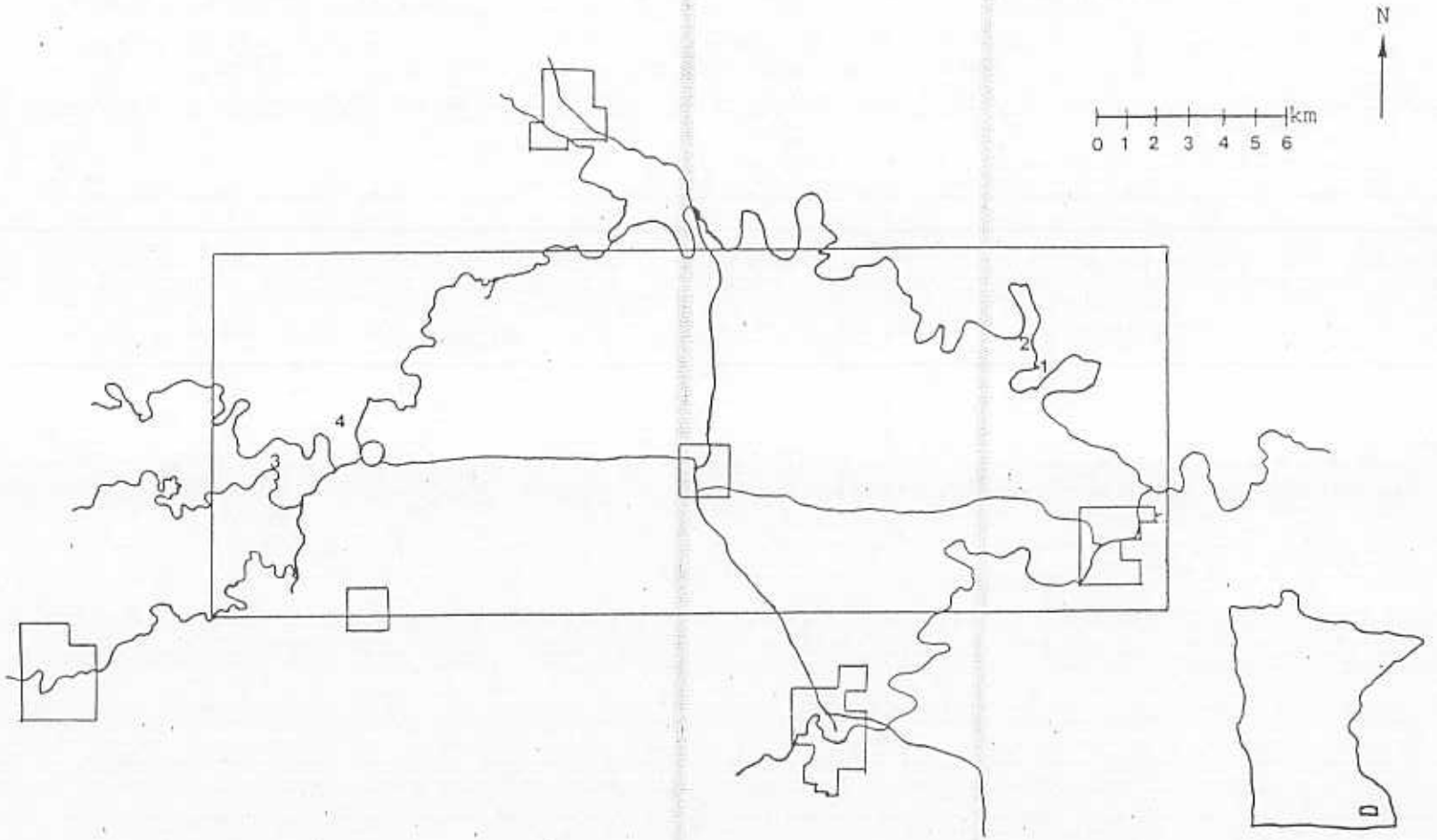

Figure 11. Location of 4 communal Turkey Vulture roosts within the RRVSA, 1984 - 1985.

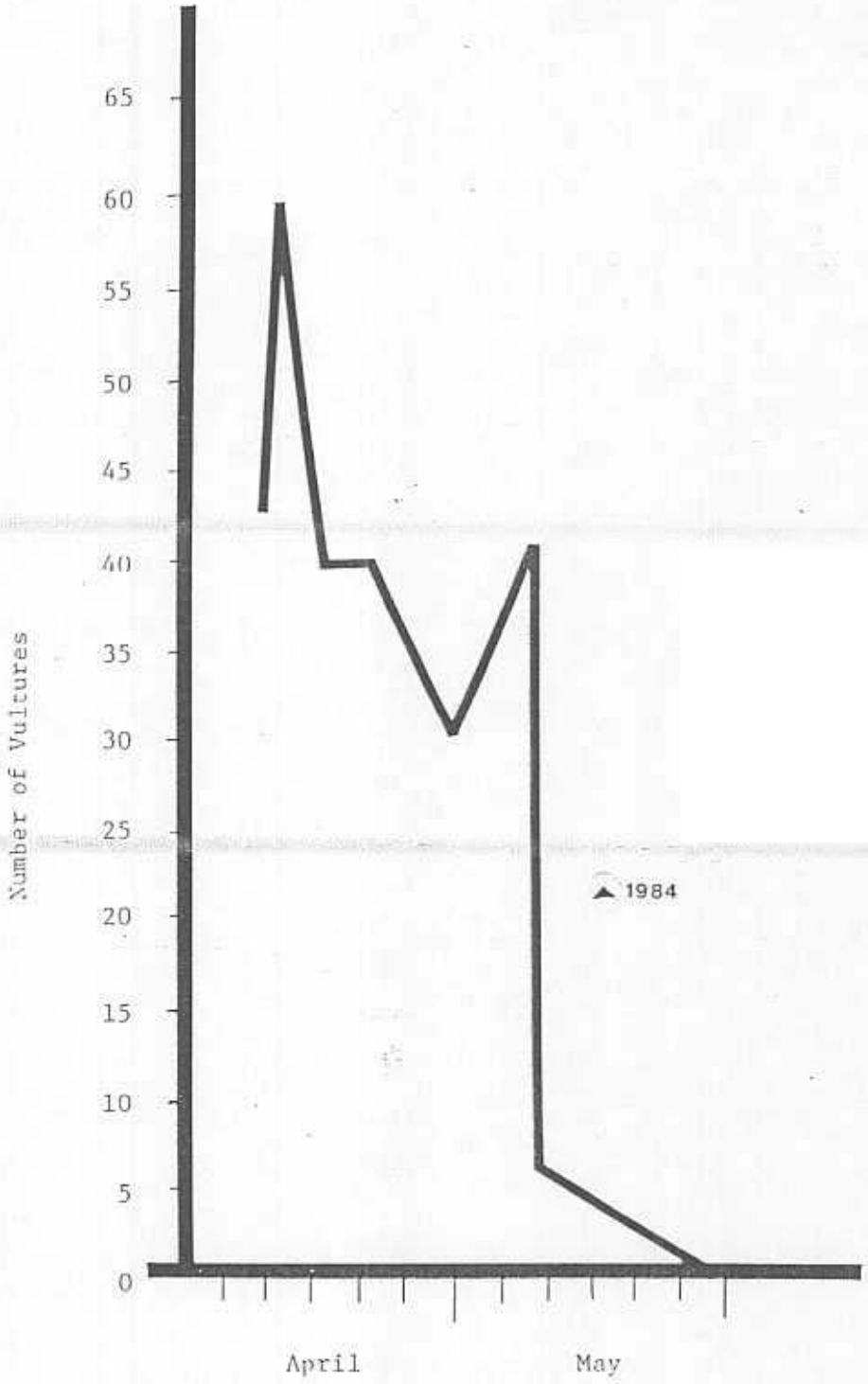

Figure 12. Counts of Turkey Vultures at Roost 1, RRVSA, in 1984 and 1985.

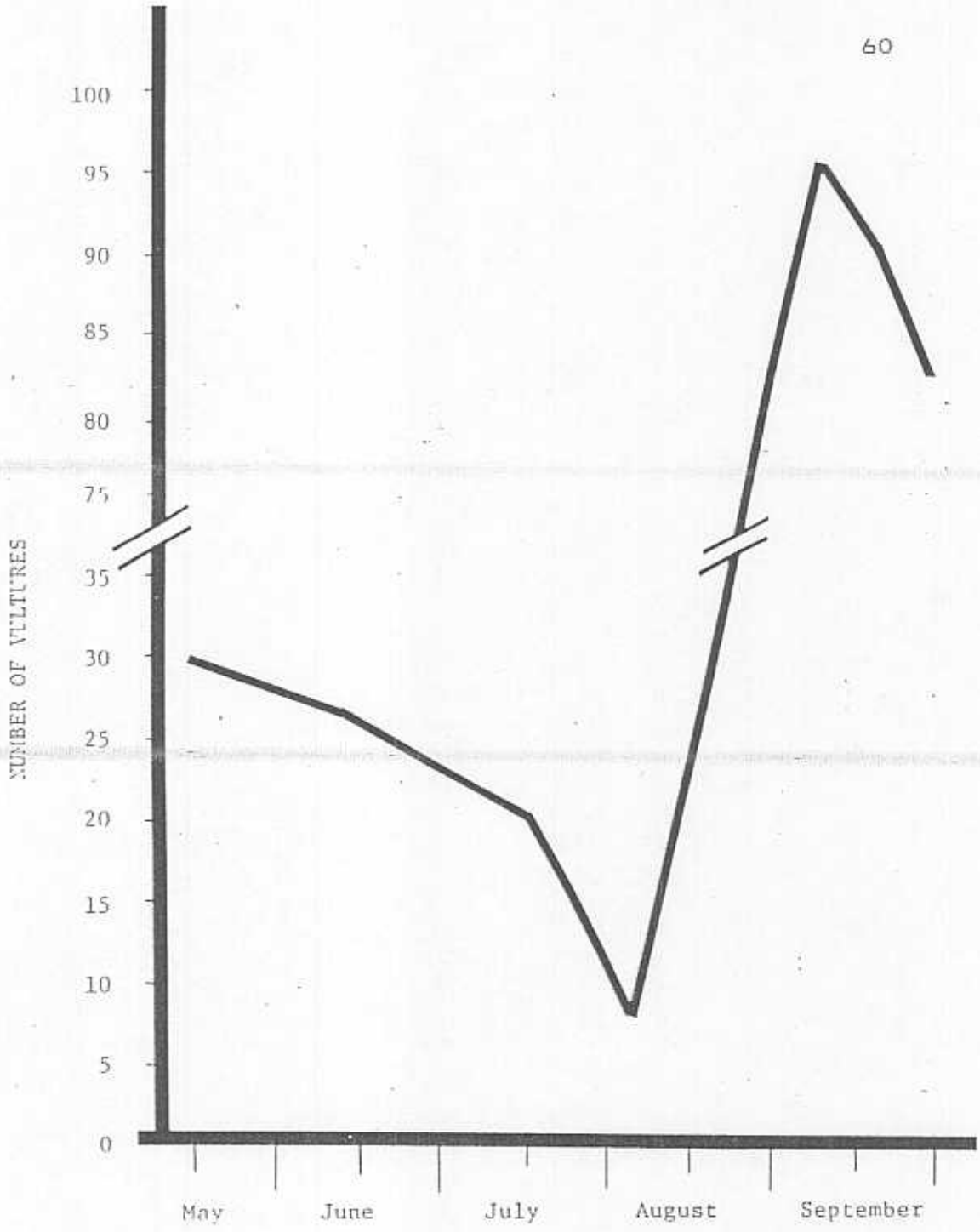

Figure 13. Counts of Turkey Vultures at Roost 2, RRVSA, in 1984.

Figure 14. Counts of Turkey Vultures at Roost 2, RRVSA, in 1985.

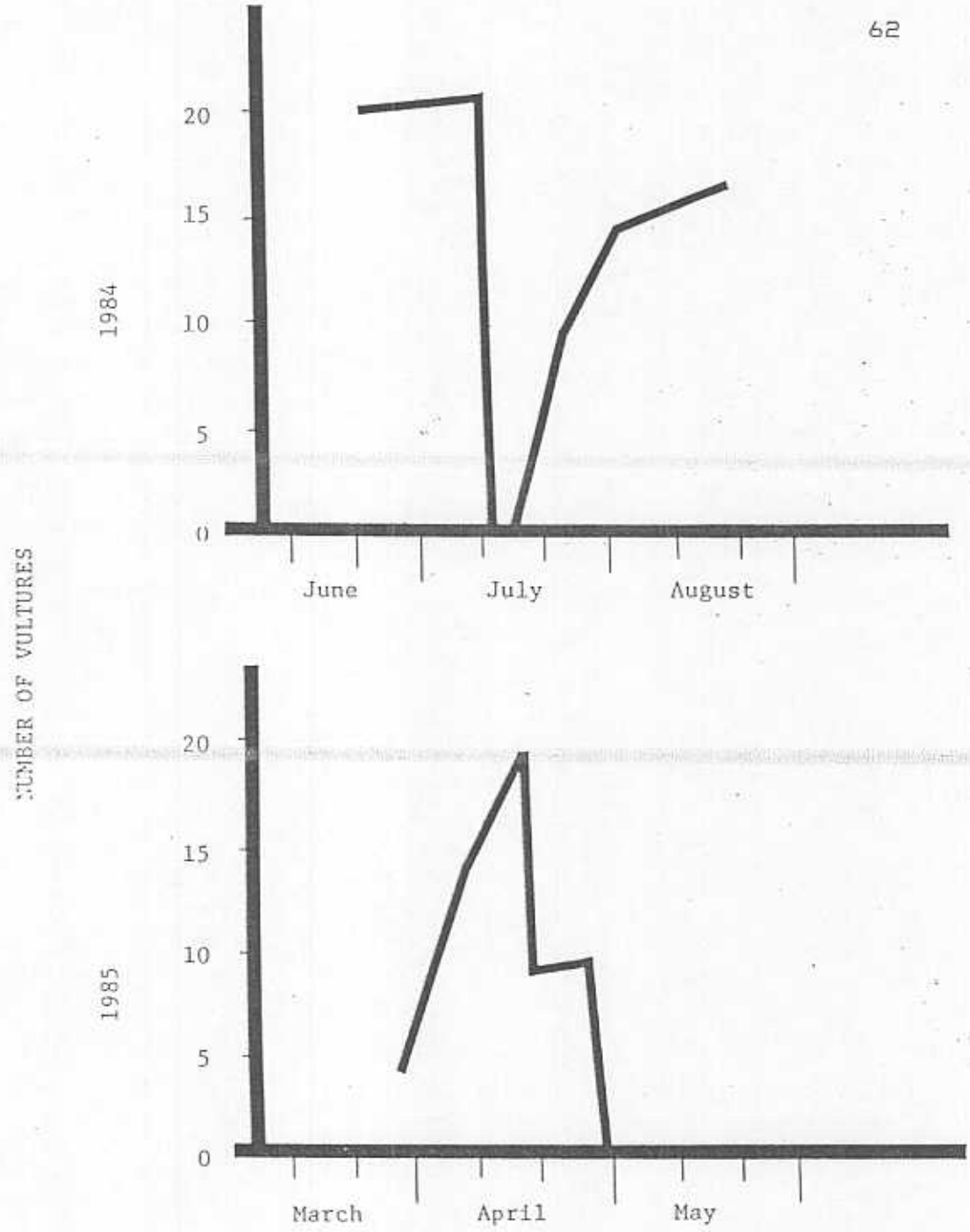

Figure 15. Counts of Turkey Vultures at Roost 3, RRVSA, in 1984 and 1985.

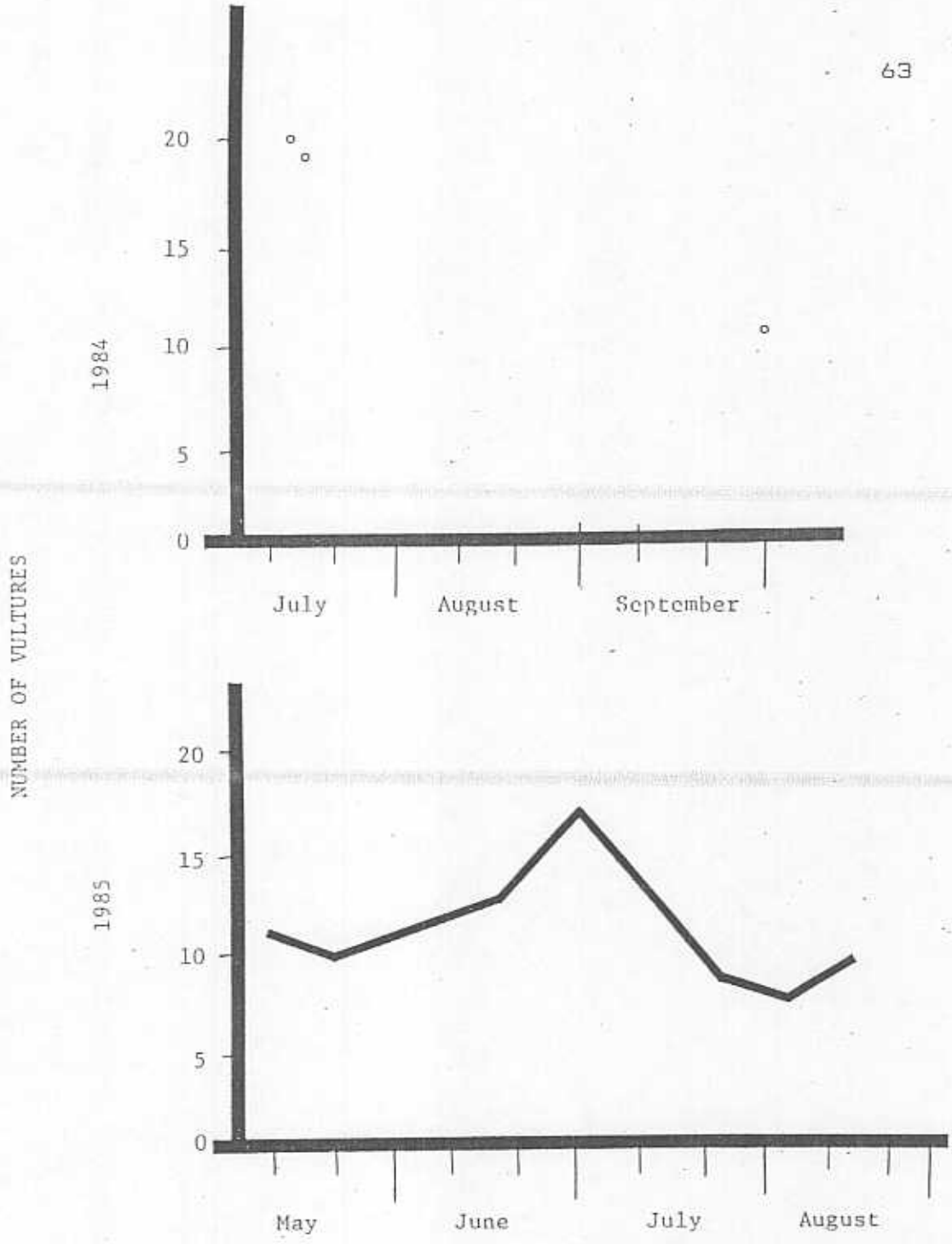

Figure 16. Counts of Turkey Vultures at Roost 4, RRVSA, 1984 and 1985.

DISCUSSION AND CONCLUSIONS

Trap Sites and Trapping

Aversion for certain trap sites can not be quantified here, but limited visibility while feeding and the lack of nearby, adequate perch trees are possible explanations. This is not to suggest that vultures would not feed under conditions of limited visibility, but trapping during this study was only successful in relatively open areas where at least 1 large, dead tree was accessible. All trap sites were baited with similar carrion types but sites 2 and 3 failed to attract any vultures, even though both were closer to a communal roost than trap site 5, where 10 vultures were trapped. Trap sites 2 and 3 also had dense edge vegetation within 10 m of the bait on 2 and 3 sides respectively.

The noose carpet proved to be an inefficient method for trapping Turkey Vultures. If the only method available, however, variations could prove successful. Painting the noose carpet foundation to match the ground cover or carcass might eliminate some suspicion on the part of feeding vultures. A more malleable foundation material, such as chicken wire,

would be less obvious and could be draped over a carcass. Similar devices could be placed at nest entrances to trap breeding adults.

Rocket nets have not always been used successfully when attempting to capture Turkey Vultures (Olson et al. 1967). Most authors, however, have reported good results (Rabenold 1983, Sweeney 1984, Coleman 1985). During this study, vultures became so accustomed to the raised projectiles that they often perched on them prior to feeding. In areas near large communal roosts, the nets could be fired several times before moving the trap site. If capturing large numbers of Turkey Vultures for marking purposes is the goal, a rocket net is perhaps the best capture technique.

Tagging

The patagial marker system employed during this study was easy to administer and proved productive. Migration information was provided when M01 and M02 were observed in NE Iowa during November 1984. M12, tagged on 14 July 1985, was the only vulture observed at both major roosting areas within the RRVSA. When following radio tagged vultures, individuals could be identified at great distances, even when soaring with

other vultures, by the presence of wing tags. The wrap around type of streamer used in this study negated the 180^{o} rotation exhibited by cattle ear tags used in other studies (Wallace et al. 1980, Sweeney 1984).

Nest Searches and Nesting

Roberts (1932) suggested that Turkey Vultures nested on the cliffs overlooking the streams and rivers of SE Minnesota, but gave no details. The cave nest discovered in a bluff along the Root River during this study is the first documented case of this type of nest in Minnesota. The small number of active nests within the RRVSA, where potential nest sites do exist, suggests that many of the Turkey Vultures in the area are non-breeders. 2 young of the year vultures were observed, however, in the RRVSA in the fall of 1985, even though no nests were discovered. The cryptic nature of vulture nests makes their discovery difficult.

The laying dates at all nests described, as estimated by chick feather development, are within the range reported for Turkey Vultures at similar latitude by Jackson (1983). Nestlings from the RRVSA nest and the Wabasha county nest are also within the limits observed for Turkey Vultures in south central

Pennsylvania by Coleman (1985).

The 71 cm DBH reported here for the Wabasha county nest is exactly the same as reported for a Turkey Vulture nest by Kempton (1927), but smaller than the 104 cm average reported for 6 Black Vulture nests by Jackson (1983). Our outside diameter of 129 cm does compare with the 122 cm outside diameter reported for the same 6 nests (Jackson 1983).

The decline in Turkey Vulture populations in Minnesota by Roberts (1932), and Green and Janssen (1975) may, in part, be due to the limited number of nest sites throughout most of the state. In areas where caves and crevices are absent, tree cavities would be the probable choice for a nest site. Trees with sufficient outside diameter to facilitate a cavity suitable for Turkey Vultures would probably be in excess of 150 years old. Present day timber harvesting practices generally eliminate trees before they reach this age. Turkey Vulture tree cavity nests east of 100° longitude prior to 1920 represented 53% of total nests discovered, while after 1920 tree cavity nests accounted for 22.3% of the total (Jackson 1983). The decline of tree cavity nests is indicative of the general decline of forest age structure

exhibited throughout eastern North America. A simultaneous increase in the use of alternative nest sites, such as caves and thickets, was noted (Jackson 1983). Of 18 Turkey Vulture nests discovered in the Gettysburg National Military Park in 1983-1984, all were found in rock caves and crevices in forested areas (Coleman 1985). The availability of suitable nest sites may be an important limiting factor concerning Turkey Vulture in Minnesota. Where suitable nest cavities are not available, Turkey Vultures will nest on the ground (W. M. Tyler in Bent 1937, Tyrrell 1938, McHargue 1977, Jackson 1983) exposing themselves, and their eggs, to potential preditors and weather.

Foraging Ranges

A wide range of 12,840 ha to 122,750 ha was observed in foraging ranges. Coleman (1983) observed similar results, with breeding Turkey Vultures having an average home range of 12,595 ha and birds of unknown breeding status having an average foraging range of 113,312 ha. No radio tagged vultures within the RRVSA were followed to nests and all were considered non-breeders. An average foraging range for RRVSA birds was 50,330 ha, 80% of the average reported

for Turkey Vultures in Pennsylvania by Coleman (1985). The 4 RRVSA radio tagged birds foraged within overlapping maximum home ranges. All foraging ranges had an area of 706 ha in common, and roost 1 and 2 were within this shared area.

Roosting and Roost Sites

Counts of Turkey Vultures at RRVSA roosts indicate that all are seasonal roosts within a communal roost system. Vultures arriving at the east end of the RRVSA in the spring use the 2 large White Pines in roost 1. The evergreen foliage may reduce daily energy requirements by reducing wind speed and air temperature decrease in the evenings as has been described for blackbird roosts (Francis 1976, Kelty and Lustick 1977). Autumn shifts from deciduous trees to conifers have been reported for vultures (Coles 1938, John Coleman pers. comm.). Here, a shift from evergreen trees to deciduous trees shortly after spring leaf out has been recorded.

The distance to water measurements at roosts 1, 2, and 3 may indicate a selection for roost trees near water. Roberts (1932) suggested that Turkey Vultures often roosted near water as their principle food was fish in some locations. Rabenold (1983) reports that

5 roosts in Chatham county, North Carolina are all near small creeks. One of the largest documented vulture roosts in the country, located 14 km W of Blacksburg, Virginia, is located on the New River, and at least 20 vulture roosts have been reported around Chesapeake Bay (Prather et al. 1976). Within the RRVSA, however, the selection of trees on slopes, and the restriction of forests to river valleys could indirectly influence the roost to water distance.

The distance to nearest clearing average of 119 m determined in this study compares with Wright's (1984) average of 109 m. The distance to nearest human activity area average of 662 m reported here suggests sensativity to human disturbance. However, vulture roosts have been reported very close to schools (Chase 1982) and housing developments (John Coleman pers. comm.).

Trees used for roosting are generally large, both in diameter and height. They are not, however, necessarily the largest or most dominant trees available. Even though roost tree species at 2 of 3 roosts had the largest average dominance values, at one roost only did the roost tree species have the largest importance value, based on point-centered

quarter analysis (Cottam and Curtis 1956).

Roost trees were large, having an average DBH and average crown height of 62.7 cm and 25.4 m respectively. This is much greater than the average DBH of 20.4 cm and average crown height of 11.7 m for non-roost trees within the 0.04 ha circular plots. Of the 4 tallest non-roost trees within each plot, the roost tree associated with each plot was, on the average, twice as tall. This supports observations by other authors that roost trees are usually taller than the surrounding trees. Vulture roost trees are often close together. Within the RRVSA the distance to nearest roost tree average of 10.5 m compares with the 7.9 m reported by Wright (1984). All trees used for roosting had large, stout, horizontal limbs.

Within the 0.04 ha circular plots, roost trees accounted for 45% of the largest diameter size class. None of the Red Oaks making up an additional 45% of this size class were used for roosting. Branch structure of Red Oaks may not facilitate roosting by vultures. Red Oak also had the highest relative dominance value and the highest importance value of all species recorded within the 6 0.04 ha circular plots. Again, as was indicated by point-centered

quarter analysis, roost trees need not be the most dominant species. Important Turkey Vulture roost characteristics as determined by this study include:

1. large DBH and height combination.
2. an average of twice as tall as non-roost trees within a 0.04 ha circular plot centered at roost tree.
3. several suitable trees within 10.5 m of one another.
4. close proximity to water and clearing.
5. large distance, > 500 m, to a human activity area.
6. large, stout, horizontal limbs.
7. dense canopy in cold weather.

These findings are similar to those reported for vulture roosts in Pennsylvania (Wright 1984). Many characteristics are similar to Bald Eagle communal roosts as desribed in South Dakota by Steenhof et al. (1980).

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APPENDIX A

Scientific Names of Speices Listed in the Text.

Box Elder	Acer negundo
Sugar Maple	Acer saccharum
Blue Beech	Carpinus caroliniana
Hackberry	Celtis occidentalis
Green Ash	Fraxinus pennsylvanica
Black Walnut	Juglans nigra
Ironwood	Ostrya virginiana
White Pine	Pinus strobus
Cottonwood	Populus deltoides
Big Tooth Aspen	Populus grandidentata
White Oak	Quercus alba
Red Oak	Quercus borealis
Bur Oak	Quercus macrocarpa
Raspberry	Rubus spp.
Basswood	Tilia americana
American Elm	Ulmus americana
Prickly Ash	Zanthoxylum americanum

Turkey Vulture	Cathartes aura
Black Vulture	Coragyps atratus
Bald Eagle	Haliaeetus leucocephalus
Groundhog	Marmota monax
Raccoon	Procyon lotor