ECOLOGY OF BREEDING YELLOW RAILS
AT SENEY NATIONAL WILDLIFE REFUGE

A Thesis

Presented in Partial Fulfillment of the Requirements
for the Degree Master of Science

by

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The Ohio State University
1982

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ABSTRACT

Ecology of Breeding Yellow Rails
at Seney National Wildlife Refuge

Habitat requirements, movements, and breeding biology of radio-instrumented yellow rails (<u>Coturnicops noveboracensis</u>) were studied at Seney National Wildlife Refuge, 27 April to 04 September 1980. All yellow rails were found in open bog/sedge meadow dominated by the tall, mat-forming sedge, <u>Carex lasiocarpa</u>. This sedge comprised 90% of the total stem density which was estimated to be 1400 stems/m^2. Willow bushes were interspersed throughout the study area and represented the advance of the next seral stage. Seasonally fluctuating water levels and periodic fires were considered to be important to habitat suitability for yellow rails. The principal study area had the highest concentration of singing male yellow rails, 1 singing male/5 ha. Four breeding pairs, 1 immature, and 1 breeding male were fitted with radio transmitters during the 1980 field season. A total of 1274 locations was plotted. Males were territorial but the boundaries of the areas of movement of amles overlapped during the period singing was heard. Areas averaged 8.3 ha, which was larger than the 1.9 ha utilized by the only male that carried a transmitter after singing ceased 14 August. The positions of male territories did not vary relative to each other throughout the monitoring period. Females moved within the territories of males containing their nest. Females used a larger area before incubation and after hatching, ~1.2 ha, than during incubation, ~0.3 ha. Seven nests, including 1 re-nest were found during the study. The average clutch size of nests with completed clutches (n = 4) was 8 (range 7-9). Incubation was estimated to require 17 to 18 days. Hatching was synchronous. One brood nest to which the young were moved shortly after hatching was found 15 m away from the egg nest. The only female that was monitored for more than 8 days after hatching of her eggs remained within the area of movement of her presumed mate. Evidence was found for 2 possible cases of serial polygyny. The immature remained near the presumed nest site and moved within an area of 3.3 ha. The primary management activity for yellow rails should be maintenance of the breeding habitat. Present management practices at Seney NWR, primarily for waterfowl, have no apparent deleterious effect on habitat used by breeding yellow rails.

ACKNOWLEDGMENTS

This work was supported by funds from the Regional Office of the U.S. Fish and Wildlife Service in Twin Cities, Minnesota. I thank John W. Ellis, Senior Staff Wildlife Biologist, Wildlife Assistance and Program Coordination, for arranging funding for this study.

I would like to thank my graduate committee: Dr. Theodore A. Bookhout for his advice, encouragement, and patience throughout the project; Dr. Tony J. Peterle for his teaching and views; and Dr. Thomas C. Grubb for his careful consideration of the study and the manuscript.

I would like to express my gratitude to my field assistants, Duane Bailey, Stuart M. Helmintoller, and Kevin Doran, who worked with me at Seney during the summer field seasons. Considerable assistance at Seney National Wildlife Refuge was provided by Young Adult Conservation Corpsmen. In particular, I'd like to thank: Richard Powell, Camp Director; Robert Billetdeaux, Administrative Officer; Larry Wargowsky, Work Coordinator, Don Stiles, Safety Officer; and the corpsmen who helped me in the field. I appreciated the cooperation extended to me by Jack Frye, Refuge Manager, Linda Hagen, Assistant Refuge Manager, and other staff of the refuge. I am also indebted to Mr. Lawrence Riley, Research Associate, for generous help in preparing the computer programs used in analyzing the data and generating many of the figures. George B. Reynard, Riverton, New Jersey, kindly provided tape recording of yellow rail vocalizations. Windsor Ford, Middlefield, Ohio, and Shirley and Cle

Carlson, St. Paris, Ohio provided excellent dogs so necessary for the detection and capture of yellow rails.

Finally, I'd like to thank Katherine H. Barrett, Gildo Tori, Richard P. Urbanek and my parents for friendship, advice, and support.

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INTRODUCTION

The yellow rail (Coturnicops noveboracensis) is a secretive bird that is difficult to observe; it has been little studied in the field and only once studied intensively in captivity. Although this rail is widely distributed in northern North America and is highly sought after by bird watchers, little is known about its habitat, nesting requirements, breeding population densities, or behavior on the breeding grounds.

The yellow rail presently breeds in northern North America, central Mexico and East Asia (Ripley 1977: 187). Virtually nothing is known about the Asian population except that specimens have been collected in China, Japan, and Korea. The yellow rail population in Mexico is apparently small and local (Dickerman 1971, Ripley 1977: 191) (Fig. 1).

Past studies of the yellow rail have been limited largely to recording sites of occurrence, descriptions of the male's peculiar territorial call call (Fryer 1937), or, rarer yet, description of a nest (Peabody) 1922, Devitt 1939, Terrill 1943, Elliot and Morrison 1979). Notable exceptions to studies that were restricted in scope or length of investigation are Peabody's (1922) description of nests and nesting habitat, Walkinshaw's (1939) life history information from many years of work in Michigan, and the study of the breeding behavior of captive yellow rails by Stahlheim (1974, 1975).

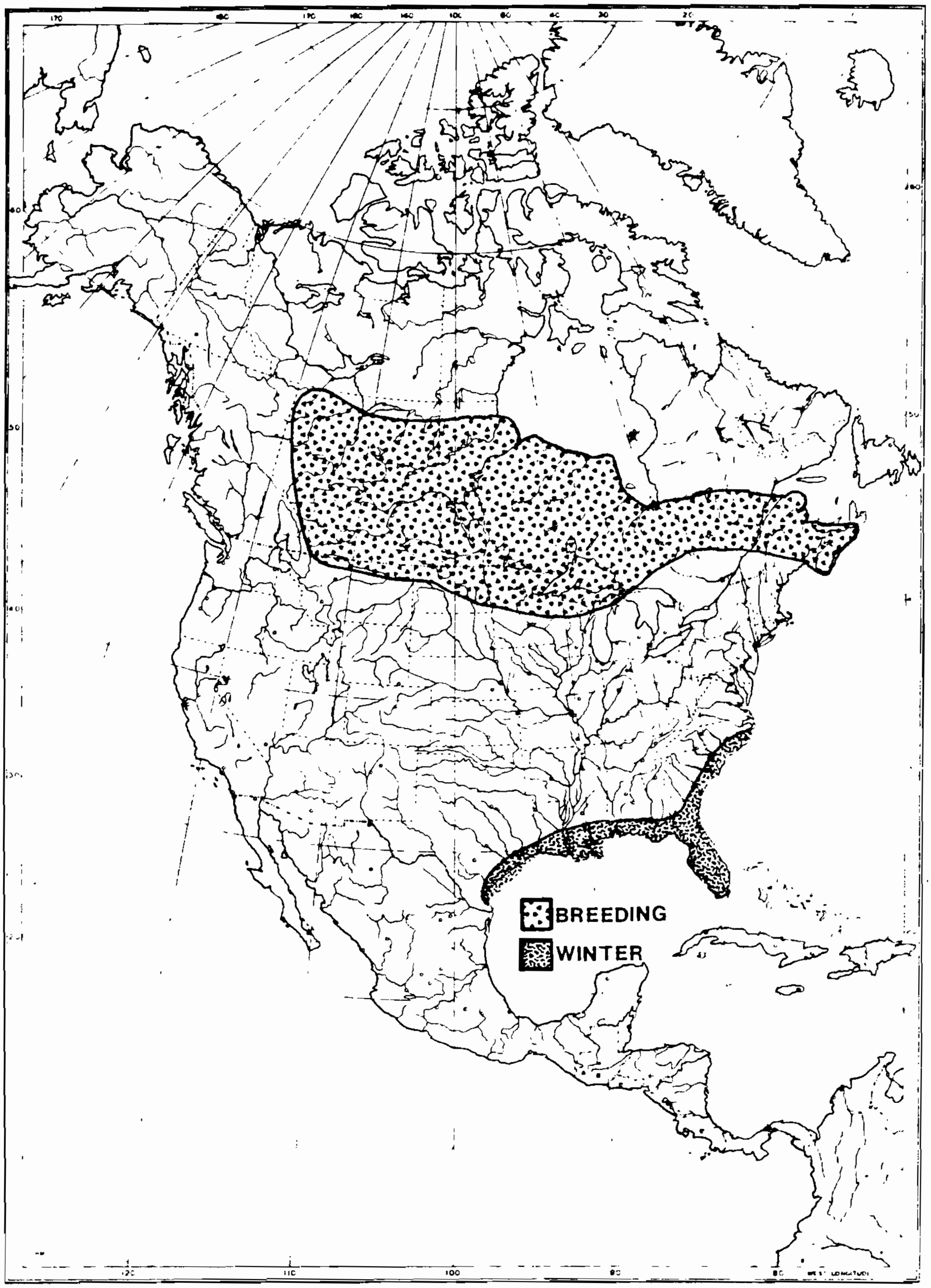


Fig. 1. Winter range in contiguous 48 states and breeding range of the northern race of yellow rail (C. n. noveboracensis) adapted from Anderson (1977:68).

Although the yellow rail likely is more common than generally supposed, the bird is extremely difficult to observe because of its secretive habits, its reluctance to fly, and its preference for remote areas. Many areas containing potential yellow rail habitat are on publicly administered lands; the bird is not endangered and of no interest to hunters, and therefore few wildlife administrators feel justified in spending money for research or management of this species (Anderson 1977:66). Nevertheless, yellow rails are eagerly sought by bird watchers (Anderson 1977: 69). Public agencies responsible for management of wetlands and the birds that utilize them have an obligation to consider the less abundant species such as yellow rails. Given the keen interest of birders in trying to observe this species, the potential for creating an educational, non-consumptive use of public land resources is high. Information on specific requirements for breeding habitat is needed so that recommendations for marsh management can be made.

The study of the yellow rail can be justified on a purely scientific basis as well as a practical one. Rallidae is the largest gruiform family and includes 129 species that are found world-wide (Ripley 1977:7). Rails are anatomically a well-defined group in spite of variation in the size of bills and feet. The body is laterally compressed to facilitate walking through dense vegetation, the wing is usually short and rounded, and the tail is short. Most rail species are closely associated with water. In contrast to the anatomical uniformity of rails, the behavioral diversity noted in the few species studied is of interest to ecologists. Stahlheim (1974) reviewed the behavior of 10 species of rails. He compared his observations of the behavior of captive yellow rails to those of other rails in terms of how rail behavior is adapted to different types of habitat.

Rails typically live in dense vegetation and move in a manner that reduces their chances of being detected (Ripley 1977:7). They are reluctant to fly unless sorely pressed, and when flushed the flight is typically short, with the legs dangling behind them, giving the impression they are incapable of flying to the next marsh, let alone able to migrate thousands of miles. Rails on migration extend the legs out evenly behind and slightly below the tail when flying (Ripley 1977:8). Evidence for their proficiency at long distance flight comes not only from the fact that temperate species undertake long migrations from wintering to breeding grounds, but from the wide occurrence of rails on oceanic islands thousands of kilometers from the mainland (Ripley 1977:15).

The study of yellow rails is difficult, although ultimately rewarding. They occur in remote areas, and can be likened to voles (*Microtus* spp.) living under the snow with regard to their habit of remaining concealed beneath a canopy of dead sedge in the extensive *Carex* marshes that typify yellow rail habitat. A recurring theme in yellow rail literature (and rail literature in general) is the problem of observing the bird's behavior. The development of light-weight (2.5-3.5-g) radio-transmitters has given researchers an opportunity to track the birds' movements.

This study was conducted between 27 April and 28 August 1979 and 30 April and 04 September 1980 at the Seney National Wildlife Refuge (NWR), Seney, Michigan. The objectives of this study were:

1. To develop techniques to find breeding yellow rails in areas of suitable habitat.
2. To measure the population levels of breeding yellow rails.
3. To correlate population density with habitat types to ascertain preferred nesting habitat.
4. To develop techniques for the study of the behavior of yellow rails on their breeding grounds.
5. To recommend marsh management practices that can maintain or enhance breeding habitat of yellow rails.

STUDY AREA

The refuge, comprising 38,630 ha, is located in the Upper Penninsula of Michigan west of the towns of Seney and Germfask, latitude 46°15'N longitude 86°12'W, and is divided into 3 management units (Fig. 2). Heinselman (1965) reviewed the geologic, physiographic, and climatic features of Seney NWR, and the following 3 paragraphs summarize his description.

The refuge lies midway between the 2 Great Lakes, Michigan and Superior, and experiences a cool continental climate. Temperature extremes range from -43.9°C to 39.4°C. The mean annual temperature is 4.4°C; mean July is 18.3°C, and mean January is -9.4°C. The frost-free season averages only 73 days, with last spring frost near June 15, and the first fall frost near August 27. Precipitation averages 68.6 cm annually, 41.9 cm of which come during the warm season, April to September. Snowfall averages about 280 cm annually, and the winter snowpack often attains a depth of 1 m or more.

The region is a vast and level sandplain, grading S 15°E at 1.1-2.2 m/km. Surface and near sub-surface water flows along this northwest to southeast gradient. The land that makes up the refuge is part of what has been known for years as the Great Manistique Swamp. The region is characterized by vast expanses of lowlands, consisting of a black spruce (*Picea mariana*) bog interspersed with patches of seasonally

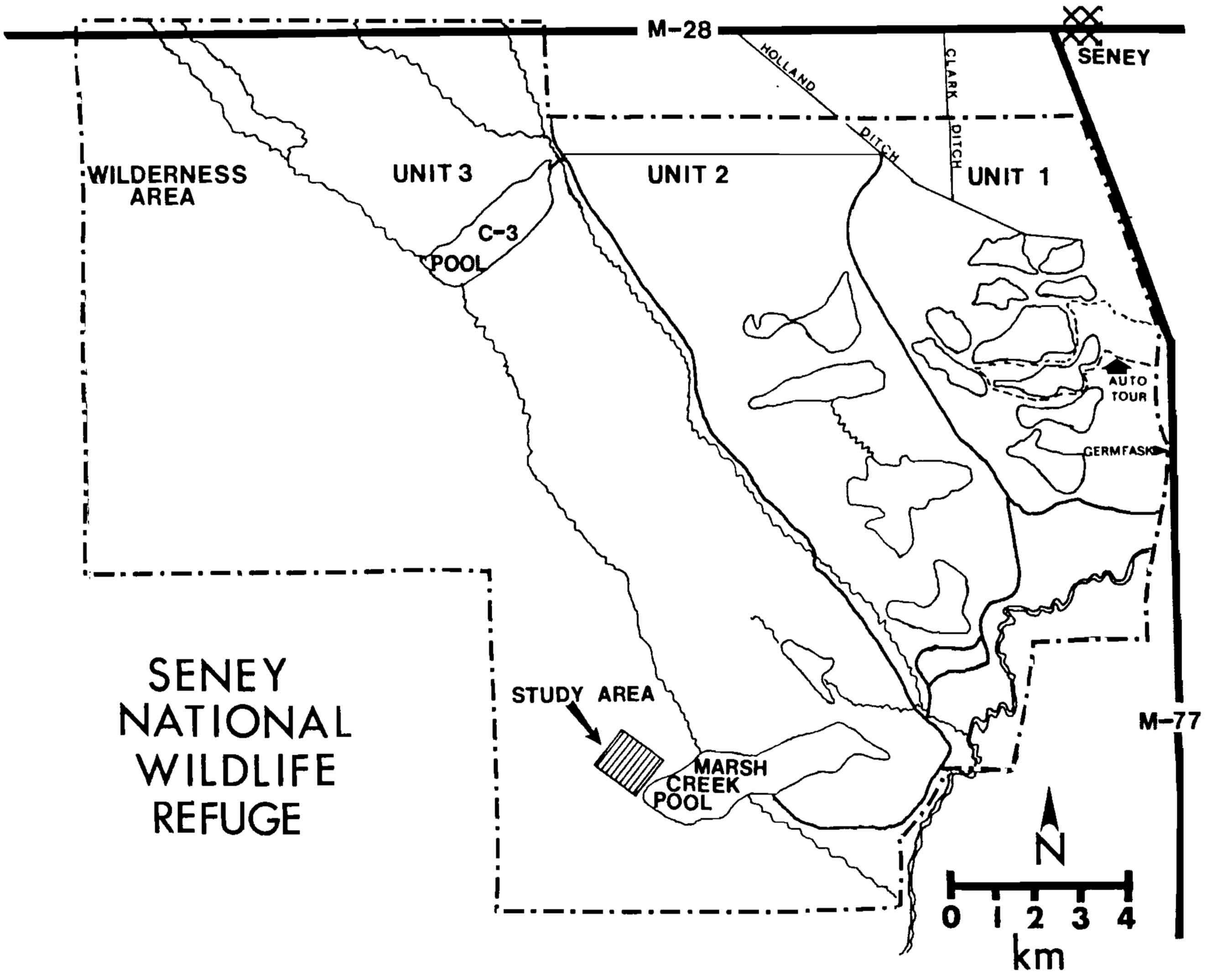

M-28
SENEY
HOLLAND DITCH
CLARK DITCH
UNIT 1
UNIT 2
UNIT 3
WILDERNESS AREA
C-3 POOL
AUTO TOUR
GERMFASK
M-77
STUDY AREA
MARSH CREEK POOL
SENEY NATIONAL WILDLIFE REFUGE
N
0 1 2 3 4
km

Fig. 2.

flooded meadow and strips of high ground that support white (*Pinus strobus*) and red pine (*P. resinosa*). The strands of high ground appear to be remnant sand dunes. They project above the plain 1-3 m and average 18 by 60 m in size. The Seney plain must have been worked by shore processes or aeolian activity during a high water phase of the post-glacial Great Lakes, sometime between 4,000 and 9,500 years ago. The peatlands have developed since dune activity ceased.

The effects of white man's early use of the land continue to have a great impact on the wetland ecology of Seney NWR. During the logging era of the late 19th century some isolated stands of white pine were cut, but of major importance to the wetlands of Seney was a series of fires, land clearing, and futile attempts at farming. Land development companies in the early 1900's constructed several ditches to drain areas of muck land for agricultural purposes. Most of the agricultural efforts failed, and a number of the private holdings reverted to the state. Accessible areas, especially close to the ditches, had their original vegetation totally destroyed (Heinselman 1965). Peterson (1971b) speculated that the flowing water, created as a result of ditchwork, continually flushed out the adjacent bogs, reducing the acidity and bog-producing characteristics.

Seney NWR was established in 1934, primarily for the propagation of waterfowl. More dikes and spillways were constructed during the Depression to impound waters of the creeks and ditches flowing through the area. More than 2,800 ha of open water in the form of 21 large, shallow pools were constructed in the eastern half of the refuge, principally in Units I and II (Fig. 2). The natural gradient of the land allowed the water to spill from one pool to the next without pump stations, and the constant flow of water kept the pools from becoming stagnant. Preferred foods of waterfowl were planted in the pools. The impact of the pools was probably to ameliorate natural wet-dry cycles in adjacent areas, and to create thousands of hectares of marsh habitat at the backsides of the pools.

Approximately 10,178 ha of the western part of the refuge was designated as a Wilderness Area by Congress in 1970. Two-thirds of the Wilderness Area is characterized by patterned bog features such as topographically oriented forest "islands" and bogs, called Strangmoor bogs or string bogs. This is the southernmost occurrence in North America of this sub-arctic formation. A description of their physiography, history, and plant associations was made by M.L. Heinselman (1965). On August 7-8, 1971, Assistant Refuge Manager J.D. Peterson hiked across this area and described plant and faunal observations (Peterson 1971b).

The string bogs run northwest to southeast as does the waterflow. The terrain consists of 3 distinct physiographic types topographically oriented in a linear series of parallel string bogs, bog forests, and pine knolls. The string bogs consist of alternate low bog ridges and wet sedge hollows. The pine knolls are relict sand dunes, and the bog forests extend in a long, narrow tail southeasterly from the pine knolls.

The principal study site was located 0.4 km from the west end of Marsh Creek Pool (Fig. 2). The Marsh Creek Pool Study Area (MCPSA) was chosen because it had the highest concentration of calling yellow rails encountered on the refuge. Water levels in the MCPSA were thought to be controlled by the water level in Marsh Creek Pool because of the study area's proximity to Marsh Creek Pool. The extension of the dike, first west 1 km and then north 0.3 km, beyond the southwest side of the standing water of Marsh Creek Pool impounded surface water flow up to 1 km away from the pool proper. This produced a seasonally flooded wet sedge meadow marsh with water depths of 30 cm or more in the spring that became moist soil by mid-summer.

The physiography of the MCPSA was similar to that of the surrounding area. Sand islands were interspersed within the sedge marsh (Fig. 3). The vegetation on the sand islands was dominated by red pine and white pine in the center of the island. Swamp birch (*Betula pumila*), speckled alder (*Alnus rugosa*), and quaking aspen (*Populus tremuloides*) ringed the edge. Bracken fern (*Pteridium aquilinum*) and blueberries (*Vaccinium spp.*) were the principal ground cover, especially in areas burned by the fire of 1975. That fire burned almost 30,000 ha of Seney NWR and surrounding land.

The principal marsh plant was a tall, mat-forming sedge, *Carex lasiocarpa*, that dominated the extensive wet sedge meadows throughout the refuge. Small colonies (0.5 ha) of blue-joint grass (*Calamagrostis canadensis*) and rushes (*Juncus* spp.) were in slightly elevated and depressed areas, respectively. Willow (*Salix* spp.) bushes, about 1 m in height, dotted the marsh portion of the entire study area, with higher concentrations in the drier areas. The 1975 fire burned back the willow bushes as evidenced by the large, charred stumps with sucker sprouts forming the new bushes.

Fig. 3. Preferred nesting habitat of yellow rails, Seney National Wildlife Refuge. Top: stand of Carex lasiocarpa near Marsh Creek Pool. Bottom: View of Marsh Creek Pool Study Area looking northeast from southwest boundary showing C. lasiocarpa with shrubs interspersed, mainly willow (Salix sp). (Photo taken June, 1982.)

METHODS

DETECTING YELLOW RAILS

The presence of yellow rails in a particular area was detected by hearing the territorial call of the male. This 'Click' call (Stahlheim 1974) is given in a five-beat pattern, Click-Click, Click-Click-Click, for hours at a time with only brief pauses (Fryer 1937, Stahlheim 1974). All terminology for yellow rail vocalizations follows Stahlheim (1974).

Audio surveys to detect singing male yellow rails were conducted during complete darkness. Surveys were done from the beginning of each field season until mid-July in areas thought to be suitable for yellow rails on the basis of descriptions of yellow rail habitat in the literature. The surveys were done at night because elicitation of Clicking by male yellow rails by the use of taped calls at that time was not necessary to detect presence or absence of yellow rails.

CAPTURE OF YELLOW RAILS

Male yellow rails were caught by imitating the territorial call of the male at night. This caused them to approach close enough to be captured by hand with or without a hand net. The best imitation was given by tapping a closed pocket knife against the femur bone of a young deer. Use of the bone seemed to provide a more resonant tone, but tapping together other objects such as 2 stones was effective.

Imitation of the call was usually started after quietly approaching to within 30 m of the calling male. The vegetation was trampled down in a radius of approximately 0.75 m around the person tapping the knife and bone. One or 2 other persons equipped with hand-nets stood motionless to either side of the trampled vegetation with nets poised. Flashlights were trained in an area in front of the person imitating the call.

The 2 objects to be tapped together were held 15 to 20 cm above the ground. Once the imitation started, stillness on the part of the investigators was required. The speed, direction, and intensity of tapping were varied according to what seemed to elicit the strongest response by the male bird. The male usually responded by approaching the "intruder", often walking or flying up to the person tapping the knife and bone, thus allowing the bird's capture by hand or hand-net.

The use of a dog was essential to the capture of yellow rails that did not respond to the imitation of the 'Click' call. Previous yellow rail investigators used both flushing and pointing dogs (Walkinshaw 1939, Stahlheim 1974). I used pointing dogs that served both to flush and point the bird. In 1979 I used a Brittany Spaniel but the stature of the breed proved too short for the high water conditions of that year. In 1980 I used a German Shorthaired Pointer that quartered closely and moved slowly enough to detect yellow rails under difficult spring and summer scent conditions.

Yellow rails flush more readily at night than during the day (Stahlheim 1974), and night proved to be the best time to pursue them with a dog. During the day birds seemed to be impossible to catch, even if pointed, because they seemed to melt away into the vegetation.

Ideally, the birds were caught upon being pointed, but usually the birds flushed at least once, flew 25 to 50 m, and had to be pursued. After several flushes the birds would often fly a great distance, and if the bird was not caught in 3 or 4 flushes, the hunt for that bird on that night was almost invariably unsuccessful.

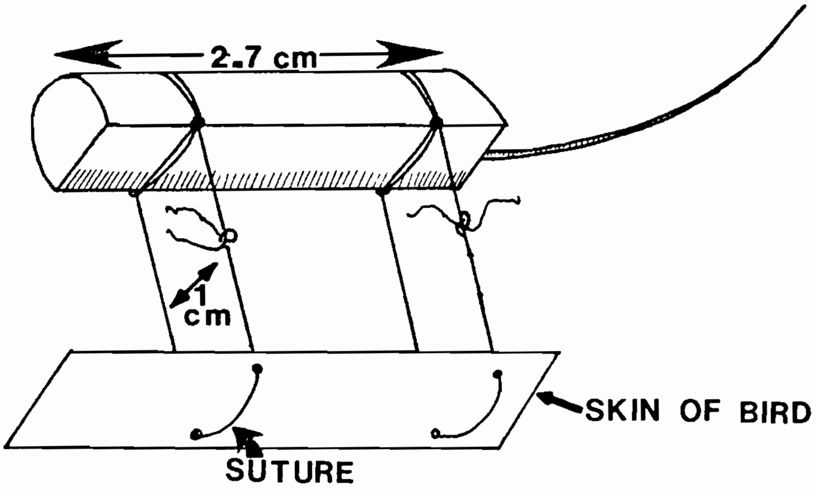
The birds in the MCPSA were designated with numbers 1 to 5. Thus, the male and female associated with the same territory were designated with the same number, e.g., male 1 and female 1.

RADIO TELEMETRY

A model MP1145LD radio transmitter (Wildlife Materials, Inc.) with doubler or tripler circuits was used to track the movements of yellow rails. Three methods of transmitter attachment, sutures, harness, and adhesive, were used.

1. Suture Method. The transmitters were held to the back of the bird with 2 sutures that were attached laterally underneath the interscapular skin (Fig. 4). The area of attachment was prepared by cutting the feathers to a length of $\leq$ 2 mm. The transmitter was then sutured to the bird, taking care to snug the thread so that the transmitter was held firmly to the skin without stretching the skin around the suture holes or pinching the skin under the transmitter. Ethicon A-184 size 000 braided silk type B suture was satisfactory because of its limpness and diameter.

2. Harness Method. The transmitter was secured to the back of the bird by means of round nylon elastic cord 1.5 mm in diameter around the wings in backpack fashion.



TRANSMITTER READY FOR ATTACHMENT

TRANSMITTER POSITION ON BIRD

Fig. 4. Suture attachment of radio transmitters to yellow rails.

3. Adhesive Method. The interscapular region was prepared in the same manner as the suture method. Several drops of cyanoacrylic adhesive were placed on the bottom of the transmitter and on the skin of the bird. The transmitter was quickly placed on the prepared area and held firmly for 4 or 5 sec.

Permanent locations for obtaining radio telemetry bearings were established in the MCPSA to facilitate plotting of locations and to minimize disturbance to the birds and habitat (Fig. 5). From these fixed locations bearings to the radio transmitters were determined to the nearest degree. The quality of the signal was noted on the field data forms if the origin of the signal seemed to be difficult to determine.

A plotted location was derived from 2 to 4 bearings taken $\leq$ 20 min apart. An error polygon was constructed if 3 or more bearings were recorded. The 3 bearings forming the smallest error polygon were used to form an error triangle if there were 4 bearings recorded. Coordinates for the plotted locations were determined on maps of the study area by dropping a perpendicular line from the widest angle halfway to the base of the error triangle This point was designated the plotted location. The time from first to last observations was divided in half and rounded to the nearest 1 min closest in time to the first observation and recorded as the time for the plotted location.

The plotted location was rejected for analysis if the error triangle was $\geq \sim 1800$ m^2. Individual bearings were rejected if they were noted as weak and if inclusion of the bearing resulted in a large error

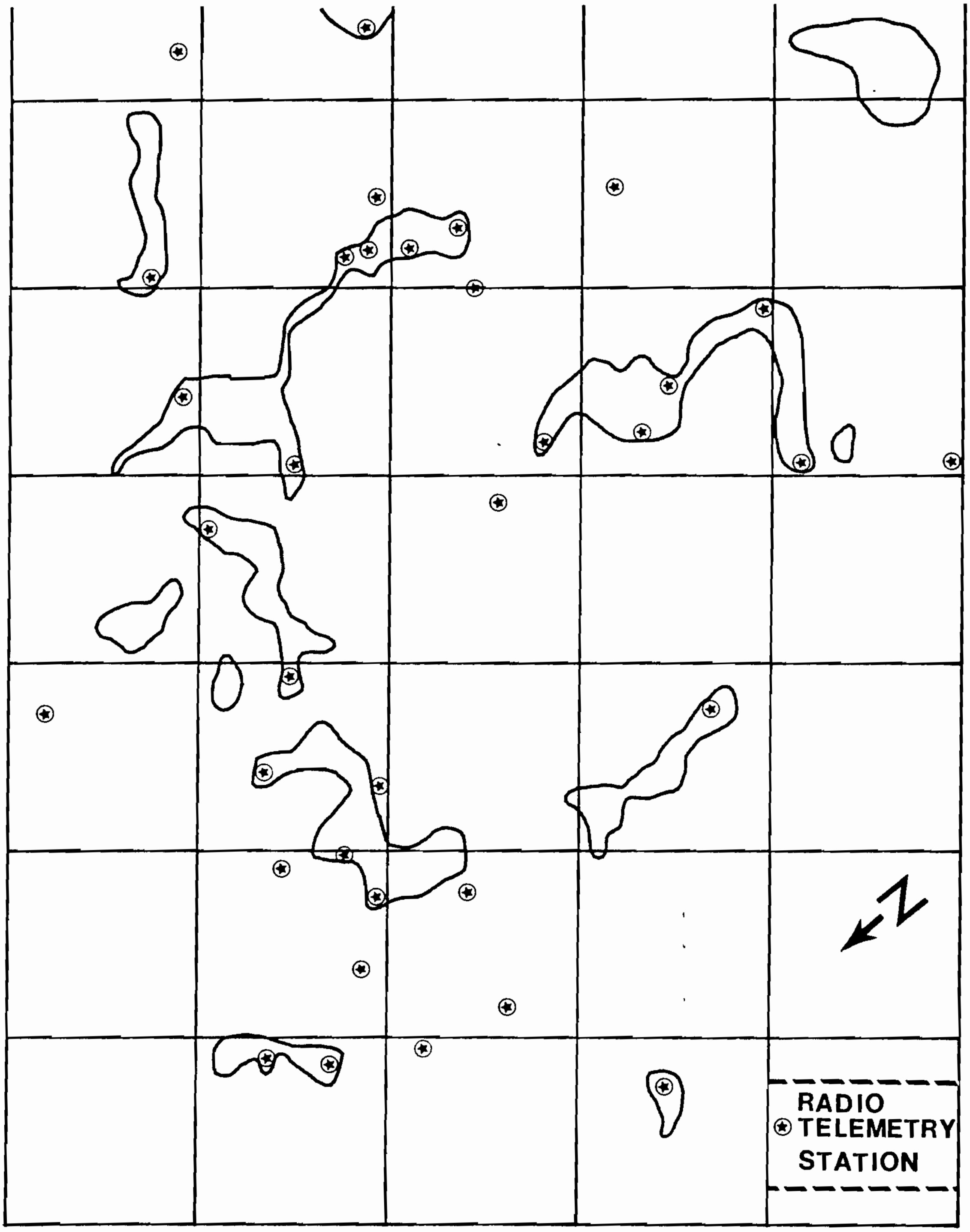


Fig. 5. Radio telemetry stations, Marsh Creek Pool Study Area, Seney National Wildlife Refuge, 1980. One grid line = 100 m.

triangle. Plotted locations were rejected in some cases if there were 2 or more bearings in a narrow arc that resulted in the bearings crossing much farther than the bird's probable location, i.e., nothing in the field data forms indicated the bird was that far based on signal strength. The area of movement was derived by connecting the outermost points to construct a minimum area convex polygon (Mohr 1947).

HABITAT ANALYSIS

A cover map of the area was prepared by visual inspection and mapping of 1-ha sections in the MCPSA from 15 August to 03 September 1980. Habitat was classified as sand island; *Carex lasiocarpa*; *Calamagrostis canadensis* - *Carex* spp; *Juncus canadensis* - *Carex* spp. Habitat types occupying less than 1% of the study area were not included in the cover map (Fig. 6).

In 1980 the 30.25-ha MCPSA was gridded into 121, 0.25-ha sections, each 50 x 50 m (Fig. 6). Stem density was determined by randomly locating 100, 0.05-m^2 plots, each measuring 10 x 50 cm. Any sample point falling under willow vegetation was moved 1 m to the west. The height of the vegetation and the height of the senescent sedge layer from the substrate were measured to the nearest centimeter. The senescent sedge was removed and stems in the plot were cut to approximately 8 cm in height for ease of counting, counted, and grouped into the following classes: *Carex lasiocarpa*, *Carex* spp. (other than

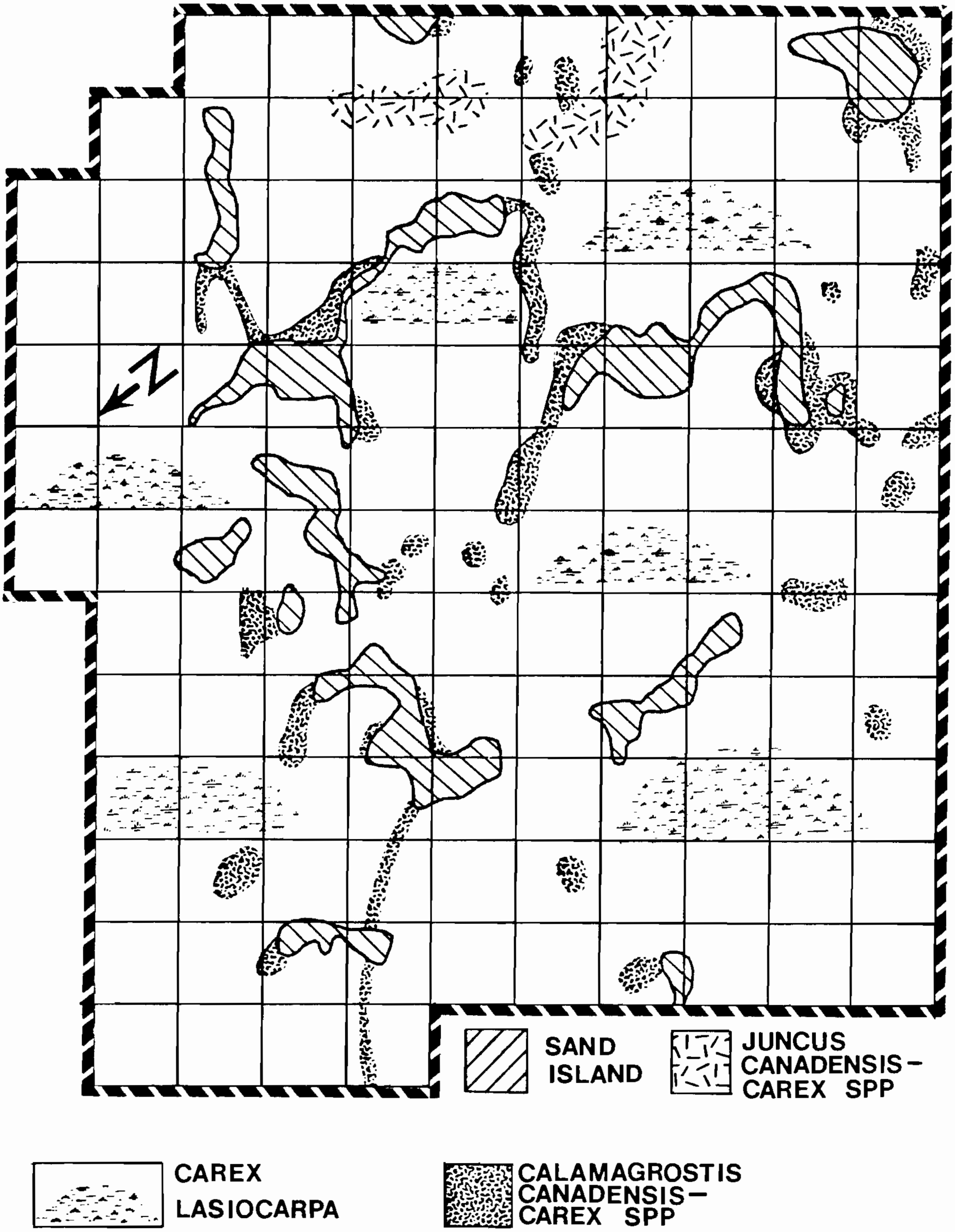


Fig. 6. Cover map of Marsh Creek Pool Study Area, Seney National Wildlife Refuge, 1980. One grid line = 50 m.

C. lasiocarpa), *Juncus* spp., *Calamagrostis canadensis*, Gramineae spp. (other than *C. canadensis*), herbaceous species, *Salix* spp., and other woody species.

In 1979, 4 stem density sample plots were centered around locations of Clicking males south of Marsh Creek Pool. The plots were 50 x 50 m in area. At 10 random locations within each plot, all stems within 0.5-m^2 (2 plots) or 0.25-m^2 (2 plots) plots were counted and assigned into the same classes as the 1980 stem count samples. The samples were considered to be comparable to the 1980 data because the locations of the 4 birds were independent, the plots were not along any gradient, and the size of the sample plots was large enough in both years to give an accurate estimate of the mean stem density.

DURATION OF CALLING

Clicking frequency was measured on two mornings, 27 May and 03 June 1980. On these mornings, I arrived at the MCPSA approximately sunrise and sat quietly on a sand island within 100 m of the birds' morning calling sites. Clicking frequency was determined by counting during alternate 300-sec periods (n = 5 counting periods) the total number of sec spent Clicking from 0600 h to 0710 h.

RESULTS AND DISCUSSION

YELLOW RAIL DISTRIBUTION

The density of breeding yellow rails can vary considerably. I assigned densities of breeding yellow rails into 3 classes (Table 1), and all 3 classes of densities were encountered on the refuge (Fig. 7). All yellow rails at the refuge were found in wet sedge meadows, the preferred habitat of yellow rails (Walkinshaw 1939, Devitt 1939, Stahlheim 1974). Yellow rails were detected in Units I, II, and III of the refuge.

Units I and II

Seney's reputation as a yellow rail 'hot spot' stemmed primarily from surveys done by Walkinshaw (1939) prior to the construction of the pools and from sightings of yellow rails around the pools of Units I and II in the 1940's and 1950's. Whether the construction of the pools caused an increase or decrease in yellow rails is unknown, but records kept at Seney seem to indicate a lack of yellow rail sightings near the pools after 1960 (Peterson 1971a). I found only 1 singing male near a pool during audiocensusing of Units I and II.

The creation of man-made impoundments for waterfowl habitat might have been responsible not only for inundating suitable habitat for yellow rails at the time of their construction, but also for providing

Table 1. Density classes of breeding yellow rails.

Density class		Examples from literature
I.	Solitary pairs	Terrill (1943)
II.	Widely dispersed (0.5 to 1.0 km between pairs)	Lane (1962)
III.	Adjacent territories	Peabody (1922), Fryer (1937), Walkinshaw (1939), Huber (1959), Stahlheim (1974)

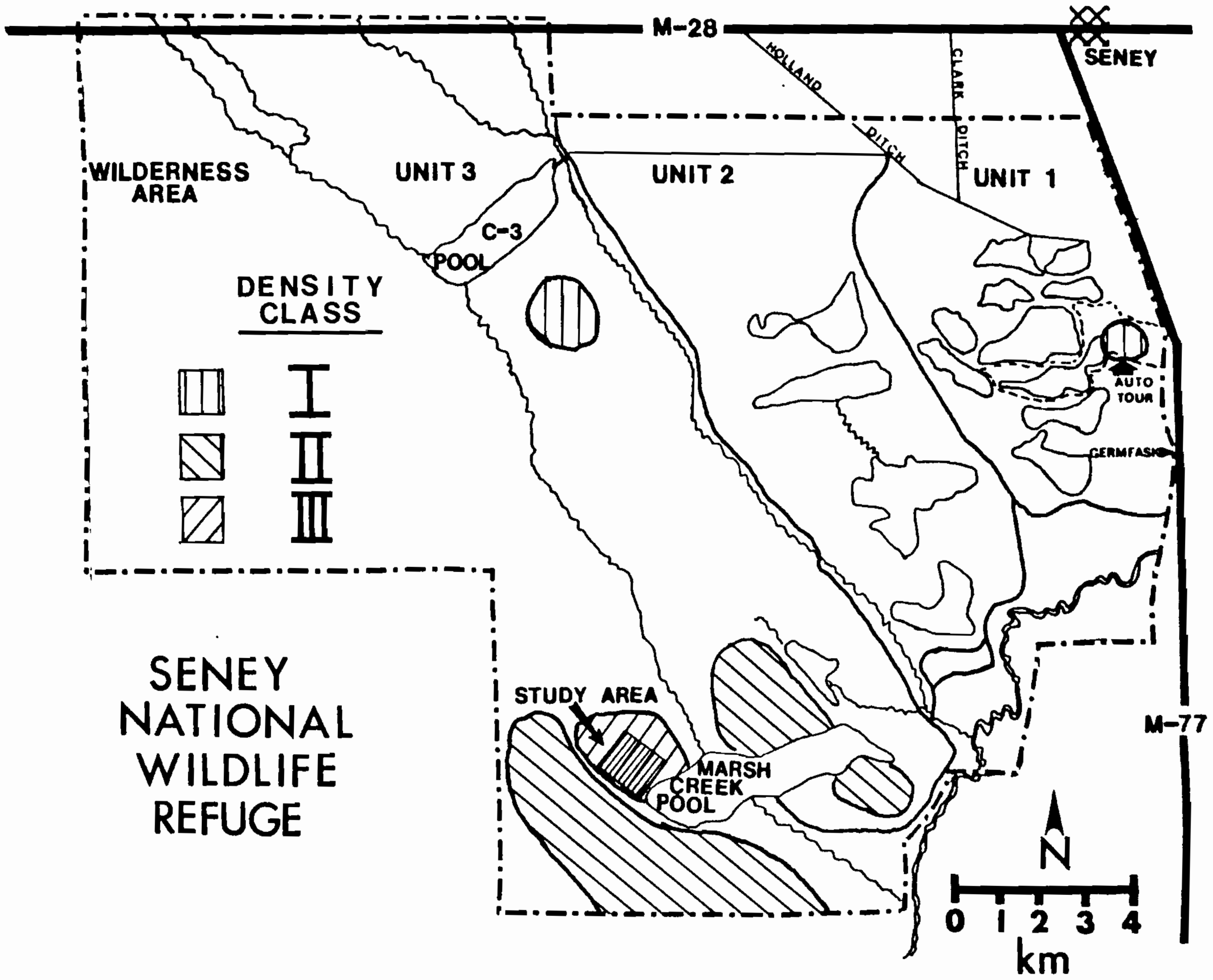


Fig. 7. Densities of breeding yellow rails at Seney National Wildlife Refuge, 1979 to 1980. I = solitary pairs, II = widely dispersed pairs (0.5-1.0 km), III = adjacent territories.

new habitat at the back edges of the pools for the period of time C. lasiocarpa and suitable water regimes persisted. This might explain the initial high number and then decrease in yellow rail sightings at most pools from sometime after their construction until 1960. Reasons for the decline in yellow rail sightings could be due to variable efforts to listen for rails, changes in water management regimes, colonization of the sites by plant species not conducive to yellow rails, or changes in pH leading to altered composition of plants and invertebrates.

I believe the effect of the pools on the natural habitat might have been to ameliorate the effects of natural wet and dry cycles relative to areas not greatly affected by pools. Water management decisions at the refuge are based on the needs of waterfowl. Since the construction of the pools in the 1930's, any changes in water management on a year-to-year basis reflected annual differences in precipitation. Pool sizes, and therefore edge habitat, have remained more or less constant within the capability of the refuge personnel to maintain similar water levels from year to year (Unpubl. annual water management plans, Seney National Wildlife Refuge). The back edges of pools can fluctuate from completely devoid of standing water to several decimeters of water depth on an annual basis. The average annual evaporation rate of Marsh Creek Pool has been 61 cm (Unpubl. annual water management plans, Seney National Wildlife Refuge).

The wetlands of the refuge affected by water management decisions for the pools encompass an area far larger than the pools themselves. Water from the rivers and ditches is diverted into the northernmost pools. This water then flows by gravity down the gradual slope of the land in a network of creeks and channels to downstream pools. Large areas to the southeast of the pools might be kept wetter than normal because of the permeability of the sand dikes to water. The pH of surrounding areas might also be raised due to the rapid drainage of water from bog areas into diversion ditches and the pools' feeder creeks (Peterson 1971b) as evidenced by differences in the vegetation adjacent to ditches and the natural vegetation. Therefore, if the decline in yellow rail sightings reflects a true downward trend in the population around the pools, it is not unreasonable to suppose that at the end of 20 years' time conditions at the back edges of pools might have changed sufficiently to make the habitat unsuitable for yellow rails.

Unit III

Virtually all of the yellow rails detected during this study were in Unit III. This unit has only 3 major pools, all near the Driggs River that roughly bisects the refuge. The part of Unit III that contained the most yellow rails at Seney National Wildlife Refuge, excluding possibly the Wilderness Area, was in a band 5-7 km wide running roughly parallel to the west side of the Driggs River from C-3 Pool on the north to the refuge boundary and beyond to the south. This area is the most extensive area of wet sedge meadow on the refuge.

The back edge of Marsh Creek Pool, site of the intensive study area, had the highest yellow rail density encountered at the refuge, 1 calling male per 5 ha. Marsh Creek Pool differs from all of the other major pools in time since flooding. All other pools have been flooded since their dikes were constructed. The dike for Marsh Creek Pool was constructed at the same time as the others, but the pool was not flooded until 1961-1962; therefore, the surrounding area has been affected for a much shorter period of time than other pool areas.

WILDERNESS AREA

Peterson (1971b) made an intense effort to detect yellow rails in the Wilderness Area but was unable to do so, probably because August is not the optimum time to search for nesting yellow rails or to detect calling males. He concluded that the yellow rails may be as rare or rarer in the string bog area than in the rest of the refuge because thick growths of sedge in wet meadows are uncommon in the string bog area. Access to this trackless area is extremely difficult, and I was only able to view the western edge of the string bog in late summer 1980 during the daytime. Field trips to the string bog during May and June would certainly be more appropriate, and possibly more productive, for the detection of yellow rails.

WEIGHTS AND PLUMAGES OF YELLOW RAILS, AND ASSOCIATED BIRD SPECIES

Seventeen yellow rails were captured, banded, and weighed during the field seasons. Males were heavier than females (Table 2). Walkinshaw (1939) also found males to be larger and 12.6 g heavier on the average than the females.

Table 2. Weights of adult yellow rails at initial capture, Seney National Wildlife Refuge, 1979-1980.

Sex	Weight (g)	Date	Notes
Male	57.9	11 May 1980	
	62.5	12 May 1980	
	96.0	19 May 1980	
	57.0	22 May 1980	
	56.0	28 May 1980	
	56.0	01 Jun 1980	
	58.0	19 Jun 1980	
	60.0	24 Jun 1979	
	57.4	10 Jul 1979	
	60.0	10 Jul 1980	
	58.0	23 Jul 1980	
	$\bar{x}$ = 57.4		
Female	61.0	28 May 1980	laying eggs
	51.0	04 Jun 1980	laying eggs
	48.0	16 Jun 1980	incubating
	59.0	24 Jun 1980	laying eggs
	41.0	14 Aug 1980	post-hatching (~7 days)
	$\bar{x}$ = 52.0		

There seem to be no differences in the plumage of male and female yellow rails (Walkinshaw 1939), but the bills of males become a distinctive corn yellow color during the breeding season (Walkinshaw 1939, Stahlheim 1974). After the breeding season the bills of males become similar in color to the dark olive-green color of the females' bills (Walkinshaw 1939, Stahlheim 1974). All males I captured had yellow bills, and all females and juveniles had olive-green bills.

Associated with yellow rails at the refuge and other parts of its breeding range are birds that are characteristic of yellow rail habitat. In Table 3 under the heading, this study, I included only those species that regularly use yellow rail habitat and whose presence, as a group, could be considered characteristic of yellow rail habitat at the refuge. Particularly visible in yellow rail habitat at the refuge were the sedge wren, (*Cistothorus platensis*), Le Conte's sparrow (*Passerherbulus caudacutus*) (Walkinshaw 1937), and bobolink (*Dolichonynx oryzivorus*).

HABITAT CHARACTERISTICS AT YELLOW RAIL BREEDING SITES

The vegetation of the MCPSA was dominated by *Carex lasiocarpa* (Fig. 8). Sand islands and slightly elevated areas dominated by bluejoint grass represented less than 12% of the study area (Table 4). Comprising less than 1% of the area each were small colonies of cattail (total area < 350 m^2, n=2), *Juncus canadensis* (total area < 270 m^2, n=2), and swamp birch (total area < 700 m^2, n=3). Standing water and soil moisture generally declined with distance from Marsh Creek Pool, but

Table 3. Associated birds in confirmed yellow rail breeding areas, as observed by Peabody (1922), Devitt (1939), Lane (1962), Terrill (1943), Stahlheim (1974), and present study. Adapted from Stahlheim (1974).

Species		Peabody	Devitt	Lane	Terrill	Stahlheim	This study
Sandhill crane	(*Grus canadensis*)						*
American bittern	(*Botaurus lentiginosus*)				*	*	*
Mallard	(*Anas platyrhynchos*)					*	
Pintail	(*Anas acuta*)				*	*	
Blue-winged teal	(*Anas discors*)				*	*	
Canvasback	(*Aythya valisineria*)					*	
Marsh hawk	(*Circus cyaneus*)	*				*	*
American kestrel	(*Falco sparverius*)						*
Sharp-tailed grouse	(*Pedioecetes phasianellus*)						*
Virginia rail	(*Rallus limicola*)					*	
Sora	(*Porzana carolina*)			*		*	
Common snipe	(*Capella gallinago*)		*	*	*	*	*
Marbled Godwit	(*Limosa fedoa*)	*				*	
Wilson's phalarope	(*Steganopus tricolor*)	*				*	
Great horned owl	(*Bubo virginianus*)						*
Short-eared owl	(*Asio flammeus*)	*				*	*
Long-billed marsh wren	(*Telmatodytes palustria*)					*	
Sedge wren	(*Cistothorus platensis*)		*	*		*	*
Bobolink	(*Dolichonyx oryzivorus*)			*		*	*
Red-winged blackbird	(*Agelaius phoeniceus*)			*		*	*
Savannah sparrow	(*Passerculus sandwichensis*)	*	*			*	*
LeConte's sparrow	(*Passerherbulus caudacutus*)		*	*		*	*
Vesper sparrow	(*Pooecetes gramineus*)						*
Sharp-tailed sparrow	(*Ammospiza caudacuta*)	*		*		*	
Swamp sparrow	(*Melospiza georgiana*)		*		*	*	*

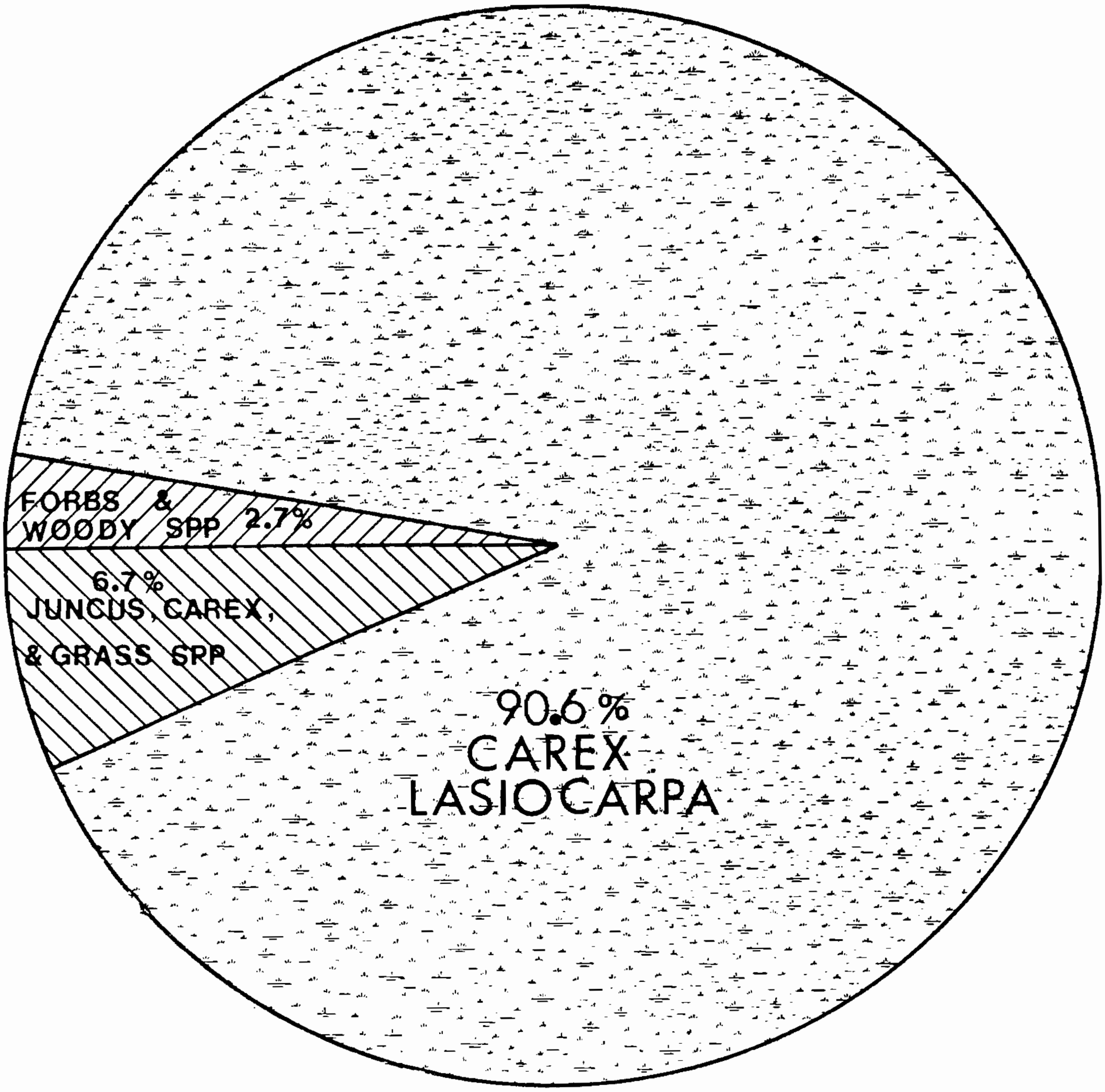


Fig. 8. Proportion of stems in 0.020 m^2 (n = 100) sample plots of Carex lasiocarpa, forbs and woody species, and Juncus-Carex and grass species, Marsh Creek Pool Study Area, Seney National Wildlife Refuge, 1980.

Table 4. Proportion of Marsh Creek Pool Study Area occupied by sedge meadow, sand island, cattail, *Juncus canadensis*, and swamp birch, Seney NWR, 1980.

Habitat type	% Total (30.25 ha)
Sedge meadow	
Carex lasiocarpa	87.0
Calamagrostis canadensis	4.3
Sand island	7.5
Juncus canadensis, cattail, swamp birch	1.2

isolated areas of wetter conditions, represented by concentrations of the hydrophytic species _C_. _lasiocarpa_, occurred north and northwest of sand islands that served as natural impoundments to the southeasterly flow of water.

Willow density at the MCPSA was generally higher on the drier downstream side (i.e. south-southwest) of sand islands and became lower with proximity to Marsh Creek Pool (Fig. 9). Willows were also common around the edges of sand islands. The mean amount of 50-m transect line occupied by willow was 1.5 ± 0.18 SE (n=121).

Many of the willows on the MCPSA were sucker sprouts that grew from short stumps (< 20 cm) remaining from the 1975 Seney fire. These sucker sprouts were not distinguished from post-fire bushes in the assessment of willow density, but in general the larger willows grew from what evidently were much larger pre-burn bushes as deduced from the diameter of the stems in the stem cluster that comprised individual bushes. Therefore, prior to the 1975 Seney fire, many large willows were present on the study area.

The relationship between willow density and habitat suitability for yellow rails is not clear. High willow density in areas of water regimes suitable for growth of _C_. _lasiocarpa_ might have no effect on yellow rail density, or high willow density might shade out significant portions of sedge and result in higher evapotranspiration from the marsh, thus decreasing the suitability of the area for _C_. _lasiocarpa_. Because yellow rails were found in areas of _C_. _lasiocarpa_ in which willow density appeared to be lower than in drier areas in which yellow rails were not present, the most likely relationship is one of correlation with habitat suitability rather than cause and effect.

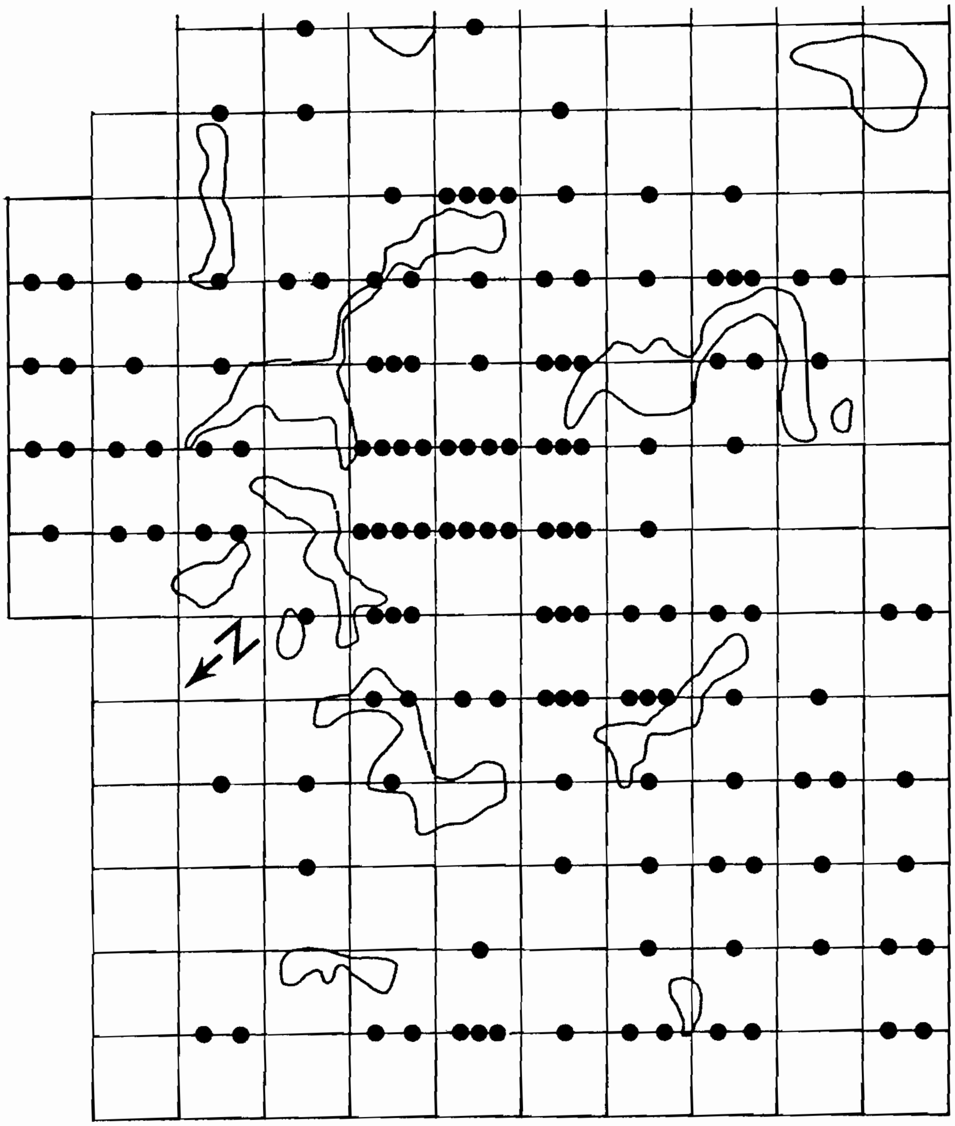


Fig. 9. Amount of 50-m transect line (n = 121) occupied by willow, Marsh Creek Pool Study Area, Seney National Wildlife Refuge, 1980. One grid line = 50 m. One solid circle/grid line = 0.1 - 1.4 m, 2 solid circles/grid line = 1.5 - 3.6 m, 3 solid circles/grid line = 3.7 - 6.2 m, 4 solid circles/grid line = 6.3 - 9.4 m.

Stem density of plants in the sample plot was higher at the MCPSA than at other sites examined (Table 5). Stems at all sites sampled were composed of more than 90% C. lasiocarpa. This sedge occurs widely throughout Michigan and its well developed rhizome system characteristically forms extensive mats under black spruce, tamarack (Larix laricina), and cedar (Thuja occidentalis) (Voss 1972).

In 1979, snowfall was very heavy (Table 6) and late in melting which resulted in high spring water levels. Standing water was present throughout the 1979 season at all areas where yellow rails were found, and depth averaged 6.5 cm (n=10/plot, total=40) 01-15 August on the sample plots examined south of the Marsh Creek Pool. From snowfall and precipitation records in 1979 and 1980, I would characterize 1979 as a wet year and 1980 as a moderately dry year in terms of water levels. Water depths on the MCPSA in the spring of 1980 were typically 20-30 cm and diminished to 5-8 cm by mid-June and early July. By Mid-July, standing water was not present, but the soil remained saturated throughout the field season.

The greatest water depth recorded at a yellow rail calling site at the refuge was 46 cm on 04 June 1979. This was higher than the 37 cm spring marsh depth recorded by Stahlheim (1974). Water depths diminish throughout the season in wet sedge meadows, and depths recorded at yellow rail nest sites have ranged from 5-10 cm (Elliot and Morrison 1979, Peabody 1922), 2-4 cm at Seney in 1979 and 1980 (2 nests), to moist soil (Devitt 1939, Walkinshaw 1939, Terrill 1943, MCPSA in 1980 [5 nests]).

Table 5. Stem densities in breeding yellow rail habitat, Marsh Creek Pool area, Seney National Wildlife Refuge, 1979-1980.

Sample site	Plot size (m^2)	n	Vegetation Class	Stems/plot ± SE	Calculated stems/m^2
MCPSA	0.05	100	*Carex lasiocarpa*	63.24 ± 2.68	1264.8
			Juncus, *Carex* & Grass spp.	4.51 ± 0.83	90.2
			Forbs & Woody spp.	2.15 ± 0.35	43.0
				69.90 ± 2.38	1398.0
Calling male sites 1,2	0.50	20	*Carex lasiocarpa*	368.85 ± 24.62	737.7
			Other	33.80 ± 1.57	67.6
					805.3
Calling male sites 4,5	0.25	20	*Carex lasiocarpa*	160.35 ± 13.16	641.4
			Other	7.60 ± 3.07	30.4
					671.8
					$\overline{X}$=739

Table 6. Precipitation at Seney National Wildlife Refuge weather station, Seney, Michigan.

Time period	Total snowfall (cm) Sep-Apr	Total rainfall (cm) Apr-Aug
20 + year average	279.4	37.7
1979	352.8	44.5
1980	269.0	26.6

Variation in reproductive effort has been correlated with differences in soil moisture for birds nesting in wet sedge meadows for such species as bobolinks (Wittenberger 1980), sedge wrens (Terrill 1943), and yellow rails (Stahlheim 1974). Therefore, annual variations in precipitation in the Seney marshes might affect yellow rail nesting effort, and habitat suitability will depend on many years of cumulative effect of water regimes on *C. lasiocarpa*.

An interesting feature of the *C. lasiocarpa* meadows at the refuge is that prevailing northwest winds in the fall align the senescent vegetation in one direction to form a permanent canopy that averaged 16 cm above the substrate at the MCPSA. A canopy layer of procumbent *C. lasiocarpa* was present at all yellow rail sites. Some sites in early spring had standing water above the sedge canopy, but all nest sites were covered by the sedge canopy. I believe the presence of the sedge canopy is important to habitat occupancy by yellow rails at the refuge because it allows the birds to move freely without visual detection from above. No yellow rail was ever seen under this canopy except when males were induced to approach within a meter of the observer imitating their call at night.

MOVEMENTS AND BEHAVIOR OF BREEDING YELLOW RAILS

Spring Migration

Male yellow rails begin calling in the spring while on migration to the breeding grounds (Easterla 1962, Stahlheim 1974). Males will give their territorial call day or night (Walkinshaw 1939), but the birds call more vigorously at night and during early morning (Devitt 1939, Lane 1962, Stahlheim 1974).

Singing males in a migratory flock were observed at the refuge in 1979. On 29 May 1979 I detected the first yellow rail of the season approximately 1 km south of the C-3 Pool at 0715 h. That night I heard at least 9 singing males in an area less than 5 ha. One male was captured by imitating the call and banded with the USFWS band. The birds occupied the area for at least 3 and not more than 7 nights before leaving. Yellow rails were not seen or heard within 2 km of that area for the remainder of the study period.

Arrival dates of 29 May 1979 and 06 May 1980 at the refuge were considerably later than the arrival dates of 01 May and 24 April in 1971-1972 recorded by Stahlheim (1974) in Minnesota. He observed yellow rails to arrive a few days before sora (*Porzana carolina*) and Virginia rails (*Rallus limicola*), but at the refuge in 1979, soras and Virginia rails arrived more than 1 week before yellow rails. Spring arrival dates for yellow rails at the refuge have also been noted as early as 09 May 1937 in Unit I (Peterson 1971a) and 06 May 1937 in Unit III (Walkinshaw 1939).

Arrival dates can be expected to vary considerably depending on spring conditions. Yellow rails, like other rails, usually avoid extremely cold weather, as evidenced by their migration dates (Stahlheim 1974). During late frosts, yellow rails, like sora and Virginia rails, become lethargic and easy to catch (Kaufman 1971, Stahlheim 1974). At the refuge, the marsh substrate can remain frozen in large areas for more than 1 week after snowmelt, probably because of insulation provided by the procumbent vegetation. An additional factor causing variation in arrival dates might be spring water depths. In 1979, water depths exceeded the canopy height of the procumbent vegetation in many areas; therefore, the lack of a sedge canopy resulted in little protection from aerial predators and reduced habitat for prey items such as invertebrates.

Pre-incubation

Results and discussion in this and the following sections will be based on observations of birds in the MCPSA during the 1980 field season, unless otherwise noted (Table 7).

Within 1 week of their arrival at the refuge males established territories that did not vary relative to each other for the duration of the breeding season. Aggressiveness by males towards intruders, as measured by ease of capture, rose in intensity during the first week, and remained high for at least 1 month, then diminished, possibly due to the experience of being captured, in some cases 4 or 5 times.

Stahlheim (1974) found that nest building in captive birds started 28 days before incubation began. Incubation in the single nest I found in 1979 could have started approximately 39 days after arrival of the

Table 7. Number of birds monitored per month and number of plotted locations for yellow rails, Seney National Wildlife Refuge, 1980.

	May	Jun	Jul	Aug	Total
No. birds	3	8	6	3	10
No. locations	63	451	445	315	1274

birds, and in 1980 incubation of the eggs in the first nest I found could have started 27-29 days after the arrival, if incubation started after the last egg was laid and lasted 18 days as suggest by Elliot and Morrison (1979). Incubation in the last nest found in 1980 could have begun 07 July; therefore, the pre-incubation period could have been as short as 27 days for 1 male and as long as 63 days for another male on the MCPSA. The length of time between abandonment by female 4 of 5 warm eggs on 05 June, and the estimated onset of incubation by her on 06 July of a second clutch of 7 eggs was 31 days. This would have allowed up to 24 days for recycling prior to laying the first egg of the new nest if she laid 1 egg per day and incubation commenced immediately after the last egg was laid.

During the pre-incubation period Clicking by the male can occur anytime during the night or day, but calling is most frequent in complete darkness (Peabody 1922, Stahlheim 1974). All males I knew to be present on the MCPSA called almost every night for at least part of the night during the pre-incubation period.

Despite almost incessant nocturnal calling by yellow rails, Stahlheim (1974) characterized this species as being far from nocturnal. Soras and Virginia rails (Kaufman 1971) and king rails (Rallus elegans) (Meanley 1969) call at night as a form of territorial advertisement, and this was not associated with other activities. Stahlheim (1974) observed no feeding by yellow rails at night and virtually no chasing or sexual behavior. He found pair formation, pair maintenance, and feeding to be diurnal activities and attributed nocturnal calling to better acoustical conditions at night or reduced risk of predation.

Plotted locations of males prior to the onset of incubation were combined with movements during the period Clicking was heard because Stahlheim (1974) found Clicking and Patrolling behaviors of captive birds continued through the incubation period, even in the absence of other males, although pairing and sexual behaviors stopped at the onset of incubation. The movement patterns I saw were consistent with the pattern of behavior observed by Stahlheim (1974) (Figs. 10, 11, 12, 13, 14, 15). The pattern of radiotelemetry locations and calling males indicates that the birds are sedentary at night and move about during the day.

A typical day's movement pattern is illustrated by male 1 on 30 May (Fig. 16). This particular day was chosen because it represented the time prior to initiation of incubation of the eggs in the nest found in this male's territory, which was the earliest nest of the season. I estimate egg-laying had just begun. Stahlheim (1974) found this time period to be the height of pairing and sexual behaviors.

The male was associated with the nest location in early evening, night, and early morning. Upon our arrival at the MCPSA at 0530 h (sunrise 0605 h), no males could be heard Clicking, but within 15 min a male began to Click approximately 350 m from the monitored bird as we made our way through the study area. Within 10 min all known males in the area began to Click. Walkinshaw (1939) noted that yellow rails would commence Clicking at almost any time because of his passing

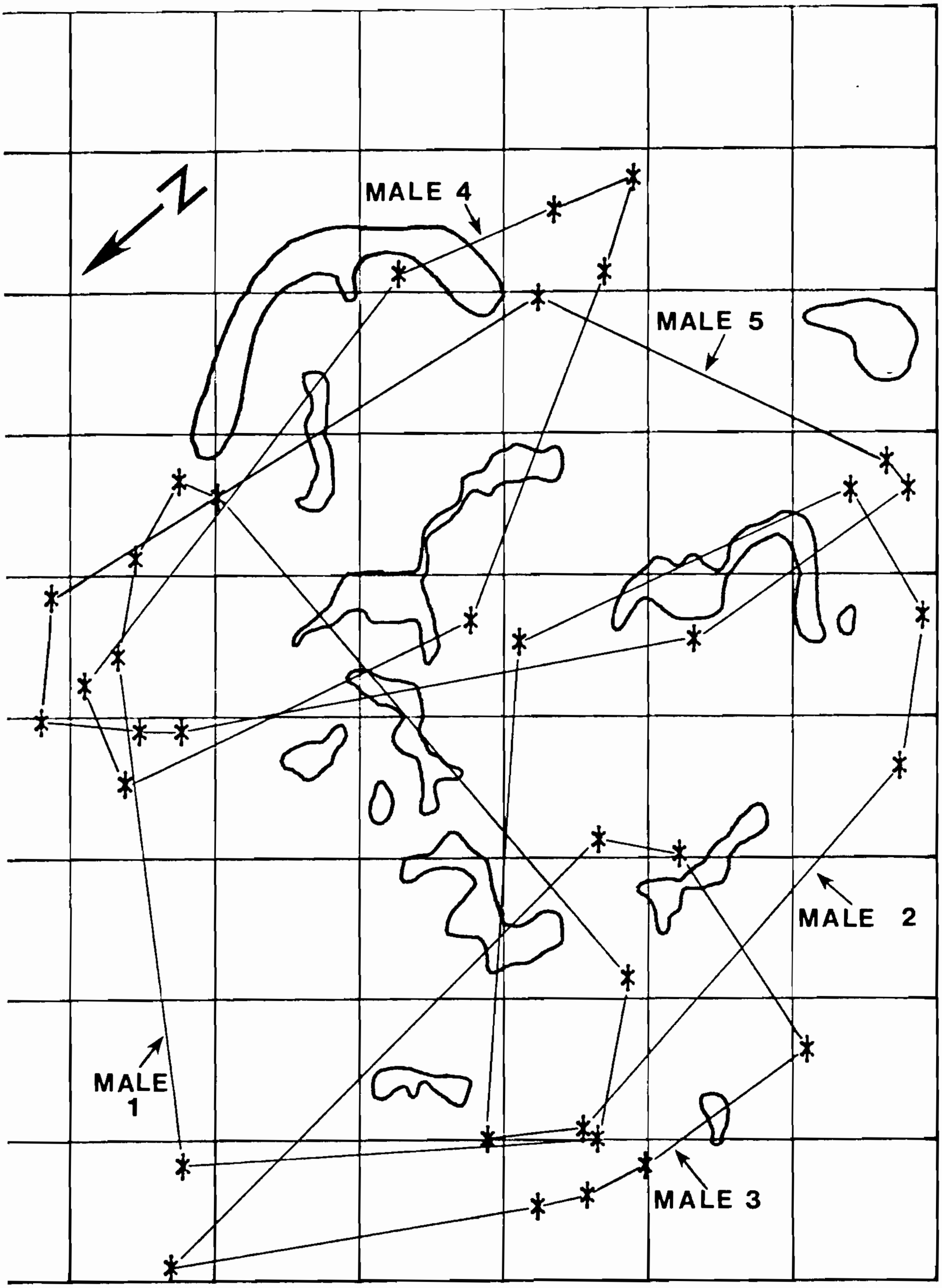


Fig. 10. Clicking and Patroling movements of male yellow rails, Seney National Wildlife Refuge, 1980. One grid line = 100 m.

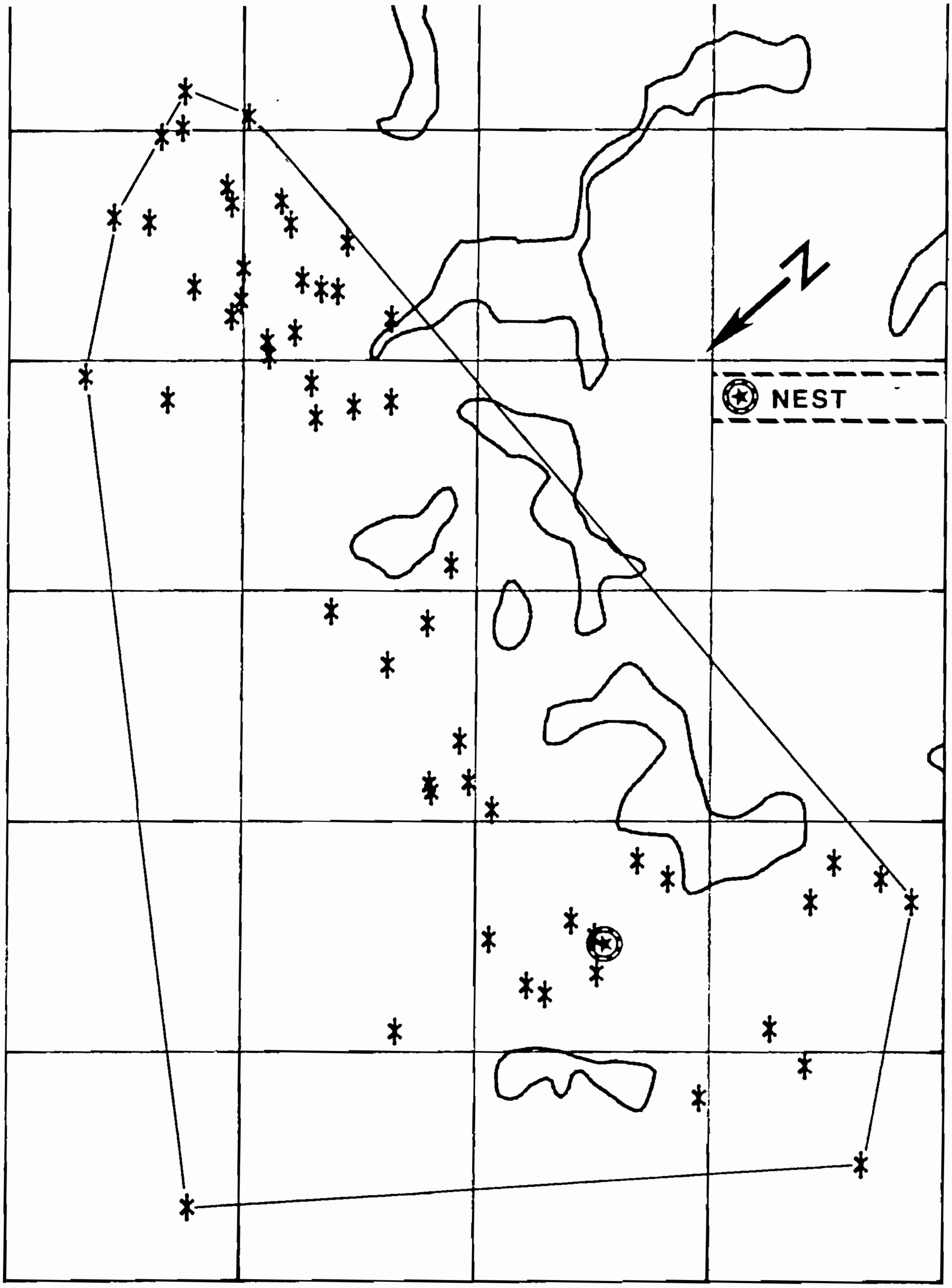


Fig. 11. Clicking and Patrolling movements of male 1 (n = 56), 21 May-10 Jun, Seney National Wildlife Refuge, 1980. One grid line = 100 m.

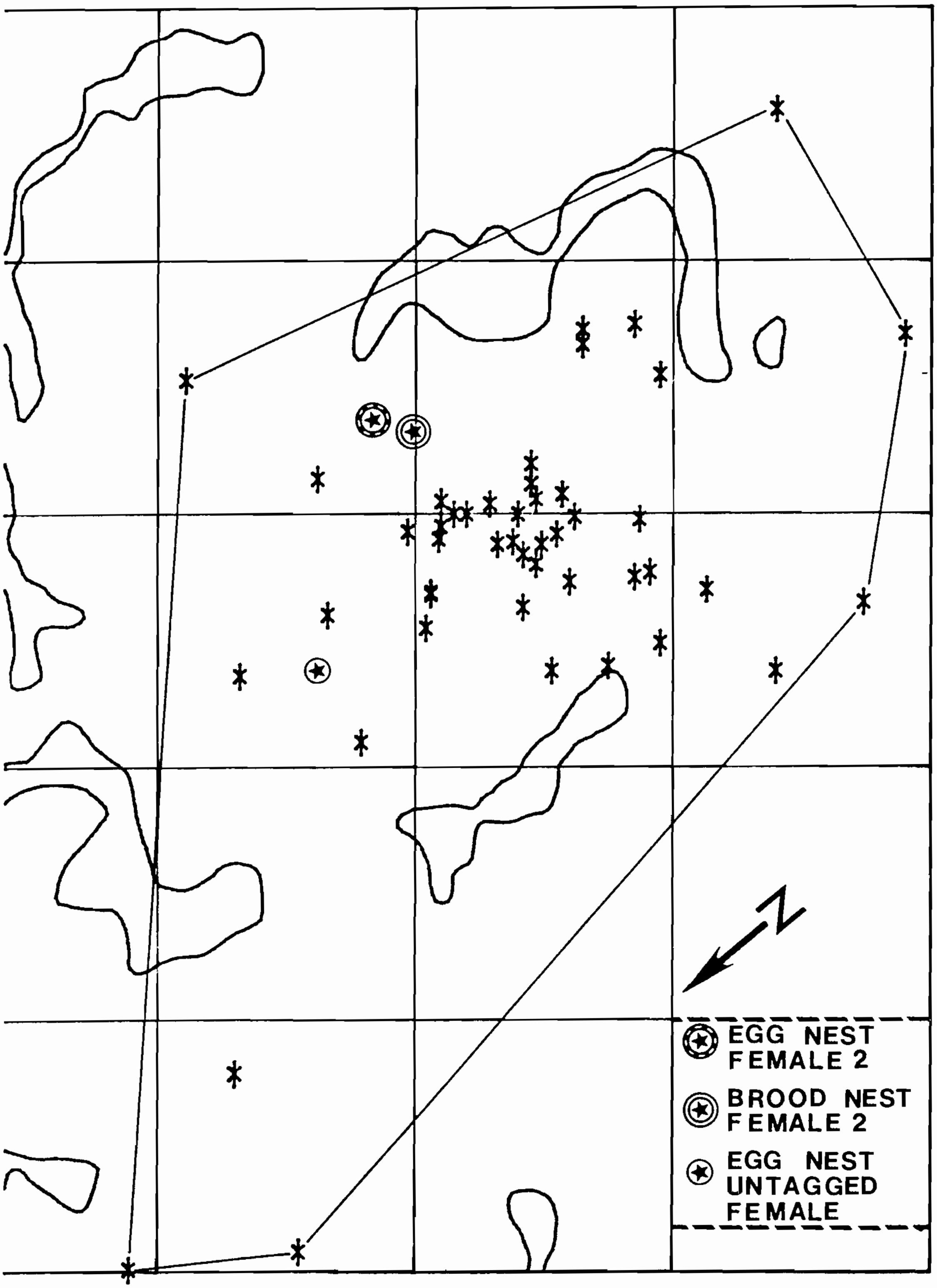


Fig. 12. Clicking and Patrolling movements of male 2 (n = 47), 01 Jun-26 Jun, Seney National Wildlife Refuge, 1980. One grid line = 100 m.

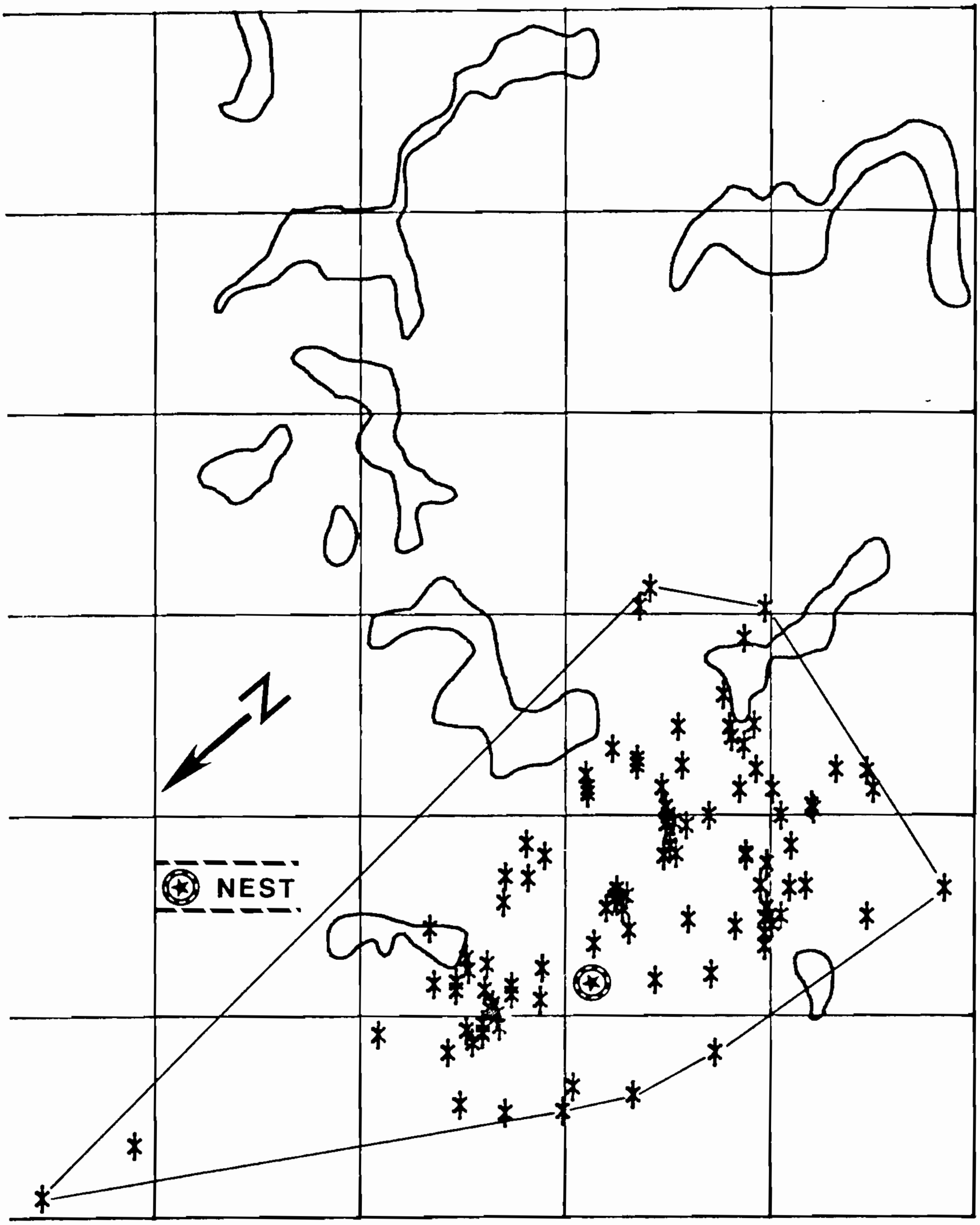


Fig. 13. Clicking and Patrolling movements of male 3 (n = 112), 20 Jun-16 Jul, Seney National Wildlife Refuge, 1980. One grid line = 100 m.

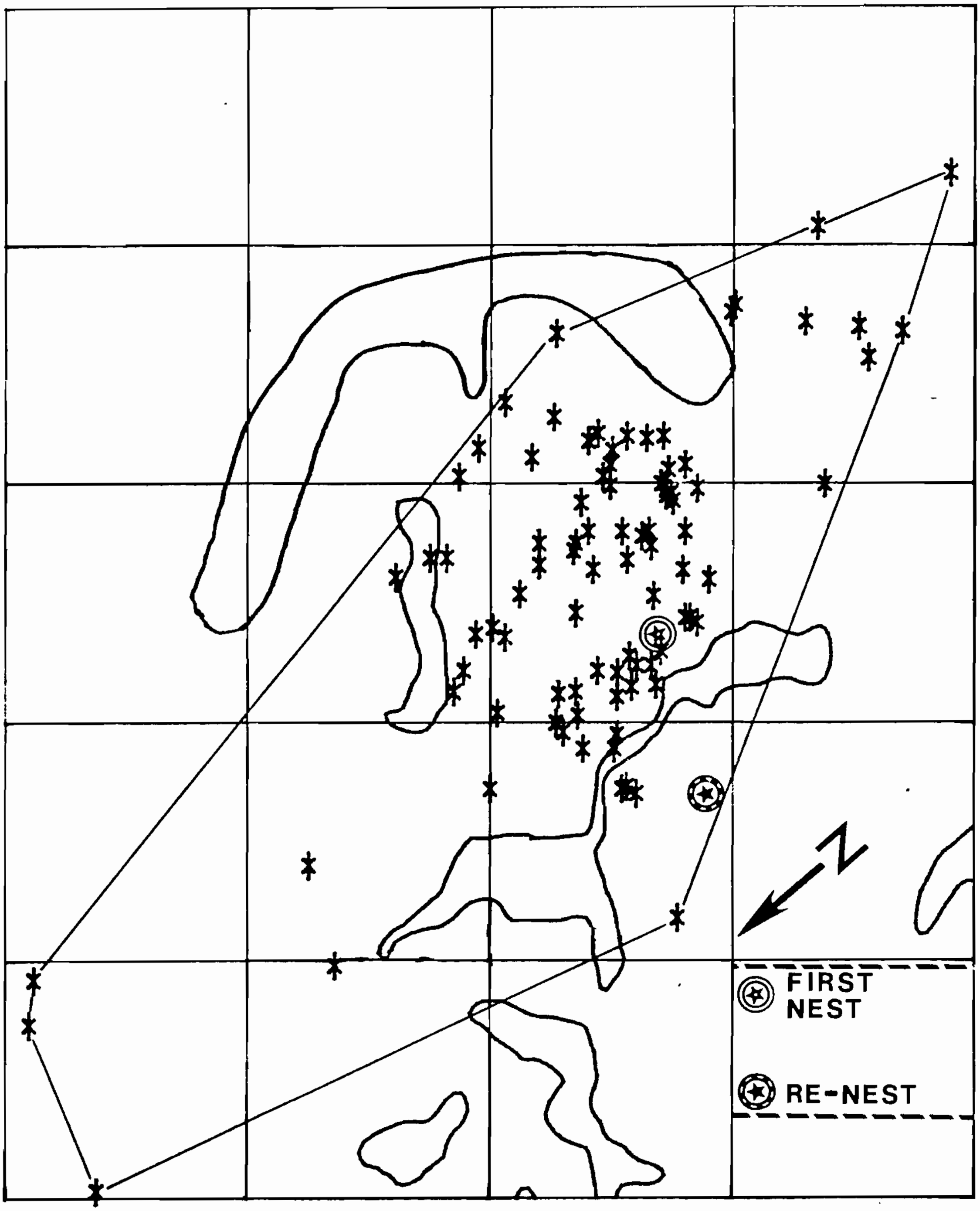


Fig. 14. Clicking and Patrolling movements of male 4 (n = 130), 18 Jul-14 Aug, Seney National Wildlife Refuge, 1980. One grid line = 100 m.

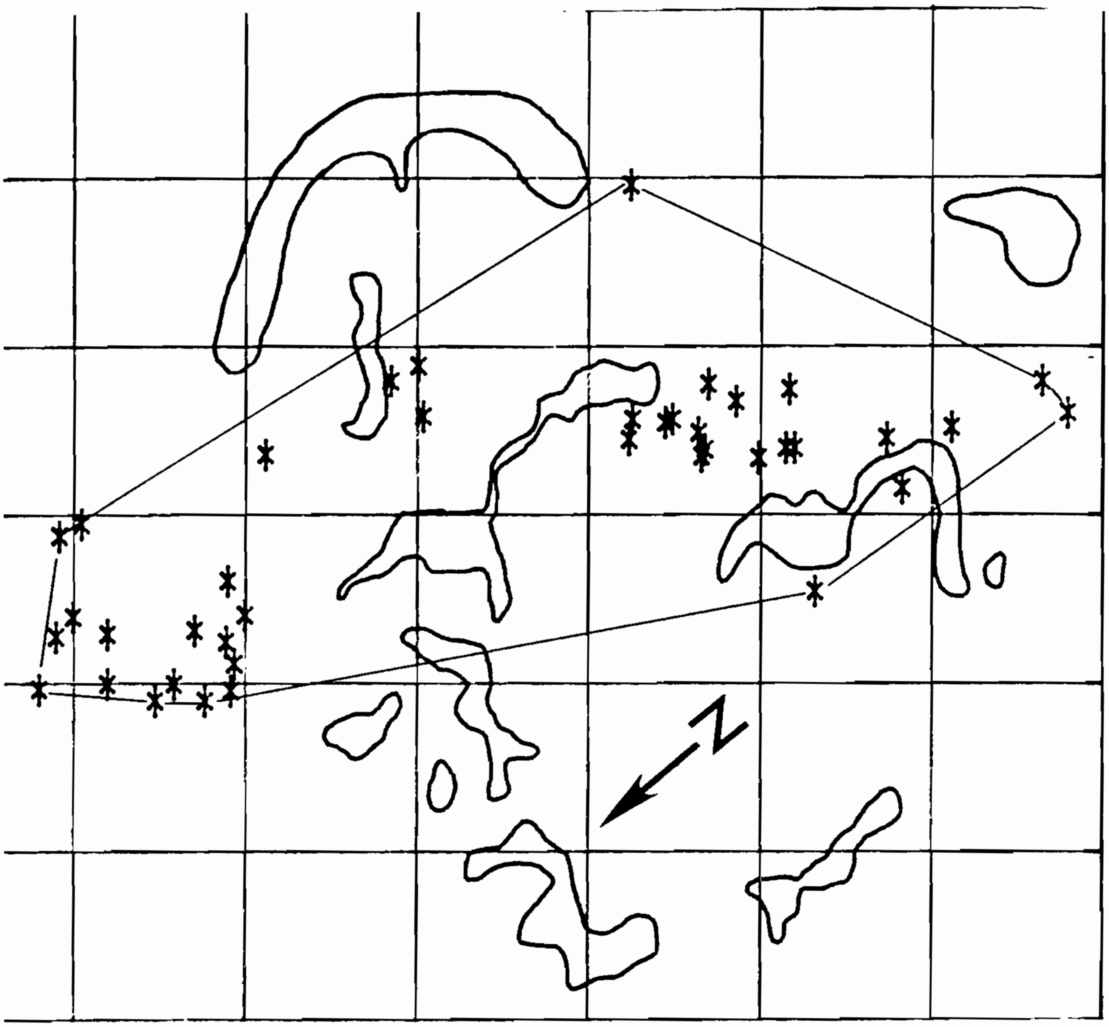


Fig. 15. Clicking and Patrolling movements of male 5 (n = 45), 28 Jun-15 Jul, Seney National Wildlife Refuge, 1980. One grid line = 100 m.

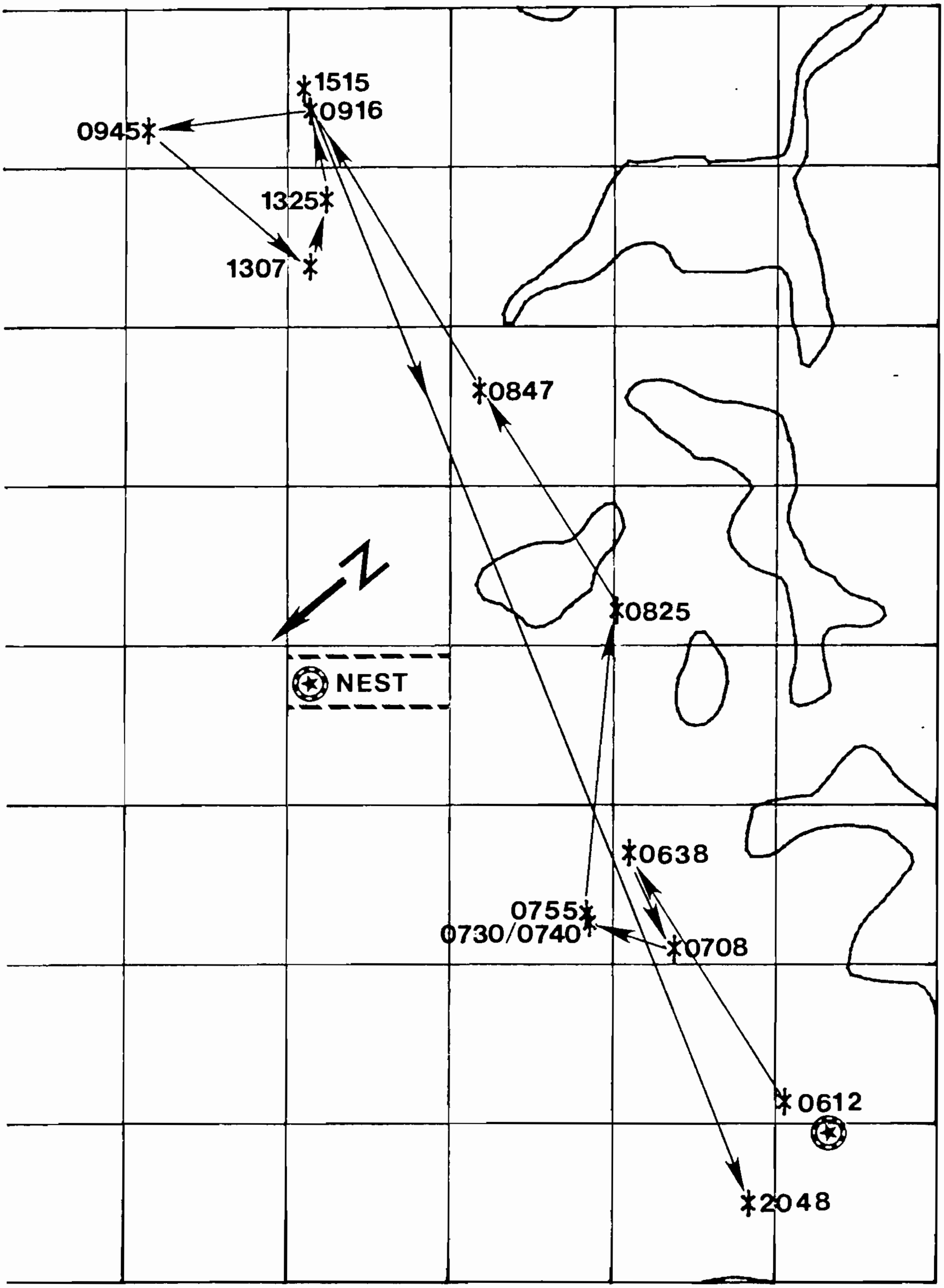


Fig. 16. Movements of male 1 (n = 14), 30 May 0612-2048 h, Seney National Wildlife Refuge, 1980. One grid line = 50 m.

through certain areas. He also concluded, as did Stahlheim (1974), that early morning, in addition to night and early evening, was a period of intense Clicking. Clicking frequency on 2 mornings was measured for 2 males, including this one, and males spent an average of 44% of the time between 0600 and 0710 h Clicking near the nest site (Fig. 17).

I did not record any data that could be quantified, but my impression based on many visits to the same areas at all times of the day and night was that although males certainly Clicked frequently during sunrise, the intense Clicking period could be very short or absent depending on the weather and time of the season. Clicking during the hours of complete darkness, however, seemed to be much more reliable in terms of detecting the same number of males in a given area over a long period of several weeks. Clicking at night lasted several hours and was, of course, not dependent on the intensity and rapidity of light change as the morning Clicking period seemed to be.

After the early morning period of Clicking, male 1 moved about his territory, periodically Clicking, particularly at the periphery of the territory. Clicking frequency generally declined between 1000 and 1700 h, but the Clicking of another nearby male could stimulate bouts of Clicking lasting up to 30 min.

Stahlheim (1974) found that hostile interactions between captive males were frequent in the spring, and that males did all of the Chasing, Clicking and Patrolling behaviors associated with maintaining the integrity of a territory. He also observed that a territorial male, upon encountering an opponent in his territory, would stop to give

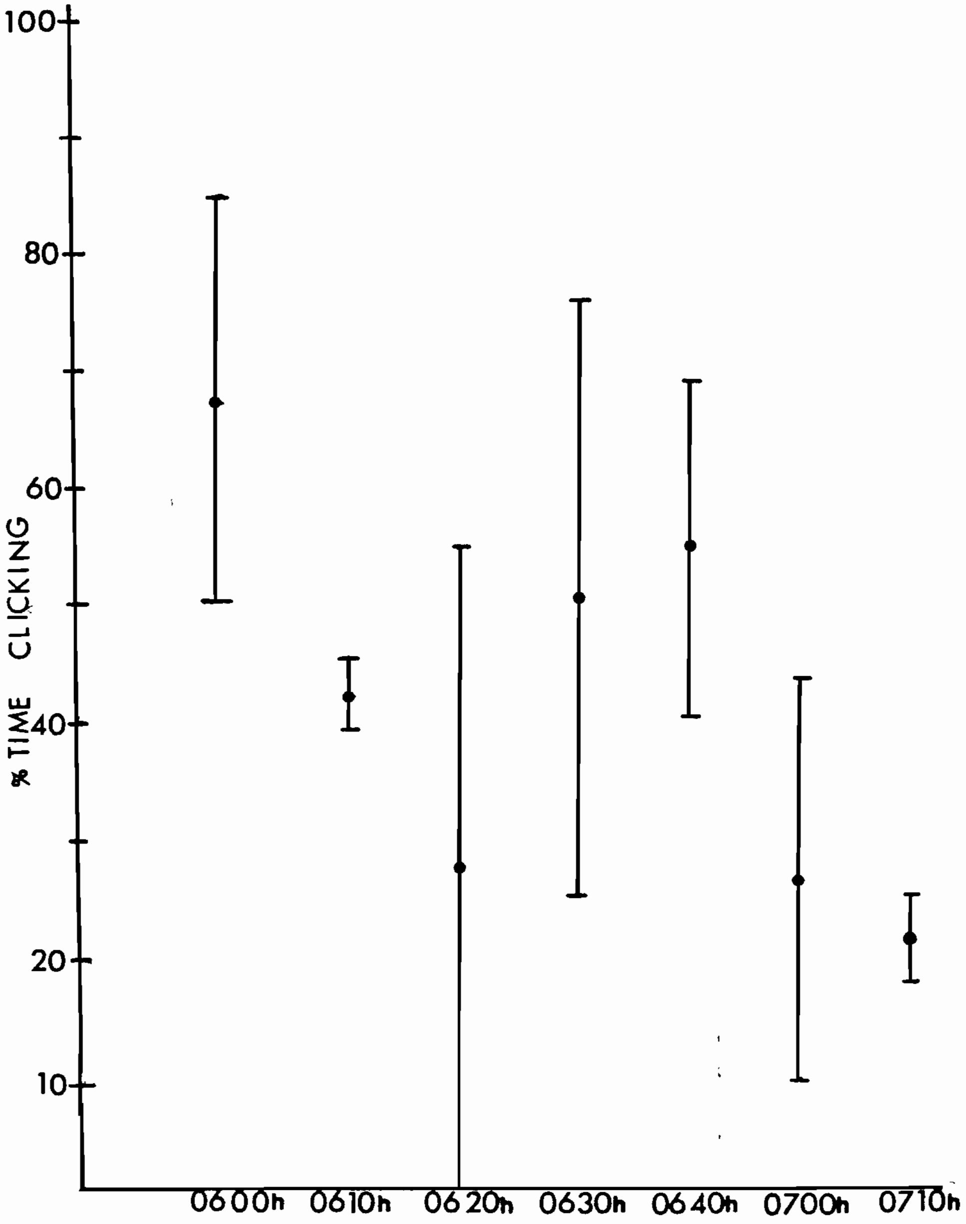


Fig. 17. Mean percentage of total time spent "Clicking" of 2 male yellow rails, 27 May (n=1 male) and 03 June (n=1 male), vertical bars are the ranges between the 2 males, solid circles are the means of the 2 males. Seney National Wildlife Refuge, 1980.

the Clicking call and chase the opponent until they reached his territorial boundary.

The total linear distance moved between plotted points by male 1 on 30 May was 983 m. I believe it is this propensity of the male during the pre-incubation period to move towards an intruder and vigorously Click that has given the mistaken impression to some investigators (e.g., Terrill 1943) that vocal activity of this rail is greater in the daytime than at night.

The behavior of females during the pre-incubation period was more difficult to determine because it was not easy to capture them prior to the start of egg-laying. Females 1, 3, and 4 were captured during egg-laying on 28 May, 25 June, and 11 June, respectively. Female 4 ceased incubation, but renested successively and did not exhibit movement patterns inconsistent with those of the other 2 females. The movement patterns during pre-incubation (Figs. 18, 19, 20, 21) showed a closer association with the nest site than exhibited by the males. All monitored females stayed within the area of movement of the male defending the territory. The average area utilized by females prior to the onset of incubation was 1.23 ha (Table 8).

Serial Polygyny

Serial polygyny was exhibited by the dominant male of the captive birds Stahlheim (1974) studied. That male paired with the first female until incubation began, after which the pair bond broke. The male then formed a pair bond with another female until incubation of her eggs

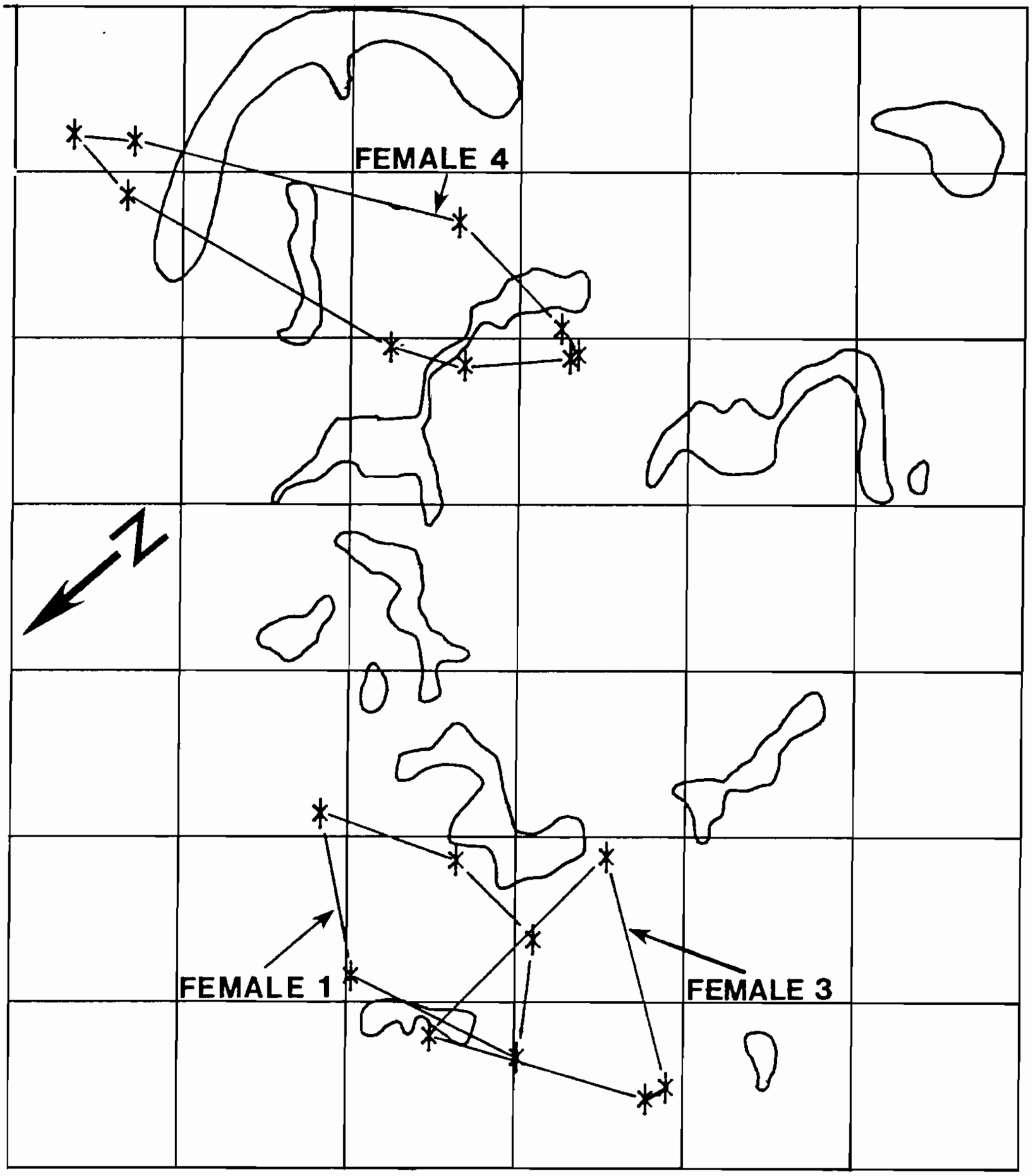


Fig. 18. Pre-incubation movements of female yellow rails 1, 3, 4, Seney National Wildlife Refuge, 1980. One grid line = 100 m.

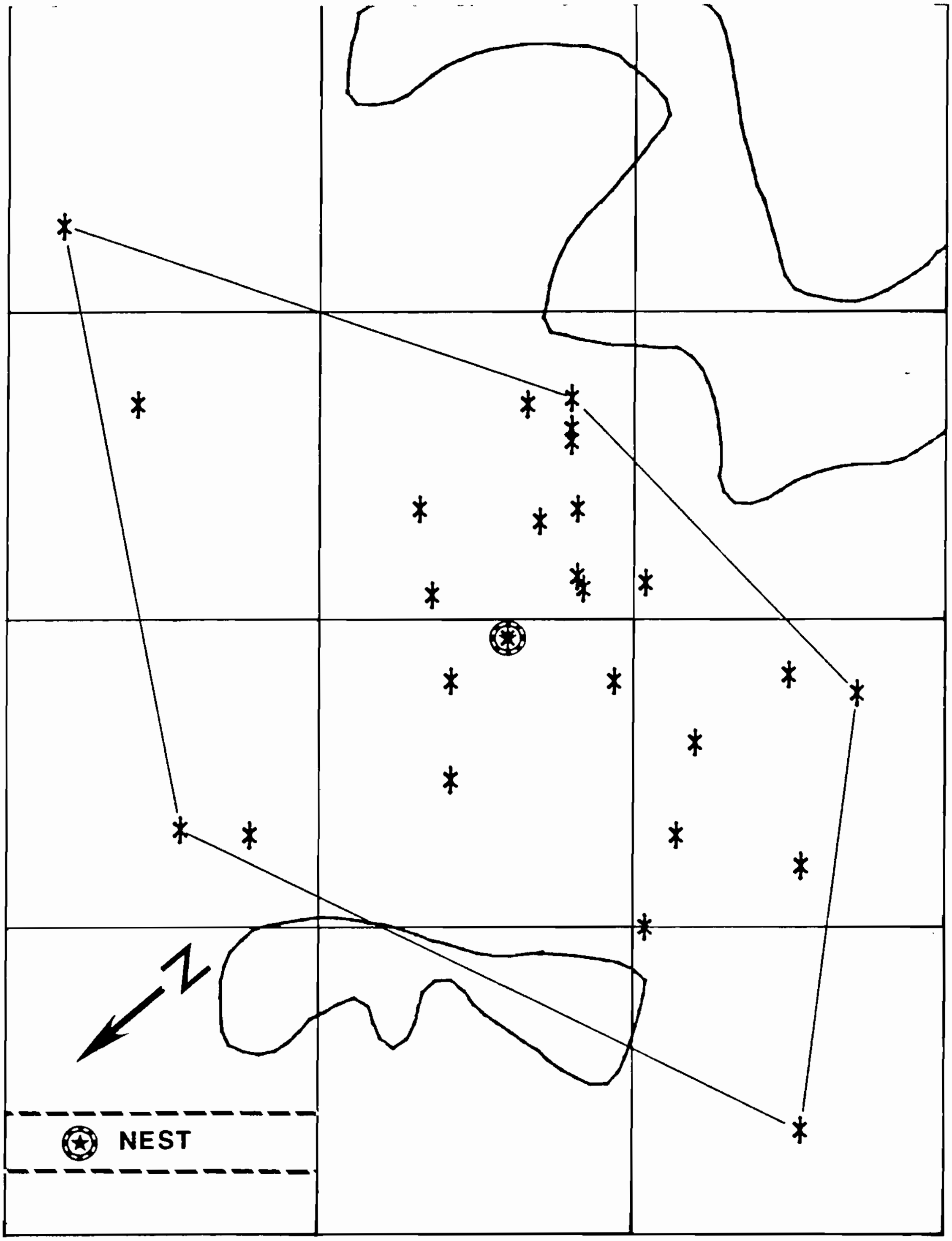


Fig. 19. Pre-incubation movements of female 1 (n = 34), 29 May-10 Jun, Seney National Wildlife Refuge, 1980. One grid line = 50 m.

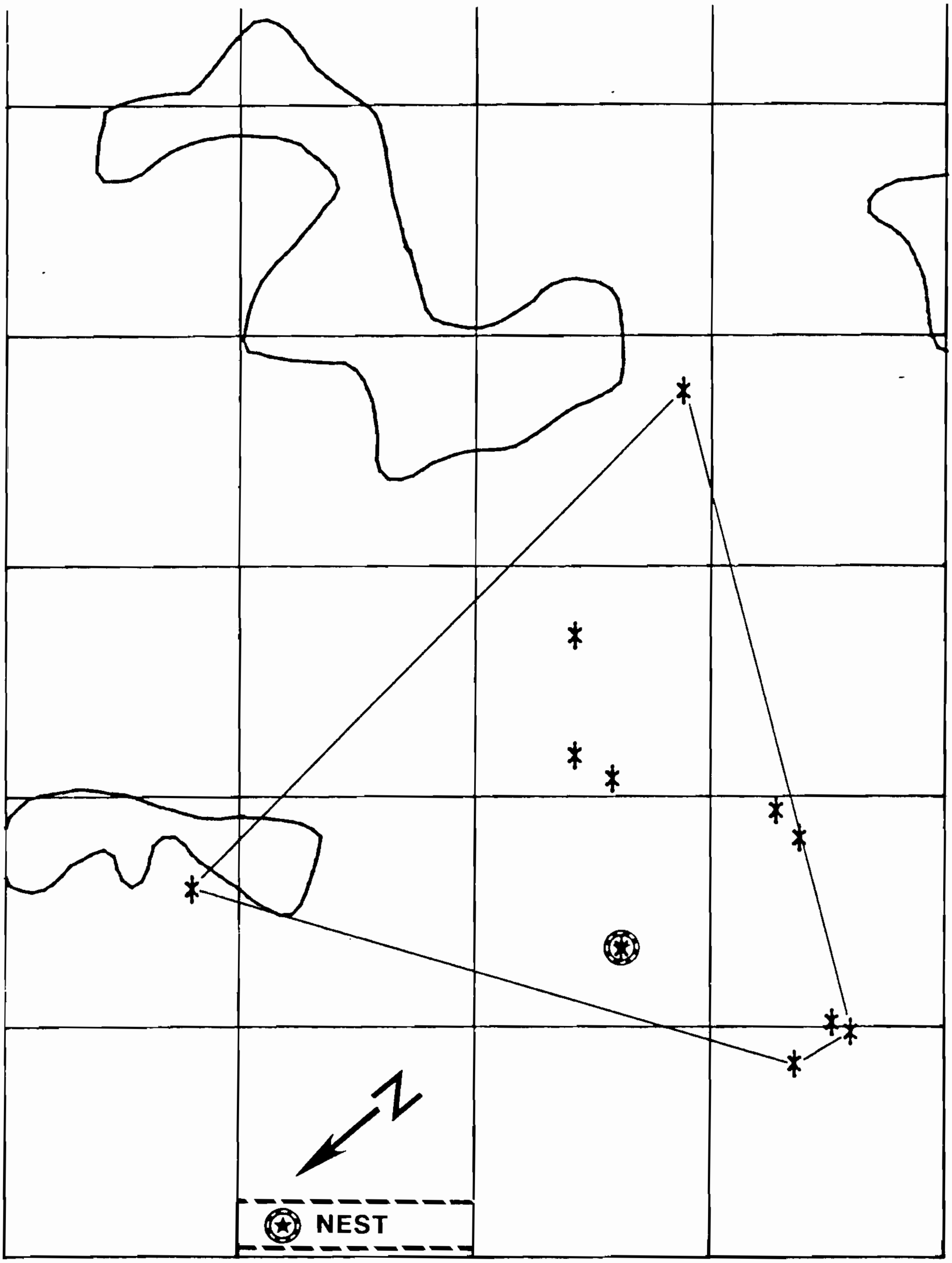


Fig. 20. Pre-incubation movements of female 3 (n = 13), 25 Jun-29 Jun, Seney National Wildlife Refuge, 1980. One grid line = 50 m.

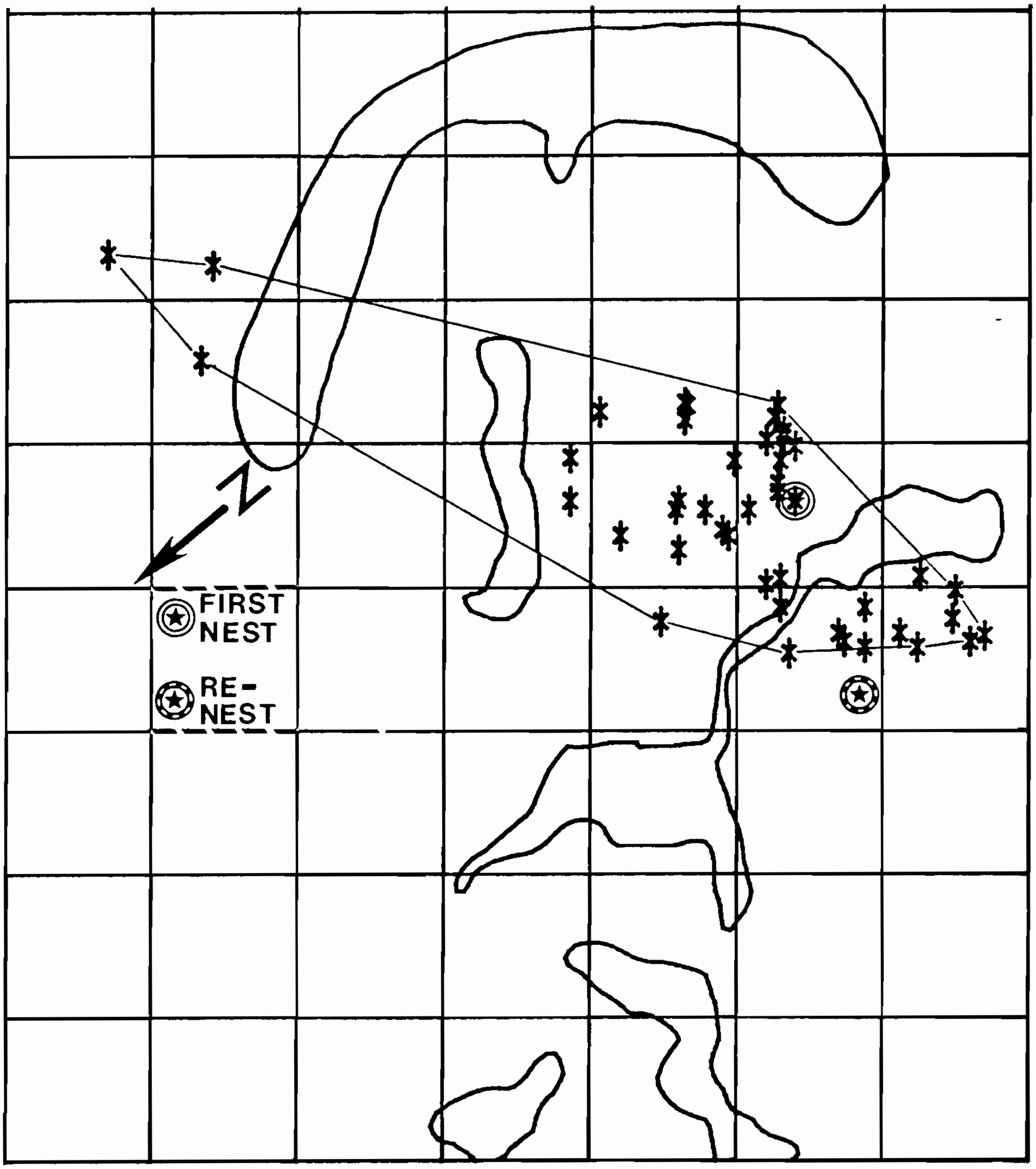


Fig. 21. Pre-incubation movements of female 4 (n = 55), 12 June-05 Jul, Seney National Wildlife Refuge, 1980. One grid line = 50 m.

Table 8. Area of movement of female yellow rails, pre-incubation, Seney National Wildlife Refuge, 1980.

Bird	Area (ha)	Date	No. of plotted locations
Female 1	1.05	29 May-10 Jun	34
Female 3	0.99	25 Jun-29 Jun	13
Female 4	1.66	12 Jun-05 Jul	55

began. Only female yellow rails incubate the eggs, unlike any other rail species that have been studied (Stahlheim 1974), in which both sexes share in incubation. Some evidence for serial polygyny in the wild was found on the MCPSA in 1980. Male 2 defended a territory that included the nest of female 2 where incubation was calculated to have begun 31 May and the nest of another female containing 3 eggs where incubation was projected to have started 07 July. The 30-35-day interval would have allowed the male sufficient time for pairing and sexual behavior with the second female after the onset of incubation of the eggs of female 2.

Male 2 was the only male observed to occupy the area where the 2 nests were found as deduced from telemetry data, calling locations, and recapture of this bird periodically during the nesting season as late as 11 August. No noticeable shift in calling locations indicated the site of the newer nest. Clicking by male 2 occurred at night in all parts of his territory and of the 46 plotted telemetry locations on 20-26 June between 0916 and 2030 h only 2 were within 50 m of the nest. Only in the early mornings of 08 and 11 June and 03 July (the morning of the discovery of the second nest) was male 2 presumed to be the male calling from near the newer nest site. Unfortunately, male 2 did not have a transmitter on after 26 June, and this presumption is based on the fact that we never captured another male or had any reason to believe that another male intruded into the territory of male 2.

Another potential instance of serial polygyny occurred in the territory of male 4. On 11 August, a female (not female 4) with a brood of at least 5 young less than 10 days old was found within the territory of male 4. The female and brood were found near (~ 130 m) the boundary of his area of movement and might have wandered in from an adjacent male's territory. If it is assumed that the young of the second female were 7 days old when discovered, they would have hatched on 04 August, and incubation would have begun 18 days earlier, on 12 July. The interval of 11 days between the onset of incubation of the new female and female 4 is considerably shorter than the 27 days between arrival and incubation of the first nest of the season, and the 18 days between onset of incubation of the 2 females that bred with the same male in Stahlheim's (1974) study.

Incubation

The average size of the 4 completed clutches at the MCPSA was 8 (range 7-9). Based on 17 nests reported in the literature, the average clutch size in wild birds is 8.7 eggs (range 6-10) (Stahlheim 1974). The clutch size of 7 was a successful renest in a second nest by a bird whose first clutch was abandoned after 5 eggs were laid but probably before incubation began. In many species that lay more than 1 clutch per year, the first clutch is usually larger than later ones (Welty 1975:305).

Seven nests of yellow rails were discovered by following females that carried a radio transmitter (2 nests) or by the dog (5 nests). Nest searching with the dog took place at night and during the day. Many field hours (> 100) were required to locate 4 nests on the MCPSA in

1980. Without the use of the dog no females would have been captured and no nests would have been found.

Incubation has been assumed to begin after the last egg is laid (Terrill 1943, Stahlheim 1974, Elliot and Morrison 1979) and has been estimated to last for 13 days (Lane 1962), 17 days (Stahlheim 1974), 18 days (Elliot and Morrison 1979). Incubation varied from 11 to 22 days (average 18.7) for the sora and from 13 to 20 days (average 17.3) for the Virginia rail (Pospichal and Marshall 1954). To my knowledge no one, including Stahlheim, has monitored a yellow rail nest on a day-by-day basis, egg-laying through hatching. Previous attempts to determine the length of incubation have depended on the assumption that incubation begins immediately after the last egg is laid (Lane 1962, Stahlheim 1974, Elliot and Morrison 1979). Lane (1962) and Elliot and Morrison (1979) found nests in the wild, and periodic visits were made to the nest site. The start of incubation was determined by back-dating to the date of the last egg, not by direct observation. Stahlheim (1974) did not observe the sequence of egg-laying in captive females and found the location of the nest, upon which he based his conclusions, only after incubation began. Again, no direct observation was made, and incubation was assumed to have begun after the last egg was laid.

Unfortunately, none of the 3 yellow rail nests found in the MCPSA during the egg-laying stage could be followed through to hatching. Two females died, probably due to transmitter-induced stress; one female renested, and the new nest was not found until after incubation commenced.

Evidence was found for a 17-18-day incubation period, with a variable number of days between the laying of the last egg and the start of incubation. Table 9 is a summary of field note data and radio-telemetry locations for females 1, 3, and 4. Eggs in the clutches of the birds were warm one day, and cold another. The eggs of female 1 remained in the nest 8 days before continuous incubation began, as deduced from radio-telemetry data. Despite cooling to ambient temperature for 26 h, the eggs of female 1 hatched in an incubator after 18 days of continuous natural and artificial incubation except for the 1 day (24 Jun) not incubated. If the egg count was correct for female 3, continuous incubation could have started 28 June and probably started 30 June, 3 days before the discovery of the 9th and last egg of the clutch. The last egg could have been laid 01 July, 24 h after the probable start of incubation.

The variability observed between the laying of the last egg and the onset of incubation could have been due to observer effect, but the data demonstrate the capability for onset of incubation to vary, the temperature of the eggs to vary, and the ability of the eggs to hatch after 17-18 days of continuous incubation.

A canopy of sedge is built in and maintained over the nest by the female, completely obscuring it from above (Peabody 1922, Stahlheim 1974). A canopy was found over all 7 active nests during 1979 and 1980. If the canopy was pulled back to count the eggs, it was restored by the female when she returned.

Table 9. Number and temperature of yellow rail eggs before and during incubation, Seney National Wildlife Refuge, 1980.

Date	Number of eggs	Egg temperature	Notes and telemetry locations
Female 1			
01 Jun	6	Cold (1130 h)	Female moving within a 1.7-ha area around the nest site.
02 Jun	7	Cold (1840 h)	
03 Jun	8	Cold (0900 h)	
04 Jun	8	Warm (2310 h)	
05 Jun	8	Warm (1515 h)	
06 Jun	8	Cold (1030 h)	
07-10 Jun	nest not checked		
11 Jun	8	Warm (2130 h)	Continuous incubation begins. One egg collected. Embryo alive.
23 Jun	7	Warm (0800 h)	Transmitter antenna entangled (1130 h).
24 Jun	7	Cold	Female dead. Eggs put in incubator (1630 h). One egg opened, embryo alive.
25 Jun	6	Warm	
28-29 Jun	3/6 hatch		Eggs hatched by 0300 h.
Female 3			
25 Jun			Bird caught & telemetered 0200 h. During day, moved around nest site within a 0.7-ha area.
26 Jun	8	Warm (0200 h)	
27 Jun	not counted	Cold (1500 h)	
28 Jun	nest not checked		Incubation begins (?). Bird at nest 1600 h (n=1 observation).
29 Jun	8	Warm (1400 h)	
30 Jun	8	Warm (0800 h)	Continuous incubation probably starts (n=7 observations).
03-10 Jul	9	Warm (various times)	
11 Jul	9	Warm (2300 h)	Female dead. Eggs collected. Embryos alive.

Table 9. Continued.

Date	Number of eggs	Egg temperature	Notes and telemetry locations
Female 4			
06 Jul			Projected onset of incubation.
17 Jul	7	not checked	Found nest.
19 Jul	7	Cold (1106 h)	Near ambient temperature (~ 23.89°C).
24 Jul	7		Eggs hatched.

Once incubation began, females were closely associated with the nest. No females were found off the nest at night. Stahlheim (1974) reported that captive females incubated 83% of the time during the day and 100% of the time at night. Therefore, incubating females spend very little time feeding. Males have not been observed to feed the females (Stahlheim 1974).

Many plotted locations were recorded at short intervals to characterize the behavior of incubating females (Table 10). During the day, captive, incubating yellow rails left the nest for 1 to 5 min between 20- to 40-min incubation periods and fed intensively. (Stahlheim 1974). The average detectable distance that incubating yellow rails at the MCPSA moved from their nests ranged from 21.5 to 35.6 m (Table 11). Females utilized an average of 0.28 ha ha during incubation (Table 12).

Short distances ($\leq$ 2 m) moved from the nest would not be resolved by the radio receiver as being different from movements by the female on the nest. Nevertheless, the data show that incubating females moved short distances from the nest site.

Hatching and Post-hatching

Two females were monitored by radiotelemetry during hatching of the young, which apparently takes place at night (Stahlheim 1974, Elliot and Morrison 1979). The young of both broods monitored at the MCPSA hatched at night through early morning. Because incubation

Table 10. Continuous (2 known locations ≤ 60 min apart) observation effort for incubating yellow rails, Seney National Wildlife Refuge, 1980.

Female	Continuous observation time (min)	# Plotted locations	Mean inter-observation interval (min)	Date
1	2855	115	24.8	11 Jun - 21 Jun
2	1193	42	28.4	28 Jun - 10 Jul
4	1150	39	38.8	06 Jul - 24 Jul
	92 h 38 min			

Table 11. Distance moved from the nest by yellow rails during the incubation period, Seney National Wildlife Refuge, 1980.

Female no.	Mean distance (m) moved away from nest ± SE	Range (m)	n	Date
1	27.6 ± 3.3	2.8 - 71.0	29	11 Jun-19 Jun
2	35.6 ± 6.0	15.6 - 60.2	9	28 Jun-10 Jul
4	21.5 ± 2.3	6.1 - 38.0	15	06 Jul-24 Jul

Table 12. Area of movement of female yellow rails during the incubation period, Seney National Wildlife Refuge, 1980.

Bird	Area (ha)	Date	n
Female 1	0.47	11 Jun-23 Jun	145
Female 2	0.14	17 Jun-20 Jun	89
Female 3	0.29	30 Jun-10 Jul	65
Female 4	0.21	06 Jul-24 Jul	90

begins about the time the clutch is completed, hatching is synchronous, unlike that of soras and Virginia rails (Walkinshaw 1940, Pospichal and Marshall 1954) (Table 13). Hatching time of the eggs in the nest of female 2 was about 15 h; on 18 June at 0930 h all eggs were unhatched, at 2245 h 1 chick, still very wet, had hatched and was assumed to be 1 h or less old, and at 1245 h 19 June all young had hatched although 1 chick was still wet.

The females removed eggshells from both nests that hatched eggs and placed them about 1 to 3 m away along "microtus-like" trails. The trails consisted of narrow runways with sedge fragments ($\leq$ 2 cm) forming the substrate of the trail. None of the literature I examined mentioned trails associated with nests of yellow rails.

The most extensive trail system found at the MCPSA had a total length of 7.2 m (Fig. 22). Trails were found at the nests of females 2 and 4 and at the first nest of female 4 but were not noticed at the other nests. The trail system at the nest of female 2 was not well developed. No trails were evident during a cursory inspection of this nest on 18 June (1750 h), but a closer inspection after the eggs hatched revealed a path used by the female when carrying eggshells from the nest (Fig. 23). The trail might not have had the substrate made of sedge fragments, because this nest was above 2 to 4 cm of water and rain fell almost continuously for 8 h during the previous night.

Stahlheim (1974) did not see the female remove any eggshells from the nest, but did see her crush some eggshell with her bill and pack it into the bottom of the nest. I could account for all eggs in the

Table 13. Duration of hatching of yellow rail clutches.

Duration of hatching (h)	Source
20	Terrill (1943)
<24	Stahlheim (1974)
21	Elliot and Morrison (1979)
15	Female 2, this study

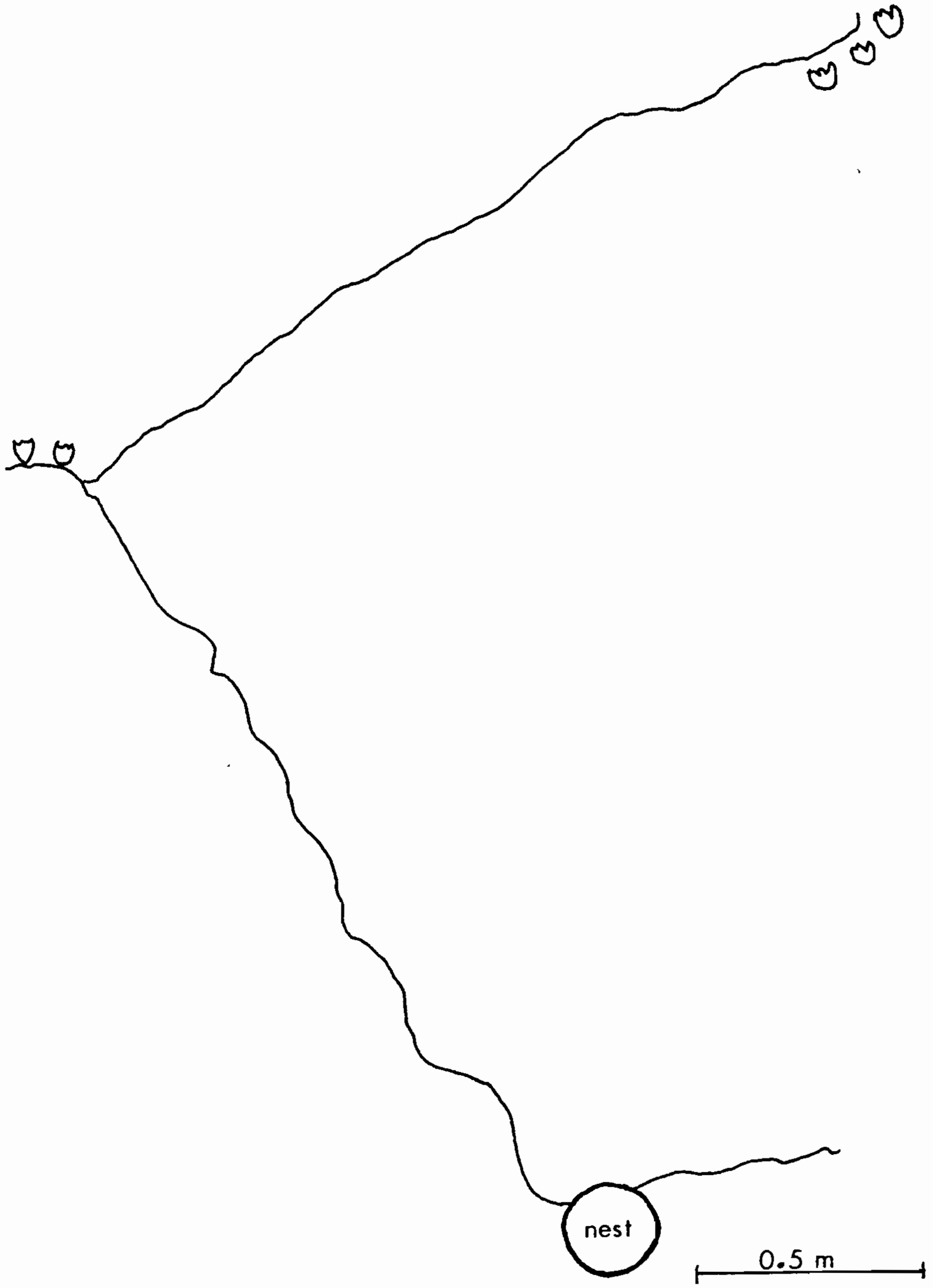


Fig. 22. Trail system and eggshell placement of female 4, Seney National Wildlife Refuge, 1980.

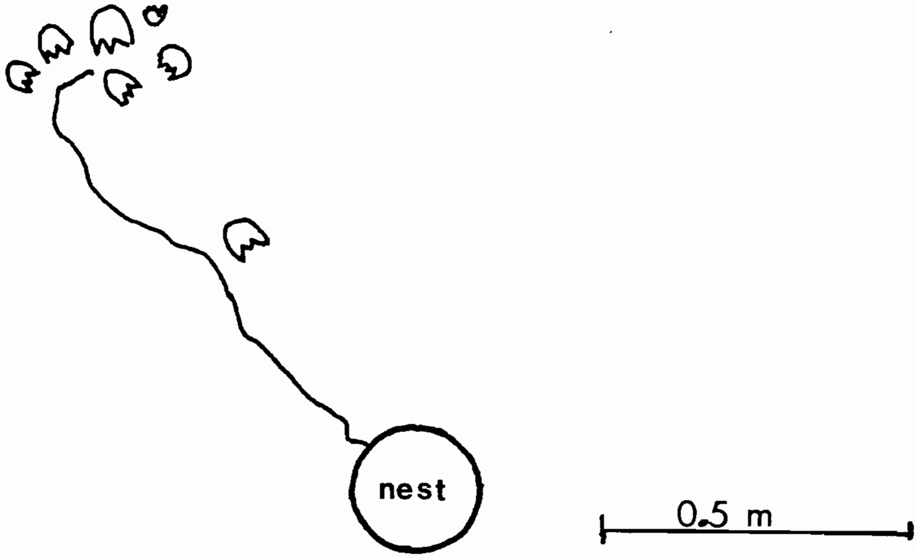


Fig. 23. Trail system and eggshell placement of female 2, Seney National Wildlife Refuge, 1980.

clutch from part or all of the eggshells on the trails. One egg that failed to hatch was left in the nest bowl by female 4.

The nest of female 4 was discovered during a search of the general area by first finding the trail and then following it to the nest. Any future nest searchers should pay close attention for the presence of trails.

Less than 15 h after hatching of the last egg, females led the broods away from the nest, and moved about in a very restricted area (Table 14). Young begin pecking at food 5 days after hatching and begin pecking at their own food more often than from their mother's bill after 2 weeks (Stahlheim 1974).

Female 2 and brood were found at a brood nest 17 m to the west of the nest on 27 June (0300 h). The brood nest appeared to be 1 year old. The bowl and the lip were well formed but nest materials were compressed, indicating the nest shape was not being actively maintained. Lichens covered the entire bottom of the nest bowl. Unlike active nests, no canopy was being maintained over the nest. Young yellow rails hatched in captivity were moved from the nest to a brood nest 2 days after hatching (Stahlheim 1974). Before egg laying, captive male and female yellow rails initiated the construction of several "scrapes" in the vegetation, after which the female finished one of the nests and laid eggs in it (Stahlheim 1974). After the eggs hatched, construction of another potential nest was finished and used as a

Table 14. Post-hatching movements of female yellow rails, <8 days (181 h) after last young hatched, Seney National Wildlife Refuge, 1980.

Female no.	Date & time	Number of plotted locations	Mean distance (m) ± SE from active (egg) nest	Area utilized (ha)
2	20 Jun (1330 h) to 23 Jun (1454 h)	21	23.6 ± 2.9	0.21
4	24 Jul (1341 h) to 01 Aug (0617 h)	33	29.7 ± 2.3	0.17

brood nest (Stahlheim 1974). Dummy nests are commonly made by soras and Virginia rails in close proximity to the active nest and seem to serve as resting and feeding platforms (Pospichal and Marshall 1954).

The frequency of dummy nests near active yellow rail nests is not known. Terrill (1943) searched for them, but found none in the vicinity of an active nest. The extra nest used by female 2 as a brood nest is the first to be found in the wild for yellow rails. I did not find any "scrapes" that might be dummy nests constructed the same year as the active nest, and the brood nest might have been last year's active nest.

Female 2 lost her transmitter after 23 June. The only female with young to retain her transmitter for longer than 5 days after hatching of the eggs was female 4. I would characterize the movements of female 4 and her brood during the remainder of the field season (01-30 Aug) as moving back and forth between 2 principal areas at intervals of about 1 week (Fig. 24). Only 1 quick excursion by the female lasting 4 h on 06 Aug was made back and forth between the principal areas of movement, and this point was excluded from the time estimates to give a better idea of the time spent in the areas in which the bird and presumably the brood spent most of their time (Table 15).

If the female and the brood were to take the shortest route between areas, they would have had to cross dry land. That this occurred was supported by hearing the young 'peeping' 28 July in one area and hearing them 'peeping' again on the other side of a sand ridge 01 August. If the young stayed in the vicinity of the mother, on the

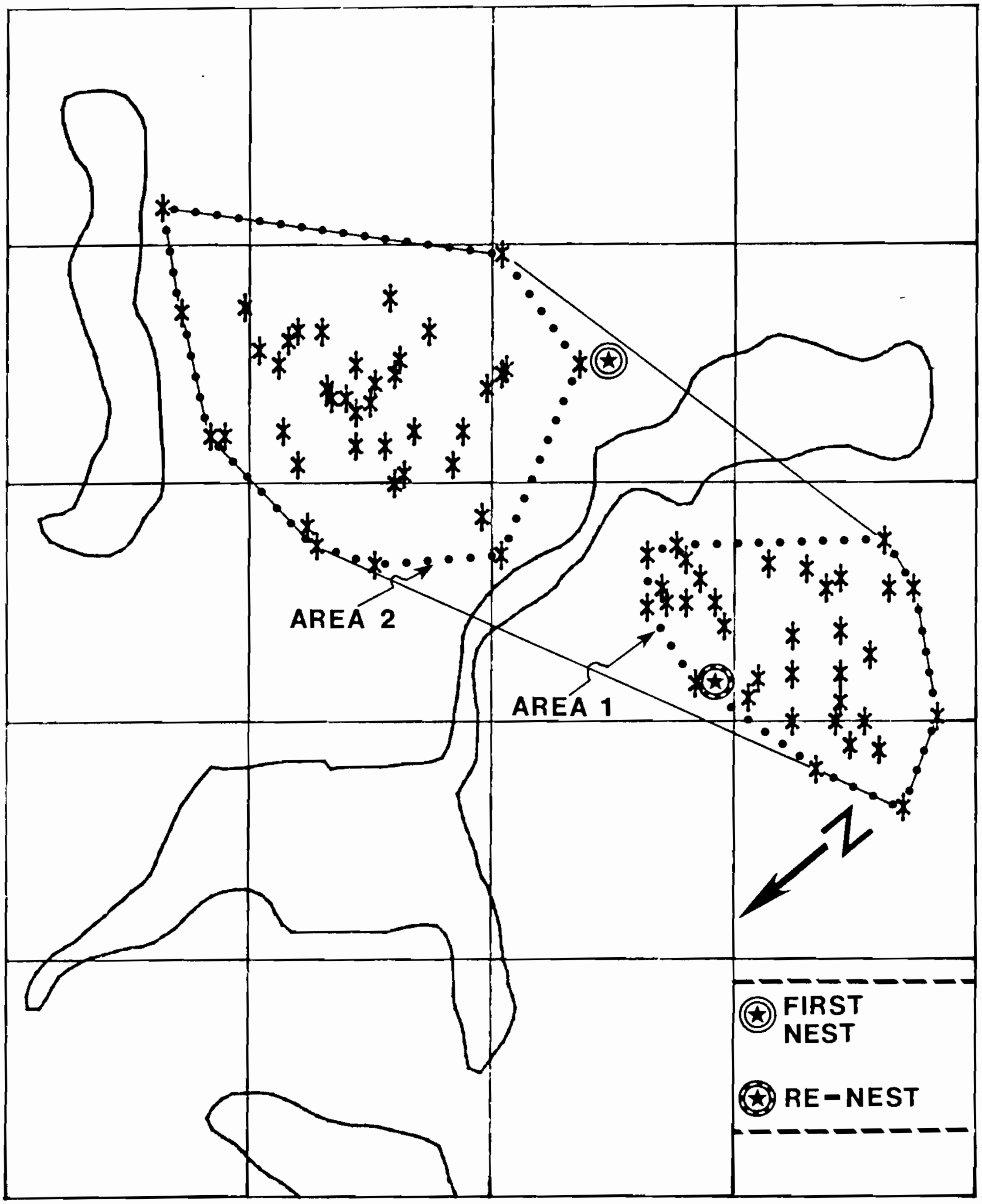


Fig. 24. Post-hatch movements of female 4 (n = 137), 24 Jul-30 Aug, Seney National Wildlife Refuge, 1980. One grid line = 50 m.

Table 15. Area of movement of female 4, post-hatching, 24 Jul-30 Aug, Seney National Wildlife Refuge, 1980.

	Date	Area (ha)	n
Movement Area 1	24 Jul-29 Jul	0.22	34
	11 Aug-20 Aug		36
Movement Area 2	01 Aug-09 Aug	0.45	30
	20 Aug-30 Aug		37
Total area	24 Jul-30 Aug	0.99	137

basis of the plotted locations before and after one of the inter-area moves, it would have been a 45-m trip between the areas across land or a 200-m trip around the island separating the two areas. Because no locations were plotted that indicated the female went around the island I assumed that she took the shorter route. The importance of walking across dry land is that it takes the young out from under the protective canopy of *C. lasiocarpa* and into more open vegetation, thus exposing them to aerial predators. A pair of kestrels (*Falco sparverius*) often hunted from a perch 80 m away from the sand ridge and might, along with other raptors such as the marsh hawk (*Circus cyaneus*), a known yellow rail predator (Walkinshaw 1939), be a mortality threat to young birds.

Another factor increasing mortality by making the birds more detectable to predators might be vocalizations made by the parents and young. The young rarely make vocalizations that can be heard by human observers in the field. When I walked up to young birds, their reaction was to scatter in all directions a distance of 1 to 3 m and then return slowly to the point from which they scattered while giving the Peep call that has been associated with young birds that are cold or hungry (Stahlheim 1974). After the young scatter, the mother Whines. This call attracts the young to the mother (Stahlheim 1974). On 3 different occasions, 2 at night and 1 during the day, I scattered young while walking through the study area, and the young gave the Peep call while regrouping around my feet. This behavior allowed the hand-capture of the young and female on 2 occasions.

The movements of 1 immature bird were followed 22 July to 30 August after capture of the bird within 50 m of the brood nest of female 2. The bird was subsequently plotted at the brood nest on 22 July and at the nest site 14 August. The capture location, subsequent movement patterns, and size of the bird at capture (39 g) suggested this bird might have been the offspring of female 2. The immature at the time of capture was in juvenal plumage with the primary feathers still partly encased in the shaft and about 2/3 the length of adult feathers. Young yellow rails are in juvenal plumage by 21 days and can fly by 35 days (Stahlheim 1974). If this bird hatched on 19 June, it would have been 32 days old at the time of capture. Young yellow rails can be independent of their mother after 3 weeks (Fig. 25), yet this bird remained in the vicinity of the nest for the duration of the field season.

The movements of the immature bird were within a 3.3-ha area (Fig. 26) and average distance moved between plotted locations was relatively short (Table 16). The movements of this bird can be divided into 3 time periods of movements that barely overlap (Fig. 27). Because the bird was able to elude capture while carrying the transmitter, I do not believe its ability to move about on the ground was impaired. However, some restriction of movement might have resulted had the bird wanted to fly. Yellow rails were never observed flying voluntarily.

Only male 4 retained his transmitter after hatching of the eggs in his territory. Location of this male was plotted 145 m from the

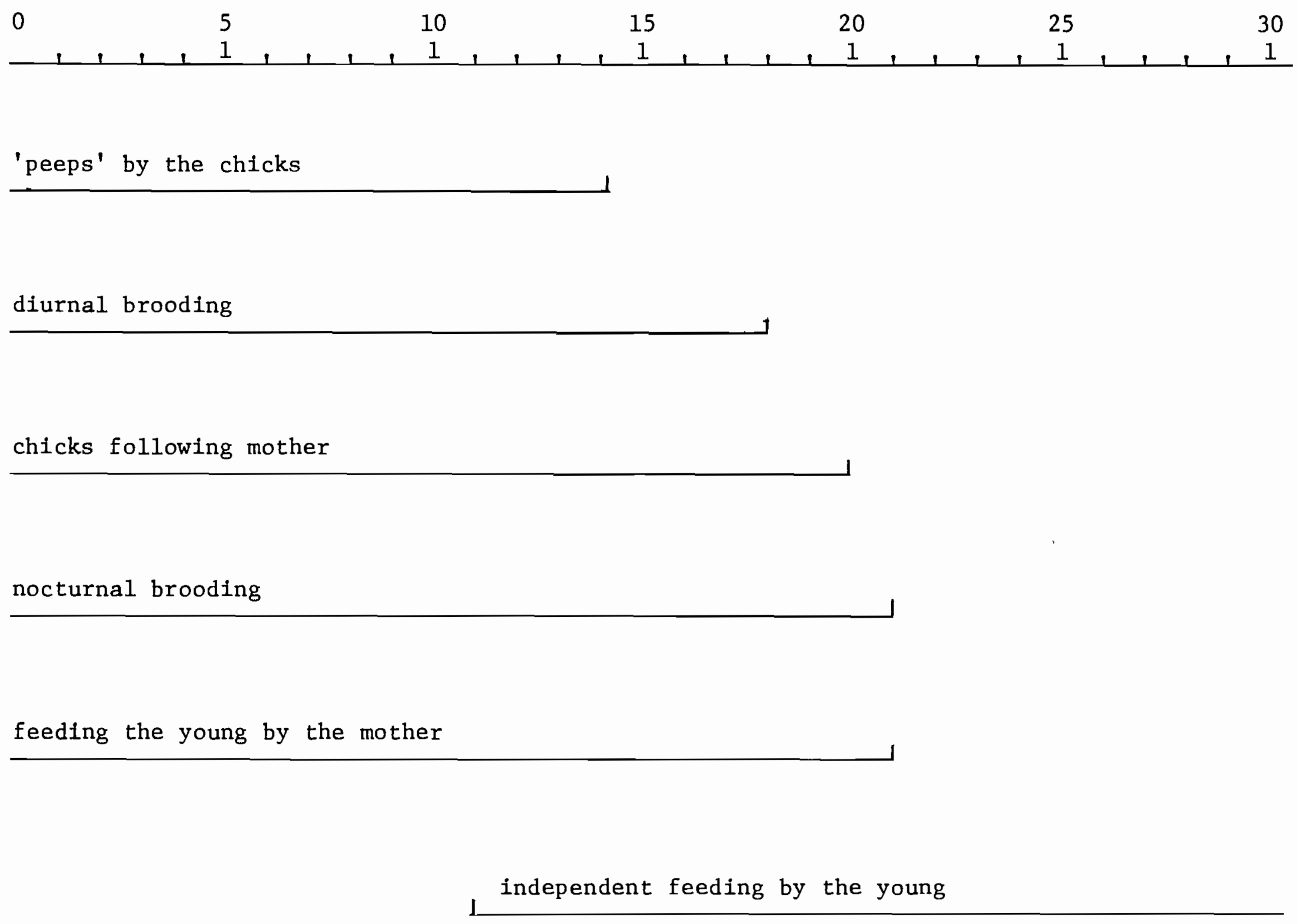


Fig. 25. The occurence of behavior patterns performed by the chicks and their mother during the first month after hatching. Adapted from Stahlheim (1974).

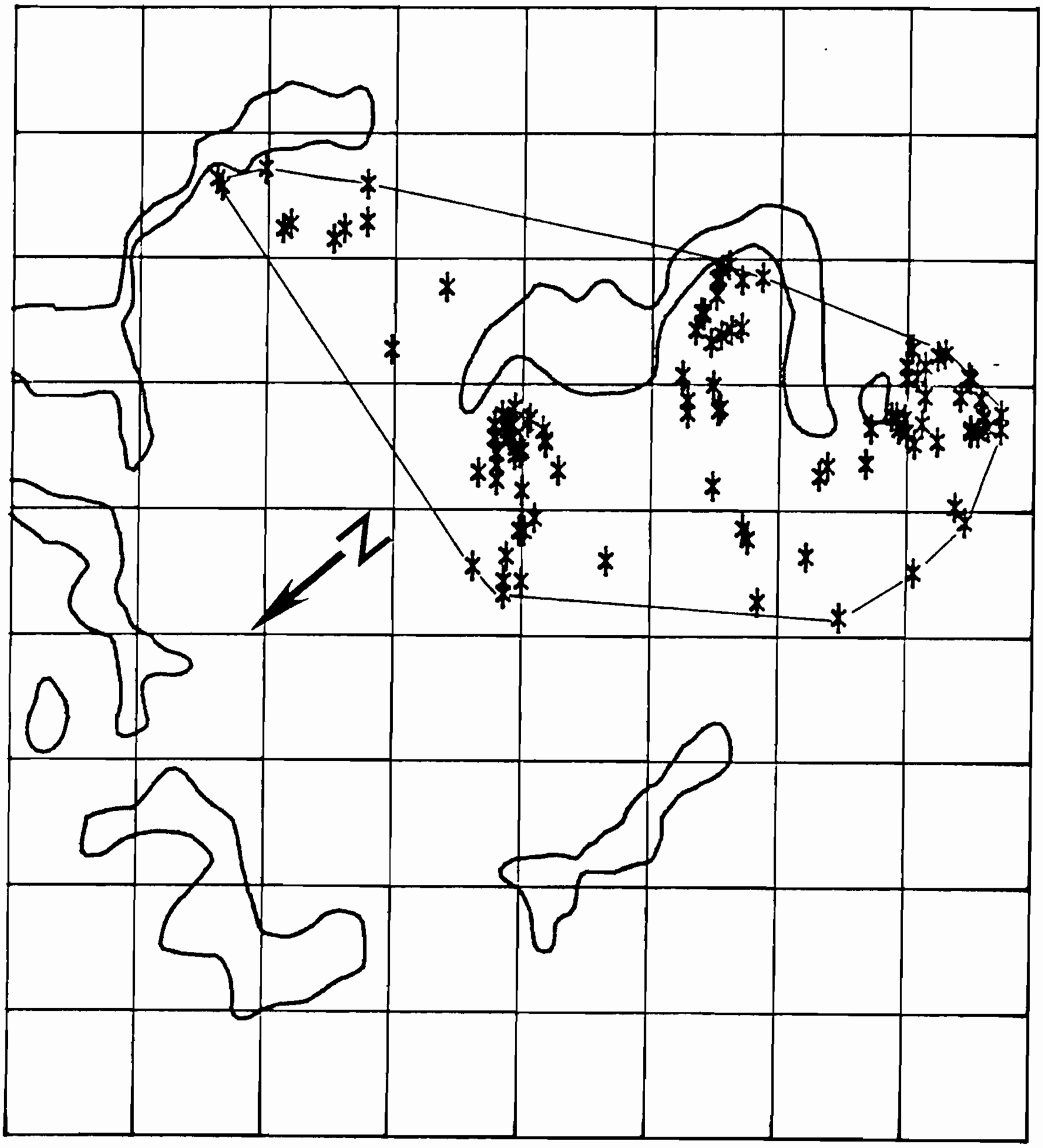


Fig. 26. Movements of immature yellow rail (n = 178), 22 Jul-30 Aug, Seney National Wildlife Refuge, 1980. One grid line = 100 m.

Table 16. Inter-observation distance (m) moved by yellow rails 24 Jul-30 Aug, Seney National Wildlife Refuge, 1980.

Bird	Sample period	Inter-observation distance; all locations	n	Inter-observation distance;non-zero distances	n
Immature	24Jul [1330 h]-30Aug [2048 h]	14.2 (± 20.4 SD)	152	35.7 (± 85.4 SD)	93
Male 4	24Jul [1358 h]-14Aug [2058 h] 16Aug [1149 h]-30Aug [2058 h]	27.5 (± 31.6 SD)	137	37.6 (± 31.4 SD)	100
Female 4	24Jul [9341 h]-30Aug [1138 h]	13.6 (± 17.4 SD)	137	24.5 (± 16.7 SD)	76

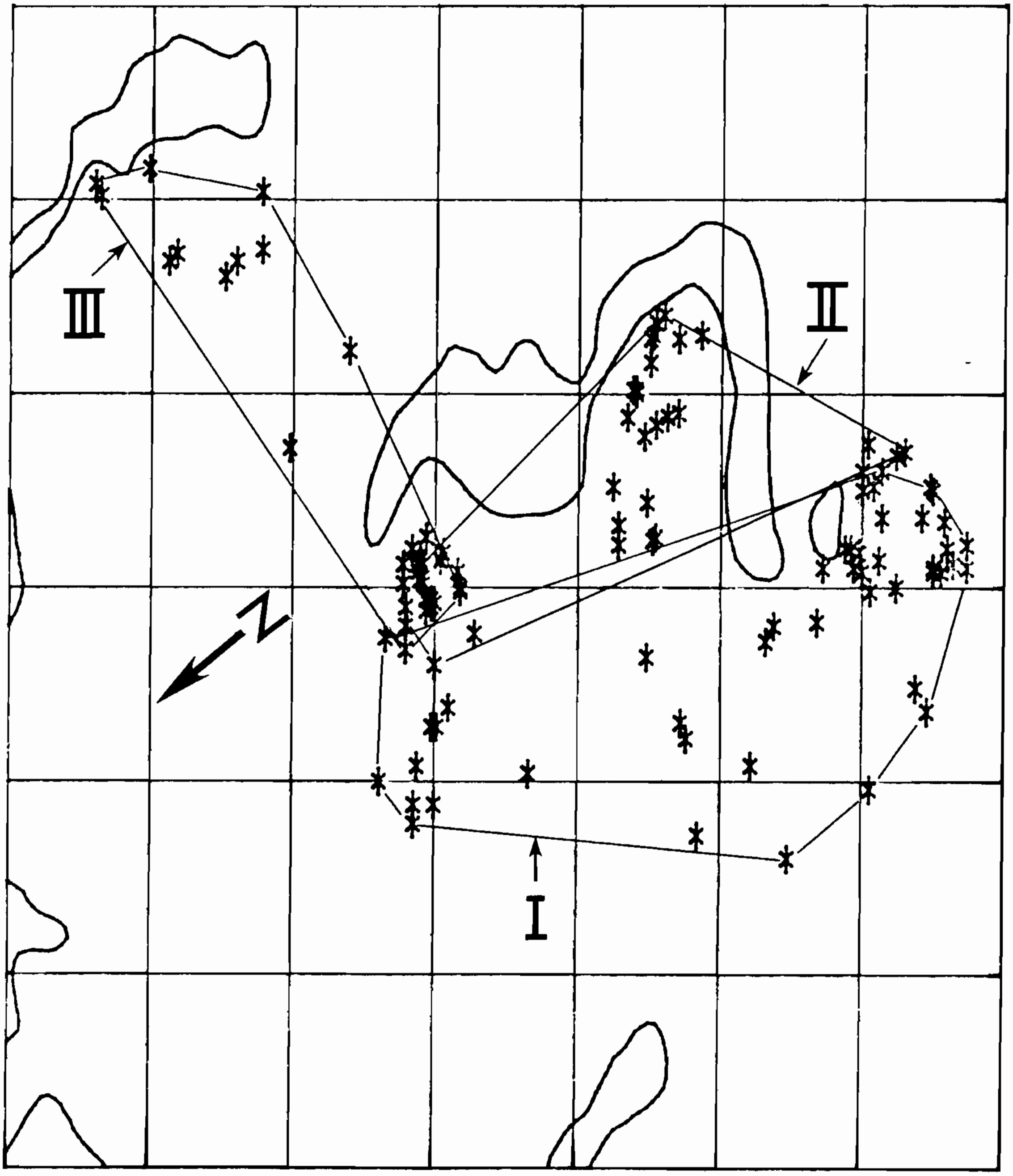


Fig. 27. Movements of immature yellow rail in consecutive time periods. I = 22-29 Jul (n = 67), II = 01-14 Aug (n = 64), III = 20-30 Aug (n = 46). Seney National Wildlife Refuge, 1980. One grid line = 50 m.

nest site when the eggs in the nest of female 4 should have been hatching. In contrast to the behavior of male 4 during hatching, male 2 was assumed to be the male heard Clicking less than 36 m from the nest while the eggs were hatching. Another male at the edge of the study area also Clicked when I scattered a brood of young on the night of 27 June. As the young regrouped around my feet, the male Clicked constantly and both the male and the female moved in and out of the sedge around my feet. Upon capture, the male Clicked while being held in my hand.

Clicking ceased after 14 August 1980. At about the same time the bills of the males began to darken, probably indicating males were no longer in breeding condition. Yellow rails undergo wing molts around this time (Stahlheim 1974). The area of movement of male 4 after Clicking by males was last heard on 14 August was 1.92 ha (Fig. 28), smaller than the 6.84 ha used while males were still Clicking. I believe the more central scatter of plotted locations indicated a general decline of territorial encounters with neighboring males as the breeding season waned.

Male 4 was plotted in the same location as female 4 (n=5 locations/bird) on 01 August (1622 h) to 02 August (1915 h), a period of at least 23 h, 7 min. During that time I also heard the young Peeping (01 August, 1940 h) in the same location as the parents. Therefore, male, female, and young were together simultaneously. I do not know whether the male and female re-formed a strong pair bond, but Stahlheim (1974) did not predict any sort of association between male and female after incubation begins. Yet I observed a male bird at or near the nest during hatching (male 2), and males associated with broods (untagged

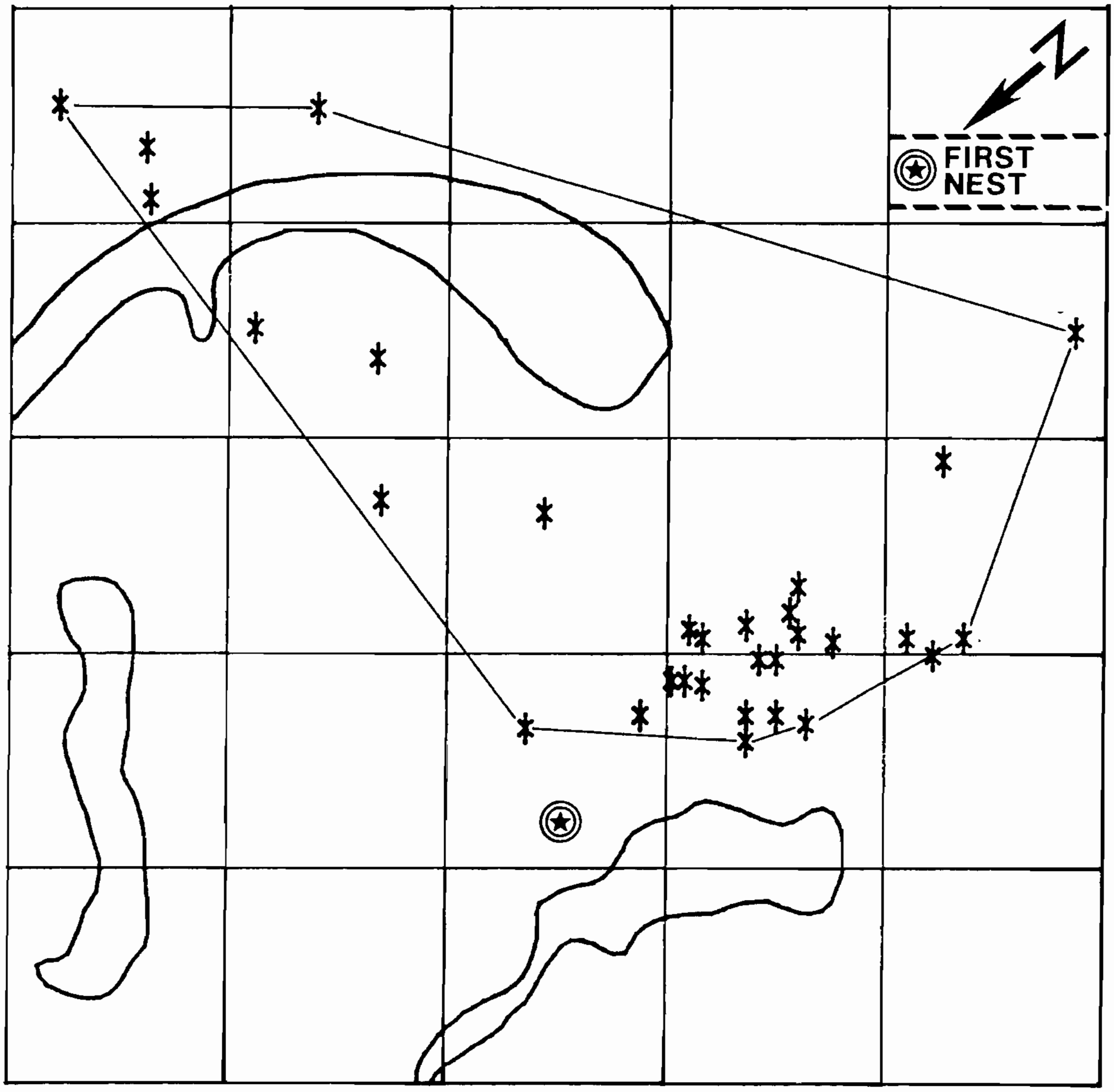


Fig. 28. Post-Clicking and Patrolling movements of male 4 (n = 45), 16-30 Aug, Seney National Wildlife Refuge, 1980. One grid line = 100 m.

male, 27 June, and male 4, 01 Aug). Female 4, after hatching of her eggs, remained within the area of movement of male 4 who moved about his territory for the duration of the field season, even after Clicking had ceased at the MCPSA. From these observations I conclude that territories established by male yellow rails in the spring are not only suitable for nesting but encompass habitat suitable for raising the brood; sora and Virginia rail broods have been observed to feed in areas of the marsh different from the nest site (Pospichal and Marshall 1954). Because yellow rails use drier parts of marshes than do soras or Virginia rails (Walkinshaw 1939, 1940) and young yellow rails stay in the vicinity of the nest site, yellow rails probably would not experience direct competition with other species of rails at the Seney National Wildlife Refuge.

MANAGEMENT OF YELLOW RAILS

Three principal management decisions could have an impact on habitat suitability for yellow rails at Seney NWR: water level manipulation, frequency of fire, and public use. These factors could act alone or in concert to enhance or reduce yellow rail habitat and therefore yellow rail populations. Conditions for yellow rails apparently are suitable in large areas of Unit III at the present time. Except for the 3 pools on the east side of Unit III, no active management of wetland areas in this unit has taken place since the early 1900's when the ditches were constructed (Linda Hagen, Assistant Refuge Manager, pers. comm.)

Rails are subject to population reduction through loss of breeding habitat (Johnsgard 1956). Because yellow rails were found only in areas of the refuge dominated by *C. lasiocarpa*, it can be assumed that any management decisions that result in unsuitable conditions for *C. lasiocarpa* would also result in a reduction of the yellow rail population.

Carex lasiocarpa can reproduce vegetatively or sexually, but most of the stalks in the extensive mats are probably derived from 1 genome (R.L. Stuckey, pers. comm.). Curtis (1959:378) classified *C. lasiocarpa* as a sedge of open bogs.

This species is often the sedge that forms the sedge mat zone around the open water of bogs, eventually covering the whole area and leading to the establishment of a tamarack and black spruce bog (Leisman 1953, Curtis 1959:235). In the Itasca State Park region of Minnesota,*C. lasiocarpa* comprised 86.22% of the undecomposed plant remains from samples in the upper 10.2 cm of the sedge mat zone (Leisman 1953). This type of bog is usually a long-lived stage in the primary hydrosere succession leading to wet conifer swamps (Curtis 1959:378). It is also related to northern sedge meadows with which it has certain features in common. Curtis (1959:378) differentiated an open bog from a sedge meadow by the possession of the former of a nearly continuous carpet of sphagnum moss (*Sphagnum* spp.) on the ground layer. A ground cover of sphagnum moss was not prominent at the MCPSA or areas south of the Marsh Creek Pool, but Curtis (1959:383) explained that periodic fluctuations in the water table, correlated with weather cycles, make the surface layers dry enough to support surface fires, and these fires destroy the advanced forest reproduction as well as bog flora. Upon return of the high water, the bog community re-enters, frequently on a greatly increased area, at the expense of the surrounding conifer swamp. If natural or artificial drainage has lowered the water table, a considerable volume of the surface layers may be removed by the fires. Under these circumstances, a hybrid community of open bog and sedge meadow may develop (Curtis 1959:383).

Seney NWR has had a series of fires over the years (Heinselman 1956, Peterson 1971b), the last one in 1975. The presence of certain plants such as blue-joint grass that are characteristic of sedge meadows (Curtis 1959:369) and the lack of sphagnum moss in the vicinity of the study area indicate that past fluctuations in water level and fires have had an important effect in shaping the floristic character of the MCPSA.

Curtis (1959:377) pointed out that on many of the lands acquired for game production purposes, the managers have failed to realize that the sedge meadow is not a permanent community but needs to be burned or mowed to be perpetuated. Therefore, excess suppression of fires can be expected to reduce yellow rail habitat, especially in Unit III, which seems to depend on periodic water level fluctuation and fire to maintain its open bog/sedge meadow character. Fire suppresssion might also allow a great amount of fuel accumulation that would eventually result in a very hot fire that would destroy the peat layer and expose mineral soil (Vogl 1974:154), as happened in the Walsh Ditch area of the refuge during the 1975 fire.

Presently, vast areas of Unit III are not directly subject to the impact of water level management decisions relating to the pool system of the refuge. However, it can be anticipated that if more water control structures were to be constructed in Unit III the present balance of water levels would change and ultimately the vegetation composition in the area would probably change. Obviously, management decisions for Marsh Ceek Pool have not yet resulted in loss of the highest yellow rail population found at the refuge, and the pool might have enhanced the density of breeding birds. But, this pool is the youngest of the major pools, and the long-term trend may be towards a decrease in yellow rail density.

Ditching can have important effects on bogs. When a bog basin is partially drained by the down-cutting of the outlet stream, the surface layer of the peat begins to oxidize and turn to muck which is favorable for the growth of speckled alder (Curtis 1959:236).

More needs to be known about the nature of the effects of the refuge pools on the native vegetation before the impact on yellow rail populations can be predicted. However, if sites of present yellow rail occupancy were to change in response to water level manipulation to much drier or much wetter conditions, then it is reasonable to assume yellow rail populations would be reduced.

The impact of human disturbance on yellow rails is difficult to predict. Uncontrolled access to breeding areas by many people would likely result in trampling of the vegetation, disturbance of breeding, or possibly death of some birds due to overzealous bird watchers as in the instance of a black rail (Laterallus jamaicensis) in New Jersey that was crushed under the feet of birders trying to encircle and flush the bird for viewing (Graham 1979).

Given the keen interest of birders in hearing and/or seeing the yellow rail, good potential exists for allowing the public to view this bird in a controlled fashion on wildlife refuges containing yellow rail habitat. The study of yellow rail territorial behaviors has revealed that the male is anything but shy when it comes to approaching a presumed intruder. Furthermore, his apparent lack of food gathering responsibility or interest in the female once incubation starts makes it probable that if yellow rails were called from under the sedge canopy by imitating the Click call for the purpose of viewing by the public, this sort of activity would not greatly affect the reproductive potential of yellow rails if the frequency of disturbance was not excessive. During this study fieldwork was conducted almost daily (and nightly); several males were pursued on many nights and captured up to 4 or 5 times in the season and still were successful in breeding. "Rail walks" conducted under the supervision of refuge personnel for the purpose of allowing the interested public to view this bird would be feasible. An education program to develop wider interest in the species could lead to support for habitat preservation and to broader support for the overall refuge program (Anderson 1977: 69-70).

SUMMARY

Habitat use, movements, and breeding biology of yellow rails were studied at the Seney National Wildlife Refuge in the Upper Penninsula of Michigan, 27 April 1979 to 04 September 1980. The objectives of this study were: 1) to develop techniques to find breeding yellow rails in areas of suitable habitat; 2) to measure population levels of breeding yellow rails; 3) to correlate population density with habitat types to ascertain preferred nesting habitat; 4) to develop techniques for the study of the behavior of yellow rails on their breeding grounds; 5) to recommend marsh management practices that can maintain or enhance breeding habitat of yellow rails.

The principal study area was located 0.4 km from the west end of Marsh Creek Pool and was chosen because it contained the highest concentration of calling male yellow rails at the refuge, 1 singing male/5 ha. The physiography of the MCPSA was similar to that of the surrounding area. Sand islands were interspersed within the sedge marsh.

All yellow rails were found in open bog and sedge meadow dominated by the tall, mat-forming sedge, _Carex lasiocarpa_. The stems at all sites sampled were comprised of more than 90% of this species. Average stem density in the MCPSA was 1398 stems/m^2, of which 1265 were _C. lasiocarpa_.

A layer of procumbent, senescent stems averaged 16 cm above the substrate and was believed to be important to habitat occupancy by yellow rails because of the protection from visual detection from above. Willow bushes were interspersed throughout the study area and represented the advance of the next seral stage. The mean proportion of transect line occupied by willows was 3%. Seasonally fluctuating water levels and periodic fires were considered to be important to habitat suitability for yellow rails.

The presence of yellow rails in a particular area was detected by hearing the territorial call of the male. Audio surveys to detect calling males were conducted during the hours of complete darkness from first arrival of the males in May until mid-July. No prior elicitation by taped calls was necessary to detect yellow rails. Yellow rails were present in all 3 management units of the refuge, but Unit III had the highest concentration.

Male yellow rails were captured as a result of imitating the territorial call of the male by tapping together a pocket knife and a deer femur. Dogs were used to capture birds that did not respond to the imitation of the call. Radio transmitters were attached to the birds by suture, harness, or adhesive. Four breeding pairs, 1 immature, and 1 breeding male were telemetered during the 1980 field season. A total of 1274 locations for 10 birds was plotted. Area of movement was estimated by constructing minimum area convex polygons.

The boundaries of the areas of movement of males overlapped during the Clicking and Patrolling period and averaged 8.29 ha which was larger than the 1.92 ha utilized by the only male that carried a transmitter after calling by males ceased 14 August. The female used a smaller area and moved within the area of movement of the male associated with her. Females used a larger area before incubation and after hatching, ~ 1.2 ha, than during incubation, ~ 0.3 ha. Movements away from the nest during incubation were limited to an average of 28 m from the nest. Onset of continuous incubation seemed to take place around the time the last egg was laid, but varied from 5 to 11 days in 2 nests monitored. Incubation was estimated to require 17 to 18 days. The nests of 6 females, including 1 re-nest for a total of 7 nests, were found during the study. The average clutch size of nests with completed clutches (n=4) was 8 (range 7-9). Hatching was synchronous.

After hatching, females led the broods away from the nest site within 24 h and moved about in a restricted area within the area of movement of their presumed mates. The only female that was monitored for more than 8 days after hatching of her eggs used an area of 1.0 ha. The immature of another brood also remained near the presumed nest site and moved about an area of 3.3 ha. One brood nest used by a female and her brood was found 17 m away from the active nest.

The general chronology of the breeding cycle and movements of wild yellow rails corresponded with the detailed study of yellow rails held in a small enclosure in another study. Serial polygyny was exhibited by captive males in that study, and evidence was found for 2 possible cases of serial polygyny at the MCPSA. Wild birds showed a higher degree of association by the males with their mates after incubation began than previously reported.

The primary management activity for yellow rails should be maintenance of the breeding habitat, i.e., open bog/sedge meadows. The impact of management projects that disrupt natural hydrologic fluctuations fluctuations and periodic fires is likely to be a change in the open bog/sedge meadows of the refuge. Presently, the management area at the refuge that contains the most yellow rails also has the least number of major pools for the propagation of waterfowl, and presumably the least human influence on natural water levels.

Developing 'rail walks' conducted by refuge personnel for the purpose of allowing birdwatchers to view this highly sought-after bird was encouraged. It is hoped that an increased public awareness of this species will result in wider public support for preservation of breeding habitat and the refuge system in general.

LITERATURE CITED

Anderson, J.M. 1977. Yellow rail (Coturnicops noveboracensis). Pages 66-70 in G.C. Sanderson, ed. Management of migratory shore and game birds in North America. International Association of Fish and Wildlife Agencies, Washington, D.C. 358pp.

Curtis, J.T. 1959. The vegetation of Wisconsin. Univ. of Wisconsin Press, Madison. 657 pp.

Devitt, O.E. 1939. The yellow rail breeding in Ontario. Auk 56:238-243.

Dickerman, R.W. 1971. Notes on various rails in Mexico. Wilson Bull. 83:49-56.

Easterla, D.A. 1962. Some foods of the yellow rail in Missouri. Wilson Bull. 74:94-95.

Elliot, R.D., and R.I.G. Morrison. 1979. The incubation period of the yellow rail. Auk 96:422-423.

Fryer, R. 1937. The yellow rail in southern Manitoba. Can. Field-Nat. 54:41-42.

Graham, F., Jr. 1979. Case of the ugly birder. Audubon 81(4):88-100.

Heinselman, M.L. 1965. String bogs and other patterned organic terrain near Seney, Upper Michigan. Ecology 46:185-188.

Huber, R. 1959. Yellow rails in Becker and Mahnomen Counties, Minnesota. Flicker 30:82-83.

Johnsgard, P.A. 1956. Effects of water fluctuations and vegetation change on bird populations, particularly waterfowl. Ecology 37:689-701.

Kaufmann, G.W. 1971. Behavior and ecology of the sora, Porzana carolina, and Virginia rail, Rallus limicola. Ph.D. Thesis. Univ. of Minnesota, St. Paul. 184 pp.

Lane, J. 1962. Nesting of the yellow rail in southwestern Manitoba. Can. Field-Nat. 76:189-191.

Leisman, G.A. 1953. The rate of organic matter accumulation on the sedge mat zone of bogs in the Itasca State Park region of Minnesota. Ecology 34:81-101.

Meanley, B. 1969. Natural history of the king rail. North Am. Fauna 67:108 pp.

Mohr, C.O. 1947. Table of equivalent populations of North American small mammals. Am. Midl. Nat. 37:223-249.

Peabody, P.B. 1922. Haunts and breeding habits of the yellow rail. J. Mus. Comp. Oölogy 2:33-44.

Peterson, D.J. 1971a. The yellow rail. File report, Seney National Wildlife Refuge. 2 pp. (Typewritten.)

________________. 1971b. A brief investigation of the string bog terrain in Seney's Wilderness Area. File report, Seney National Wildlife Refuge. 29 pp. (Typewritten.)

________________. 1972. Record of a yellow rail. File report, Seney National Wildlife Refuge. 1 p. (Typewritten.)

Pospichal, L.B., and W.H. Marshall. 1954. A field study of sora rail and Virginia rail in central Minnesota. Flicker 26:2-32.

Ripley, S.D. 1977. Rails of the world. David R. Godine, Boston. 406 pp.

Stahlheim, P.S. 1974. Behavior and ecology of the yellow rail (*Coturnicops noveboracensis*). M.S. Thesis. Univ. Minnesota, Minneapolis. 79 pp.

________________. 1975. Breeding and behavior of captive yellow rails. Avicult. Mag. 81:133-141.

Terrill, L.M. 1943. Nesting habits of the yellow rail in Gaspé County, Quebec. Auk 60:171-180.

Vogl, R.J. 1974. Effects of fire on grasslands. Pages 139-194 *in* T.T. Koslowski and C.E. Ahlgren, eds. Fire and ecosystems. Academic Press, New York. 542 pp.

Voss, E.G. 1972. Michigan flora Part I. Cranbrook Inst. Sci., Bloomfield Hills, Mich. 488 pp.

Walkinshaw, L.H. 1937. LeConte's sparrow breeding in Michigan and South Dakota. Auk 54:309-320.

________________. 1939. The yellow rail in Michigan. Auk 56:227-237.

________________. 1940. Summer life of the sora rail. Auk 57:153-168.

Welty, J.C. 1975. The life of birds. W.B. Saunders Co., Philadelphia. 623 pp.

Wittenberger, J.F. 1980. Vegetation structure, food supply and polygyny in bobolinks (Dolichonyx oryzivorus). Ecology 61:140-150.