Duck breeding ecology and harvest characteristics on Grand River Marsh Wildlife Area. No. 145 1984

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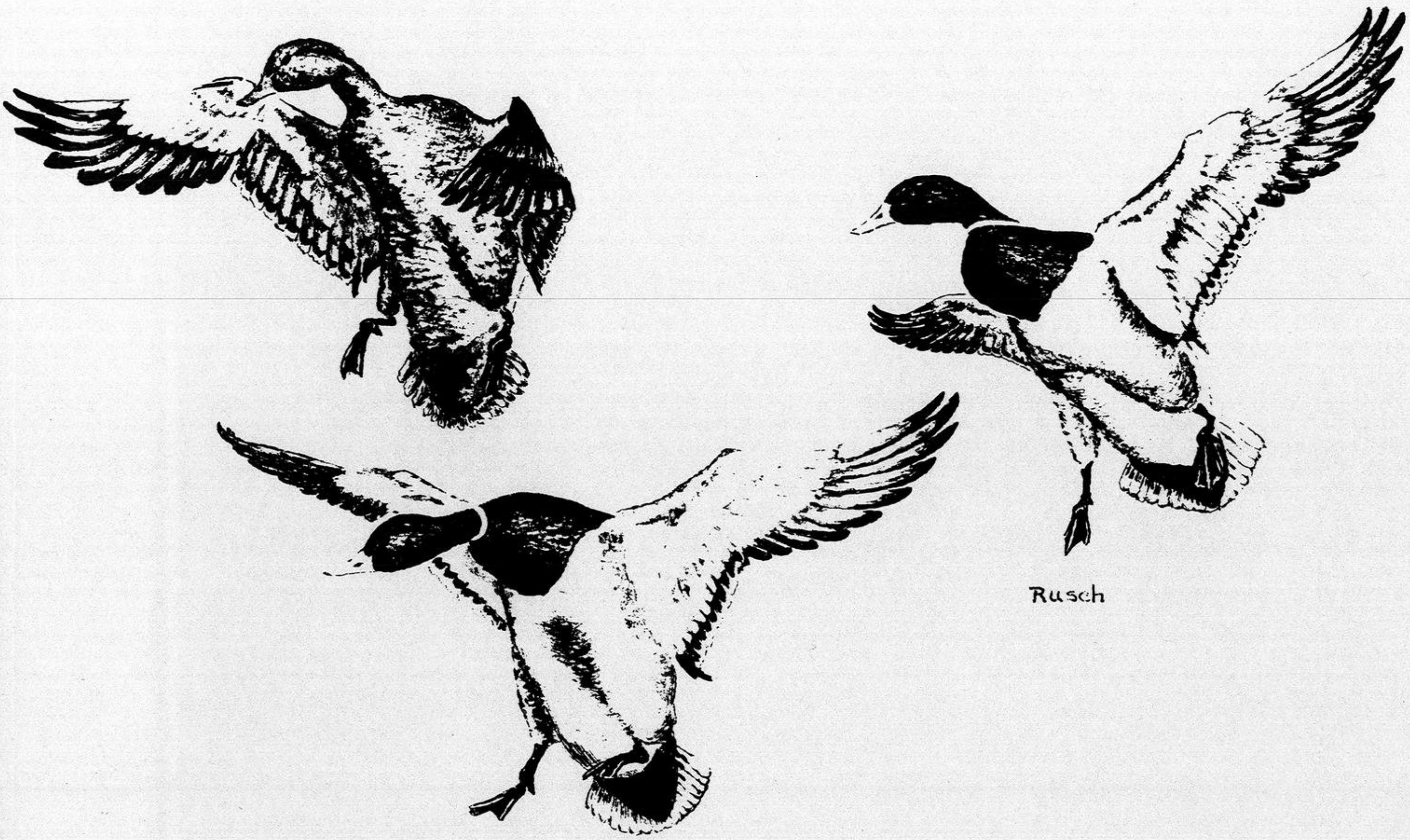

DUCK BREEDING ECOLOGY AND HARVEST CHARACTERISTICS ON GRAND RIVER MARSH WILDLIFE AREA

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ABSTRACT

Breeding ducks were studied from 1977-81 on the Grand River Marsh Wildlife Area (GRM) and the Grand River Extensive Area (GREA), a 50-mile square block of land surrounding the GRM. The 2,500-mile^2 study area includes parts of Adams, Columbia, Dodge, Fond du Lac, Green Lake, Marquette, Sauk, Waushara and Winnebago counties in southeastern Wisconsin.

Based on the work at these study areas, large management areas in southeastern Wisconsin may not be effective in producing enough ducks to contribute significantly to the fall population. Private property provided habitat for the major portion of all breeding waterfowl on the GREA. Seven public lakes and 5 state wildlife areas represented 3% of the total GREA and supported 11% of the mallard, 30% of the teal, and 21% of the other duck species breeding in the area. Doubling breeding mallards on all public lands would only increase the area population by 10%.

GRM held only 3% and 6% of the total study area's breeding population of mallards and blue-winged teal, respectively. A drawdown of the main flowage and the removal of nearly all carp favored the growth of submergent vegetation and resulted in double the number of breeding ducks present during the pretreatment years. Nest success averaged only 17% due to mammalian predation of nests, and brood mortality on the water neared 50%. As a result, the contribution to the fall population by ducks hatched at Grand River Marsh was small (50-160 mallards and 350-800 blue-winged teal). Only 0.1% and 0.5% of the mallard and blue-winged teal harvest at Grand River Marsh was made up of birds from the Grand River Marsh hatch. Local mallards and blue-winged teal did add to the Wisconsin harvest as 77% and 46%, respectively, of the recoveries of ducklings banded on the GREA occurred in Wisconsin.

Use of planted nesting cover by ducks on GRM was low until 5-6 years after planting. No deterrent effect against predation by cover "quality" could be consistently documented within the range of cover height-density available on Grand River Marsh. Predator removal on small areas of high nest densities did not raise nest success on these areas.

GRM provided fall staging habitat for both ducks and geese as well as hunting recreation for waterfowl hunters. However, uncontrolled hunter access resulted in the severe crowding of 1 hunter/2 acres during the first week of the season when 30% of the hunting pressure occurred. Duck crippling rates ranging from 24-32% and skybusting were also resulting problems.

INTRODUCTION

The major thrust in wetland preservation in Wisconsin in past years has been to acquire large marshy areas along streams and build impoundments on them. Impoundments have contributed greatly to the acreage of wetlands on the approximately 370,000 acres acquired which have importance to waterfowl (Wisconsin Department of Natural Resources [DNR] Central Files). The cost of such acquisition, construction, and maintenance has been immense. Although these impoundments benefit many game and nongame species, the primary reasons for purchase were to: (1) provide refuges and hunting areas for waterfowl during fall migration, and (2) develop or preserve breeding habitat needed during spring and summer for resident waterfowl.

The success of these large management areas is readily seen by the number of waterfowl attracted in both spring and fall. Peak fall populations of ducks at times reached 10-20,000 on each of the several major waterfowl areas (Grand River Marsh, Crex Meadows, Mead Wildlife Area, Collins Marsh) during the 1970's (DNR Central Files). These areas also attract large numbers of Canada geese.* Heavy use by hunters occurs on the areas soon after establishment.

During recent years increased emphasis has been placed on waterfowl production, especially the establishment of dense upland nesting cover for waterfowl. Many acres once devoted to food plots have been converted to nesting cover on state and federally owned waterfowl areas.

There has been a general lack of follow-up evaluation of the large impoundments created for waterfowl and of the efforts to later establish nesting cover. Such an evaluation, during 1977-81 on Grand River Marsh Wildlife Area, is the subject of this study. The immediate questions addressed by this report are: (1) How many breeding ducks does a large impoundment attract or support? (2) How successful are these ducks at producing and rearing broods on managed lands? (3) What percent do they contribute to the fall duck populations of the area or state? (4) Can planting and managing various forms of nesting cover increase nest success? (5) What proportion of the harvest on these areas is produced there vs. attracted there from nearby wetlands or from distant breeding areas? (6) What effect does the heavily concentrated hunting pressure on management areas have on locally produced ducks?

During the 1977 and 1978 field seasons on Grand River Marsh, it became evident that large carp populations were destroying submergent vegetation in the 3,000-acre main impoundment. The removal of carp during a drawdown in 1979 allowed us to study the effect of carp removal on use of the impoundment by waterfowl.

Opportunities to study the effects of limited predator removal on nest success and examine hunter characteristics also developed during the study.

*Scientific names appear in Appendix A.

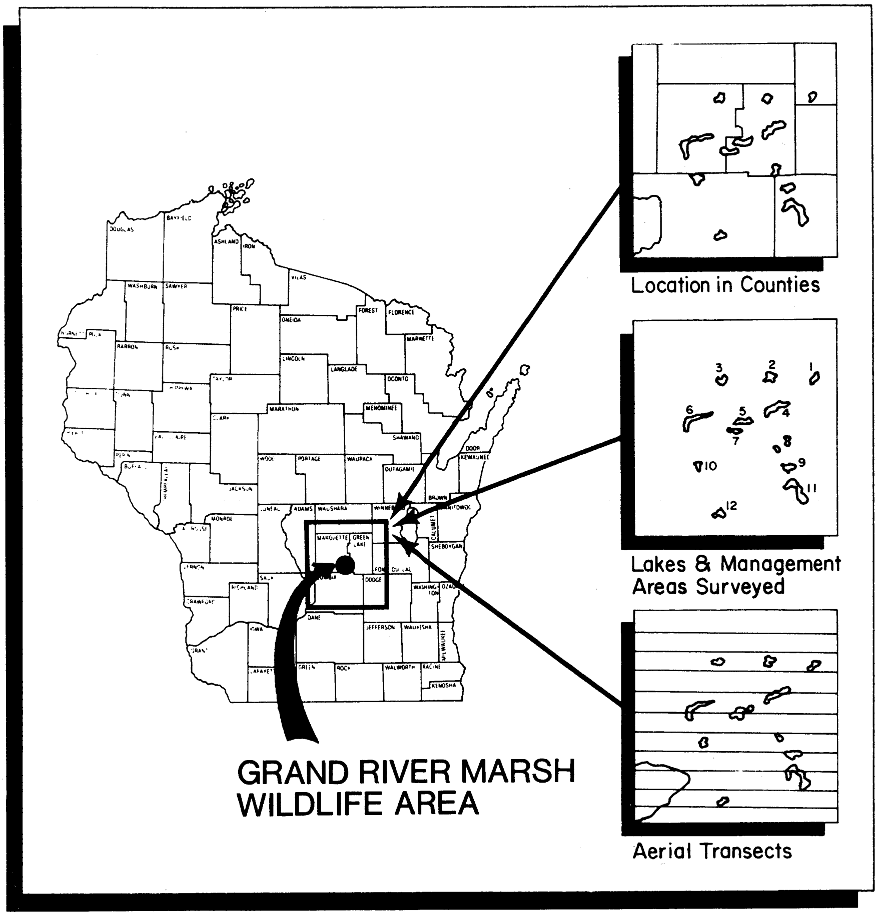


FIGURE 1. *Location of Grand River Extensive Area, lakes and management areas surveyed, and aerial transect routes.*

STUDY AREA

The Grand River Marsh Wildlife Area (GRM) was selected as a typical impoundment-type wetland, attracting large fall concentrations of both ducks and hunters, with a large acreage of managed nest cover for breeding ducks. Statewide aerial waterfowl surveys indicated that the area immediately surrounding GRM had the highest density of breeding mallards in Wisconsin as well as high densities of other duck species breeding in Wisconsin (March et al. 1973).

The study area consisted of wetlands within the Grand River Extensive Area (GREA), a 50-mile square block of land (2,500 mile^2) centered on Grand River Marsh (Fig. 1), and the GRM itself (Fig. 2). The GREA included parts of the counties of Adams, Waushara, Winnebago, Marquette, Green Lake, Fond du Lac, Sauk, Columbia and Dodge.

The topography of the region varies from level to rolling as a result of the most recent glaciation. The soils vary from rich silt loams in the east and southeast to sands in the west and northwest. Lowlands contain peat and muck soils which, when drained and cleared, are highly productive (U.S. Department of Agriculture 1975, 1977). Annual precipitation on the study area averages approximately 30 inches (76 cm)(U.S. Department of Commerce—Environmental Data Services 1977-81).

GRM is located just west of Kingston, Wisconsin at the confluence of Spring and Belle Fountain creeks with the Grand River. It lies in a glacial lake bed (Thwaites 1956) and consists of a 3,000-acre impoundment of the Grand River and two smaller impoundments of 100 acres and 35 acres, which rely on annual runoff and rainfall. The 7,000-acre area contains 64% lowland and marsh, 27% upland grass and cropland, and 9% forested land (Fig. 2). A 3000-acre waterfowl refuge occupies the western portion of the project and the remaining 4,000 acres are open for public hunting of waterfowl and other game species (Fig. 3).

The five major cover types available to nesting dabbling ducks were: wet marsh, dry marsh, old fields, planted nesting cover 4-8 years old, and planted nesting cover greater than 9 years old. Wet marsh cover type consisted primarily of emergent cattails. Dry marsh cover type consisted of the areas between upland fields and wet marsh areas. These areas were too wet for cultivation and typical cover ranged from goldenrod and aster to sedge hummocks and canary grass. Old field areas were primarily bluegrass, quack grass, goldenrod and invading box elder seedlings. The planted nesting cover in the 4- to 8-year-old category consisted of brome-alfalfa mixes with some timothy and clover. The planted cover greater than 9 years old consisted primarily of brome, as the legumes originally seeded died out over time.

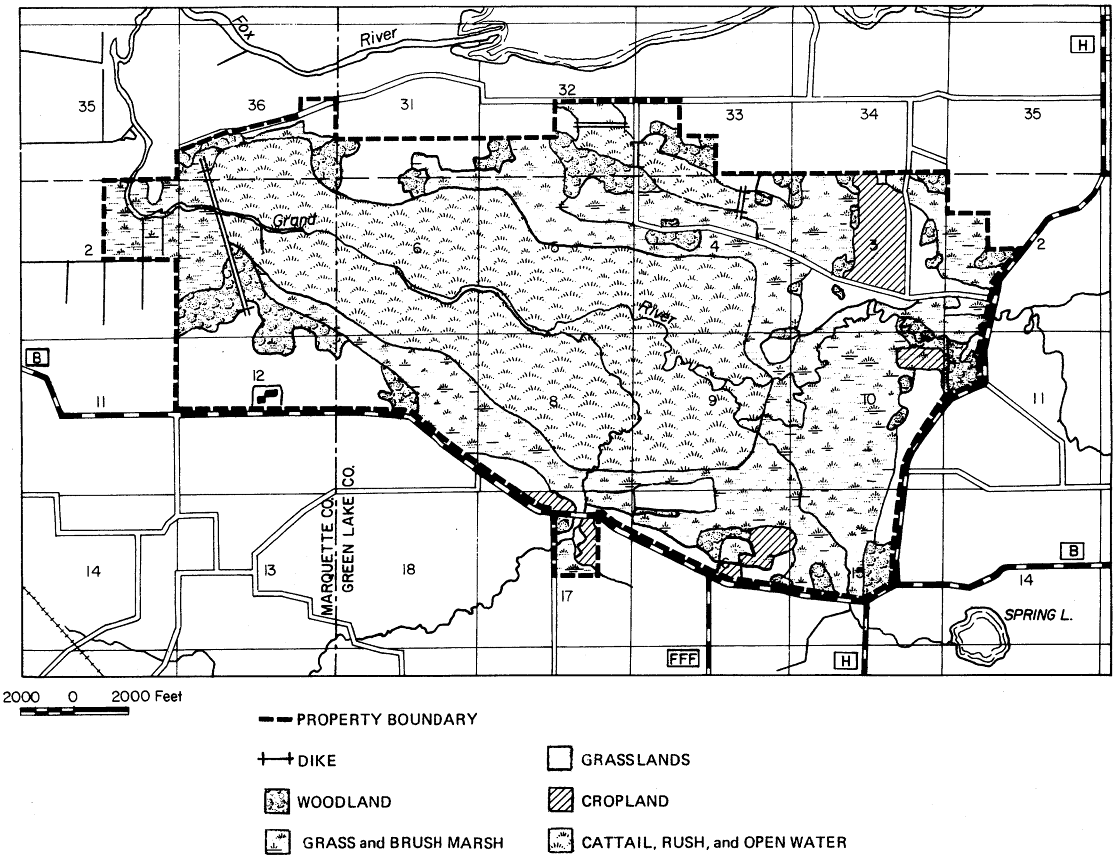


FIGURE 2. *General vegetation patterns of Grand River Marsh Wildlife Area (Hansen et al. 1982).*

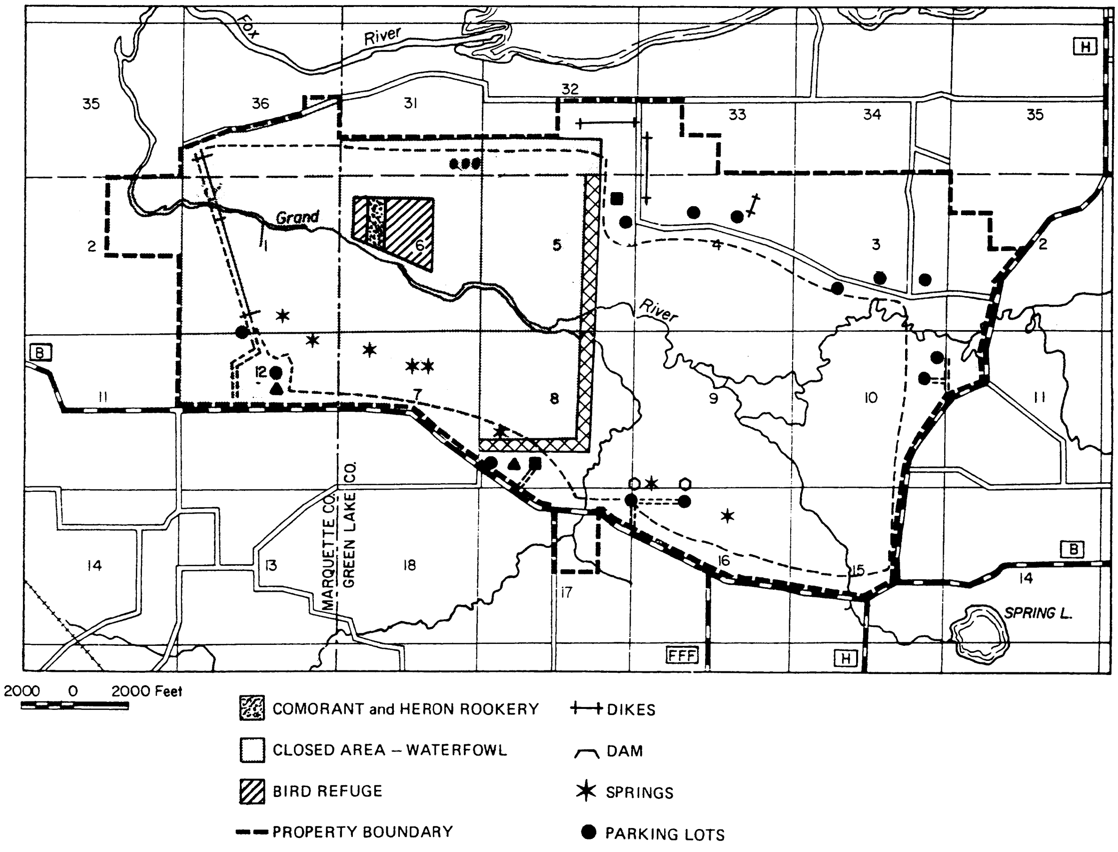


FIGURE 3. *Refuges, public hunting area, and developments on Grand River Marsh Wildlife Area.*

METHODS

BREEDING POPULATION SURVEYS

Transects were conducted annually by helicopter to estimate duck breeding pair populations in the GREA. In addition, large duck production lakes and management areas (Table 1) were also flown for total counts. These areas were surveyed separately since past studies recognized that they had higher breeding densities than the surrounding countryside and would best be treated as a separate sampling stratum. (March et al. 1973, Wheeler and March 1979).

Surveys of breeding pairs were also conducted on the GRM by boat and on foot. These surveys added information on the chronology of nesting and provided better estimates of breeding pair numbers and fluctuations on the GRM.

TABLE 1. *Lakes and wildlife management areas within the Grand River Extensive Area surveyed for breeding ducks, 1977-81.*

Area	Approximate Size (miles^2)
Rush Lake	6
White River Marsh Wildlife Area	8
Germania Marsh Wildlife Area	4
Green Lake	2
Lake Puckaway	12
Buffalo Lake	6
Grand River Marsh Wildlife Area	12
Lake Maria	2
Fox Lake	2
French Creek Wildlife Area	6
Beaver Dam Lake	5
Mud Lake Wildlife Area	5
Total	70

Helicopter Surveys

Aerial Transects. Aerial transects (each 50 miles long and 1/4 mile wide) were used to estimate the number of breeding pairs on the GREA (Fig. 1). A starting point for the first transect was selected in the northeast corner of the study area for ease in location and so that 10 transects spaced 5 miles apart would fit into the study block. Each succeeding transect starting point was 5 miles south of the preceding one. Five-mile spacing was used to minimize the problem of counting the same birds on more than one transect. This systematic transect scheme sampled 5% of the total area (125 mile^2). Flying the 10 transects required approximately 10 hours at 45-50 mph and 100 ft above ground level. Two observers were used, each recording all ducks seen on a 1/8-mile strip on his side of the aircraft. Ducks seen were recorded by species and as pairs, lone drakes, lone hens, groups of drakes, or mixed flocks. Pairs, lone drakes and groups of 5 or less drakes were later tallied as indicated breeding pairs (U.S. Bureau of Sport Fisheries and Wildlife 1969). Helicopter flights were flown during the first week in May as suggested by Wheeler and March (1979) for a single annual survey.

As a measure of the variability of sampling and habitat heterogeneity the sample standard deviation was calculated using the individual transects.

Total Wetland Surveys. Seven lakes and five state waterfowl management areas were also surveyed from the air in conjunction with the aerial transects. The wetlands flown and their approximate sizes are listed in Table 1. Flight patterns varied with the shape of the lake or management area and were designed to cover all water areas and yet avoid double-counting birds.

Air:Ground Comparisons. Because not all breeding ducks are seen during aerial surveys, an adjustment was made to correct the number of ducks seen on helicopter surveys for those ducks present but missed from the air. Air:ground correction ratios were determined by ground searches of accessible segments of aerial transects (Martinson and Kaczynski 1967). During 1977-81, 18% of all aerial transects were censused on the ground the day following aerial surveys. An air:ground ratio (correction factor) was established separately for mallards, blue-winged teal and all other species combined for each flight. The number of pairs seen from the air was divided by the appropriate correction factor to obtain breeding population estimates. These correction factors were applied to aerial indices from transects and the lakes and management areas to estimate those populations.

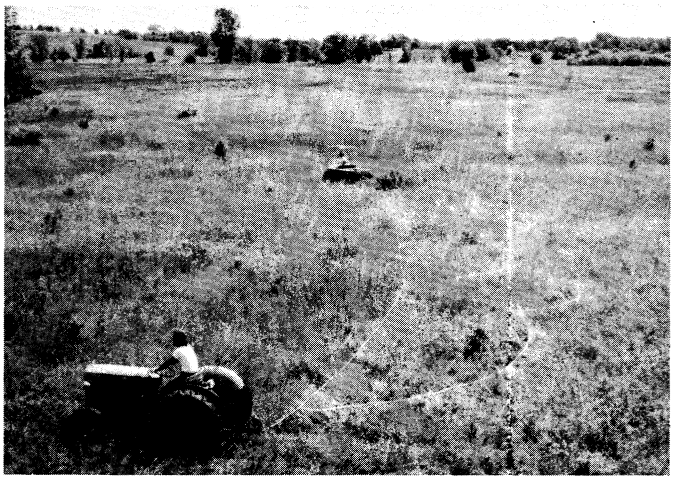
Ground Censuses

Four boat censuses of breeding pairs were conducted from 20 April to 30 May on the main impoundment of the GRM. Two sport canoes with 8-hp air engines were used to simultaneously traverse the opposing marshy shorelines of the 3,000-acre impoundment. Care was taken to minimize recounting of moving birds. Small impoundments, ditches, and ponds were censused on foot.

NEST STUDIES

Nest Searching

During 1977-81, approximately 1,000 of the 2,500 acres of potential nesting cover were searched each year for duck nests at GRM. A chain drag as described by Higgins et al. (1969) was used on all areas that could be driven on by vehicles. Areas that were too wet or too rough were searched on foot by crews of 20 to 40 (Gates and Hale 1975). Fields were searched 2 to 3 times between 1 May and 1 July.

Large acreages of nesting cover must be searched to provide adequate nest samples when nest densities are quite low.

Estimates of the height-density or visual obstruction of vegetation were measured in all regularly searched nesting fields (Robel et al. 1970). Measurements were taken in the four cardinal directions at 10 points along a transect laid diagonally across the study field (40 measurements/field). Vegetation measurements on each transect were taken in early April to measure residual vegetation and in early June to measure new and old growth nesting cover at midbreeding season for ducks.

Nest Data Collection and Cover Analysis

Each nest bowl containing one or more eggs was considered a nesting attempt. Active nests were marked with a numbered, colored, plastic flag tied to a willow stick placed 5 yards north of the nest. Eggs were candled (Weller 1956) and nests were revisited on or soon after the calculated hatch date. All clutches with at least one hatched egg were considered successful. Nests destroyed by predators were examined and the responsible predator was determined according to characteristics of predation listed by Rearden (1951). At each nest, the distance to nearest water was recorded and visual obstruction measurements were taken (Robel et al. 1970) outward from the nest bowl in each of the four cardinal directions.

Nest success was estimated using the Mayfield—40% method (Johnson 1979) and abandoned nests were excluded from the observed sample. Success was compared among nests in: major cover types, categories of field vegetation height-density, categories of nest vegetation height-density, and categories of nest distance to water. The total number of nests on GRM was estimated by dividing the number of successful nests found by the Mayfield estimate (Miller and Johnson 1978). This estimate likely is biased, resulting in a low estimate, because not all successful nests are found.

Predator Removal

During 1978-80, predators were trapped on 4 fields on GRM (64 acres). Thirty live-traps were operated on these fields from 1 April until all the nests in the fields were either hatched or destroyed. Traps were baited with sardines, fresh carp, or duck eggs and were checked daily. All captured skunks were killed. In 1978 and 1979, captured raccoons were transported at least 20 miles from the area and released. In 1980, all raccoons were sacrificed to obtain jaws for age determination (Grace et al. 1970), and examined for fowl cholera virus. Recent Canada goose losses from that disease prompted these additional tests. No attempt was made to age skunks due to their high potential for rabies. Mayfield nest success rates on the predator reduction areas were compared to a control area of 64 acres, containing the same cover types as the reduction area, and to overall success rates.

MARKING AND MONITORING

Marking Hens and Broods

During 1979-81, hens were captured on the nest using long-handled nets and nest traps (Weller 1957, Salyer 1962). Hens were also trapped in bait traps during April and May. Captured hens were marked with leg bands and colored nasal saddles (Doty and Greenwood 1974) so they could be identified throughout the season and subsequent seasons should they return to GRM to nest.

Mallard and blue-winged teal hens were also equipped with back-mounted radio transmitters. In 1979 and 1980 a tubular harness was used as described by Dwyer (1972). In 1981, due to past experience with transmitter loss and entanglement, a flat nylon-elastic harness was used to attach the transmitters at the wing articulation (Schulz 1974, Church 1980). Radio weights averaged 23.9 g for mallards (2-3% of body wt.) and 17.6 g for blue-winged teal (5-6% body wt.).

Nests were checked at the estimated hatch date and any ducklings caught at the nest bowl were individually marked with numbered fingerling tags inserted in the foot webbing (Alliston 1975).

Nightlighting (Cummings and Hewitt 1964) was used to capture ducklings at GRM and GREA during July. All flightless ducklings were fitted with nasal saddles and bands or with web tags if they were too small to band. Hens captured with broods were also fitted with nasal saddles but all other ducks were only banded. All broods observed or captured on the GREA were aged according to criteria of Gollop and Marshall (1954). The attrition between average Class I and III brood sizes was used to estimate duckling mortality. Broods of radio-equipped hens were also observed to document duckling loss.

Cannon netting was used to capture mallards during the prehunting season buildup on Grand River Marsh.

Retrapping of Marked Ducks

Nest trapping, bait trapping, and nightlighting were all used to recapture birds marked in previous seasons to document any homing to wetlands or nest sites. Cannon netting was used to capture mallards during the August and September (prehunting season) buildup on GRM to: (1) identify the source of ducks in the late summer-early fall concentrations; (2) determine departure dates of birds marked during spring and summer on GRM; and (3) determine the movements and recovery rates of the mallards present in August-September.

Fall Waterfowl Surveys

Each year (1977-81) the 12 lakes and management areas were surveyed by air during the week prior to the opening of the Wisconsin waterfowl season (26 Sep-10 Oct). A fixed-wing aircraft and two observers were used to estimate fall prehunting season populations on these areas.

HARVEST SURVEYS AND HUNTER INTERVIEWS

During the waterfowl hunting season, vehicles were counted at all GRM parking lots at 8:00 a.m. and 4:00 p.m. Total vehicle numbers were adjusted downward for vehicles present during both counts. Hunters returning to their cars were interviewed throughout the day and the age, sex, and species of any waterfowl they possessed was recorded. Information on the number of hunters in each vehicle, number of waterfowl shot down but not retrieved, gauges of guns, and types of shot used was recorded. Ducks were checked for bands, color markers and webtags. Counts were then expanded by the average number of hunters per car to get daily estimates of hunting pressure. Daily duck kill estimates were calculated by expanding the kill per hunter in the checked sample by daily total numbers of hunters estimated from vehicle counts.

CARP REMOVAL AND ASSOCIATED MONITORING

During the third year (1979) of the 5-year study, the main impoundment at GRM was drawn down. The drawdown began in April and was completed in late June. On August 6, rotenone was applied to kill all fish. Invertebrate samples were taken during 1978, 1980, and 1981, 1 year before carp removal and 2 years after carp removal. Three sites on the main impoundment and 3 adjacent carp-free wetlands (a 100-acre impoundment, a 35-acre impoundment, and a 0.2-acre dug pond) were sampled. Sampling was done with light traps (Espinosa and Clark 1971) during 2-hour periods (10:00 p.m.-12:00 a.m.) every 10 days from the last week in June until the first week in August. Invertebrates collected were identified to family, counted, and volumes determined by water displacement.

Submergent vegetation was surveyed on the main impoundment once in August during 1978, 1980 and 1981. Vegetation diversity and density was indexed using a rake sampling technique on a previously established transect (Linde 1971—90 samples/year). The number and percent frequency of occurrence of plant species, percent of samples having submergents, and percent average ocular rake-sample density were compared for years before and after carp removal.

STATISTICAL ANALYSIS

T-tests (Steele and Torrie 1960) were performed to compare nest success in cover of differing Robel categories (visual obstruction) and to compare mean brood sizes on various areas. Chi-square tests (Steele and Torrie 1960) were used to compare direct recovery rates and crippling rates between years.

GLOSSARY

Indicated Pairs. Pairs of ducks, lone drakes and groups of 5 or less drakes are tallied as indicated breeding pairs during duck surveys.

Local. A young-of-the-year duck not yet capable of sustained flight when banded. Locals are known to have been hatched in a particular geographic region.

Immature. A young-of-the-year duck capable of sustained flight when banded. Geographic region of hatching is uncertain.

Adult. A sexually mature duck in at least its second calendar year of life when banded. Geographic region of hatching is unknown.

Band Recovery Rate. The proportion of banded birds that is recovered and reported to the Bird Banding Laboratory.

Harvest. Retrieved hunting kill.

Direct or First Hunting Season Recovery Rate. Proportion of banded ducks reported killed or found dead during their first hunting season following banding.

Indirect Recovery. A banded duck reported killed or found dead in any hunting season following the first hunting season after banding.

Age Ratio. Number of young-of-the-year ducks per adult in the harvest or banded sample.

Pioneering. Breeding ducks attracted to and nesting in an area different than the general area where they were raised or previously nested.

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RESULTS AND DISCUSSION

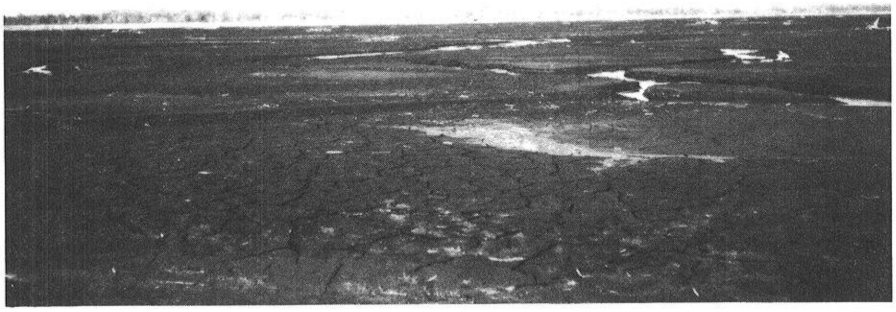
BREEDING DUCK POPULATIONS

Grand River Extensive Area (GREA)

Annual estimates of breeding mallards on the scattered wetlands of the 2,500 mile^2 GREA ranged from approximately 2,400 to 5,500 pairs. Mallard pair estimates on the large lakes and management areas of the GREA ranged from approximately 260 to 650 (Table 2). Lakes and management areas had 5-14% of the breeding mallards with the balance counted on small private wetlands in the GREA.

Estimates of breeding blue-winged teal populations on the transect wetlands of the GREA ranged from approximately 4,500 to 10,000 pairs. The pair estimates from the lakes and management areas ranged from approximately 500 to 2,300 pairs (Table 2). The blue-winged teal population indices on the transect wetlands were the highest in 1977 and 1981, and appeared rather stable during 1978-80. Lakes and management areas had 7-30% of the blue-winged teal breeding pairs with the rest being found on small private wetlands in the GREA.

Other species of ducks averaged 9% of the population index on transect wetlands and 20% on lakes and management areas (Table 2). Although data for other species were insufficient to calculate yearly air:ground ratios, population estimates in Table 2 indicate that lakes and management areas attracted a larger proportion of the other breeding species than did scattered wetlands.



Water levels at Grand River Marsh were lowered to allow carp removal from the reduced water area.

Over 1,000,000 lb of carp were removed from the main impoundment at Grand River Marsh.

Grand River Marsh Wildlife Area (GRM)

Ground surveys produced highly variable pair estimates for both mallards and bluewings (Table 3). Mean annual estimates ranged from 23 to 125 mallard pairs, and from 146 to 323 blue-winged teal pairs. Optimum survey periods for mallards and bluewings on Grand River Marsh appeared to be 24-27 April and 13-16 May, respectively, since flocks and large groups of drakes were absent during these periods. Other duck species comprised 15-23% of the total breeding pairs counted at GRM (Table 4). Mean pair estimates indicated a ratio of 1 pair of breeding ducks/8 acres of permanent water on

GRM or a range of from 1 pair/5 acres to 1 pair/13 acres during the 5-year period. Mallard and blue-winged teal breeding pairs on GRM comprised 1-3% and 2-6%, respectively, of the estimated GREA breeding populations.

Effects of Drawdown and Carp Removal

The main impoundment was drawn down during the summer of 1979 and approximately 1,000,000 lb of dead carp were removed following rotenone treatment (by Fish Management). The pretreatment standing crop of carp would have been nearly 333 lb/acre. Carp are thought to compete for food with ducks (Moyle 1964) and destroy vegetation beds which are prime waterfowl feeding areas (Anderson 1950, Cahoon 1953, Threinen and Helm 1954, Tryon 1954, Robel 1961). Chironomids (midge larvae) have been identified as foods of both carp (Frey 1940) and waterfowl (Wheeler and March 1979) in Wisconsin waters. Carp were found to consume 51.5% crustaceans and 36.5% insects (Ewers and Boesel 1935). Other studies indicate young carp feed on zooplankton but adults shift to vegetation (Shimadate et al. 1957). Prior studies on Horicon and Theresa marshes in Wisconsin documented major increases in submergent vegetation with the drawdown of waters and the removal of carp (Beule 1979). Drawdowns alone have been shown to promote increases in submergent vegetation (Linde 1969, Kadlec 1962).

Submergent vegetation improved greatly after drawdown and carp removal (Table 5). The number of submerged and floating plant species increased from 8 to 15. The percent of samples containing vegetation increased from 59 to 100 ($P < 0.01$) and the average density of plants per rake sample increased from 37-68% ($P < 0.01$) (Table 5).

The effects of drawdown and carp removal on the diversity and abundance of aquatic invertebrates was less clear. The diversity of insect families trapped was greater after treatment (1980, 1981) than before treatment (1978) (Table 6). However, insect diversity on the untreated carp-free impoundments and ponds also increased during 1980, indicating annual variability may also have accounted for some of the increased diversity in the treated area. The abundance of invertebrates during pretreatment and posttreatment years did not seem to follow any discernible pattern of increase or decrease (Table 6). The only consistent changes in invertebrate abundance at all three sampling sites on the main impoundment were a decrease in the number of aquatic spiders and increases in Mayflies and Haliplid beetles (Append. B). More intensive sampling may be required to avoid variability associated with yearly differences in invertebrate abundance and periodicity of insect emergence.

The improved aquatic habitat at GRM attracted additional breeding mallards and blue-winged teal despite reduced breeding numbers in surrounding habitats (Tables 2, 3 and 4). Following the drawdown and carp removal the estimated number of mallard breeding pairs using GRM more than doubled, while mallard pairs on the surrounding GREA declined (Fig. 4). Blue-winged teal breeding pair estimates on the GRM increased in the first year following drawdown and treatment (1980) while they decreased on the surrounding GREA (Fig. 5). The increase on GRM in the second year following treatment (1981), also occurred on the GREA, and hence cannot be attributed to the management.

Breeding duck densities on Grand River Marsh Wildlife Area equalled 1 pair per 8 acres of permanent water.

TABLE 5. *Comparisons of floating and submerged plants before and after drawdown and carp removal on the main impoundment of Grand River Marsh, August, 1978-81*.*

Parameters	Before Treatment	After Treatment 1 Year (1980)	After Treatment 2 Year (1981)
Frequency of occurrence (%)			
Ceratophyllum demersum	38	71	86
Utricularia spp.	8	18	1
Elodea canadensis	3	1	16
Myriophyllum spp.	1	0	0
Potamogeton pectinatus	31	25	37
Potamogeton crispus	4	3	5
Potamogeton foliosus	0	2	0
Potamogeton pusilus	0	1	0
Polygonum amphibium	5	3	7
Sagittaria latifolia	0	31	4
Scirpus fluviatilus	0	3	0
Lemna minor	15	28	49
Lemna trisulca	0	22	64
Wolfia spp.	0	3	12
Algae	0	3	38
Phalaris arundinacea	0	7	2
Samples having submergents (%)	59	100	99
No. of plant species	8	15	12
Average rake-sample density (%)	37	68	52
Average water depth (ft)**	1.5	3.9	2.0

*Carp removed by chemical treatment in August 1979.
**Water level changes due to planned management.

GRM or a range of from 1 pair/5 acres to 1 pair/13 acres during the 5-year period. Mallard and blue-winged teal breeding pairs on GRM comprised 1-3% and 2-6%, respectively, of the estimated GREA breeding populations.

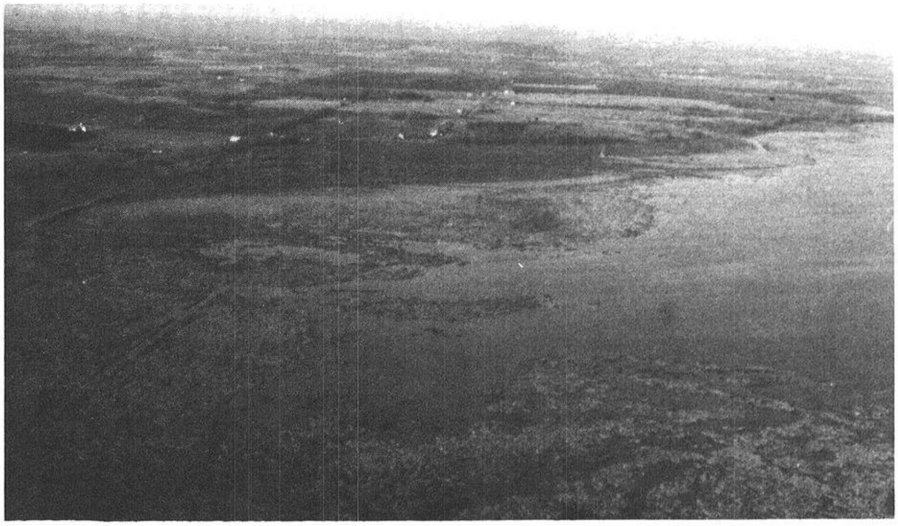
Effects of Drawdown and Carp Removal

The main impoundment was drawn down during the summer of 1979 and approximately 1,000,000 lb of dead carp were removed following rotenone treatment (by Fish Management). The pretreatment standing crop of carp would have been nearly 333 lb/acre. Carp are thought to compete for food with ducks (Moyle 1964) and destroy vegetation beds which are prime waterfowl feeding areas (Anderson 1950, Cahoon 1953, Threinen and Helm 1954, Tryon 1954, Robel 1961). Chironomids (midge larvae) have been identified as foods of both carp (Frey 1940) and waterfowl (Wheeler and March 1979) in Wisconsin waters. Carp were found to consume 51.5% crustaceans and 36.5% insects (Ewers and Boesel 1935). Other studies indicate young carp feed on zooplankton but adults shift to vegetation (Shimadate et al. 1957). Prior studies on Horicon and Theresa marshes in Wisconsin documented major increases in submergent vegetation with the drawdown of waters and the removal of carp (Beule 1979). Drawdowns alone have been shown to promote increases in submergent vegetation (Linde 1969, Kadlec 1962).

Submergent vegetation improved greatly after drawdown and carp removal (Table 5). The number of submerged and floating plant species increased from 8 to 15. The percent of samples containing vegetation increased from 59 to 100 ($P < 0.01$) and the average density of plants per rake sample increased from 37-68% ($P < 0.01$) (Table 5).

The effects of drawdown and carp removal on the diversity and abundance of aquatic invertebrates was less clear. The diversity of insect families trapped was greater after treatment (1980, 1981) than before treatment (1978) (Table 6). However, insect diversity on the untreated carp-free impoundments and ponds also increased during 1980, indicating annual variability may also have accounted for some of the increased diversity in the treated area. The abundance of invertebrates during pretreatment and posttreatment years did not seem to follow any discernible pattern of increase or decrease (Table 6). The only consistent changes in invertebrate abundance at all three sampling sites on the main impoundment were a decrease in the number of aquatic spiders and increases in Mayflies and Haliplid beetles (Append. B). More intensive sampling may be required to avoid variability associated with yearly differences in invertebrate abundance and periodicity of insect emergence.

The improved aquatic habitat at GRM attracted additional breeding mallards and blue-winged teal despite reduced breeding numbers in surrounding habitats (Tables 2, 3 and 4). Following the drawdown and carp removal the estimated number of mallard breeding pairs using GRM more than doubled, while mallard pairs on the surrounding GREA declined (Fig. 4). Blue-winged teal breeding pair estimates on the GRM increased in the first year following drawdown and treatment (1980) while they decreased on the surrounding GREA (Fig. 5). The increase on GRM in the second year following treatment (1981), also occurred on the GREA, and hence cannot be attributed to the management.



Breeding duck densities on Grand River Marsh Wildlife Area equalled 1 pair per 8 acres of permanent water.

TABLE 5. *Comparisons of floating and submerged plants before and after drawdown and carp removal on the main impoundment of Grand River Marsh, August, 1978-81*.*

Parameters	Before Treatment	After Treatment 1 Year (1980)	After Treatment 2 Year (1981)
Frequency of occurrence (%)			
Ceratophyllum demersum	38	71	86
Utricularia spp.	8	18	1
Elodea canadensis	3	1	16
Myriophyllum spp.	1	0	0
Potamogeton pectinatus	31	25	37
Potamogeton crispus	4	3	5
Potamogeton foliosus	0	2	0
Potamogeton pusilus	0	1	0
Polygonum amphibium	5	3	7
Sagittaria latifolia	0	31	4
Scirpus fluviatilus	0	3	0
Lemna minor	15	28	49
Lemna trisulca	0	22	64
Wolfia spp.	0	3	12
Algae	0	3	38
Phalaris arundinacea	0	7	2
Samples having submergents (%)	59	100	99
No. of plant species	8	15	12
Average rake-sample density (%)	37	68	52
Average water depth (ft)**	1.5	3.9	2.0

*Carp removed by chemical treatment in August 1979.
**Water level changes due to planned management.

The drawdown and carp removal resulted in improved brood cover. . .

. . .and large expanses of moist soil duck foods such as smartweeds.

TABLE 6. *Insect abundance* and diversity at Grand River Marsh before and after carp removal.*

		Pretreatment		Post-treatment			
		1978		1980		1981	
Invertebrate Group	Common Name	Treatment** Area	Control[1] Area	Treatment Area	Control Area	Treatment Area	Control Area Area
Gastropoda	Snails	4±3	106±87	11±4	5±3	2±1	2±2
Crustacea		5866±1833	1302±1141	3288±1123	813±653	4753±4300	448±244
Arachnida	Spiders	2558±1979	44±21	177±50	193±79	168±119	225±159
Ephemeroptera	Mayflies	2±1	2±1	136±63	29±28	21±11	16±12
Odanata	Dragonflies	2±2	1±1	2±1	0	2±1	1±1
Hemiptera	True bugs	4858±2353	518±393	5623±967	2099±803	819±435	2383±1135
Coleoptera	Beetles	6±2	156±35	242±181	268±153	81±39	240±76
Diptera	Flies	48±28	419±411	23±7	53±7	10±5	5±3
Total insect families		7±0	11±2	10±2	13±1	11±0	7±1

*Mean number caught per sample site.
**Drawdown and carp removed 1979.
[1]Carp free, freeze-out impoundments and ponds.

DUCK PRODUCTION

Breeding Chronology

Mallard nest initiation at GRM typically began during 17-23 April and was broadly spread through early June with no definite peaks of nesting effort (Fig. 6). When comparing nest initiation dates, back-calculated from brood surveys, mallard nesting attempts on the GREA appear to extend later than those on GRM (Fig. 7).

Blue-winged teal nesting peaked 8-14 May during 1977, 1979 and 1981. The nesting peak in 1978 was a week later than in these years. During 1980 the nesting was broadly spread from 1 May to 18 June (Fig. 8); this year had the lowest nesting success (discussed later) and a late spring with exceptionally cold weather in April and early May. Average nesting chronology on GRM and the GREA were very similar for blue-winged teal (Fig. 9).

Nesting

Nests Studied. During the present study 918 duck nests were located (Table 7). The nests were mainly of blue-winged teal (84%), with mallard (10%) gadwall (4%), and 4 other dabbling duck species (2%) in lesser numbers. Comparisons of the numbers of nests found with the estimated number present, indicates that 38-74% of the nests present on the areas searched were located. Estimated nest densities of all duck species per 100 acres of cover were 28-30 in 1977 and 1978, 21 in 1979, and 50 in 1980 and 1981. The estimates of duck nest density during 1977-81 were positively correlated (r = 0.885) with estimates of blue-winged teal and mallard breeding pairs. Few nests (10%) were found in early laying stages due to the short period that the hen is present at the nest and the small chance of encountering her with only 2-3 nest searches (Table 8). Few nests (8%) were found in late incubation due to high predation rates and because hens did not flush as easily when the clutch neared hatching.

Nest Locations. Mallard nest locations were scattered over the entire

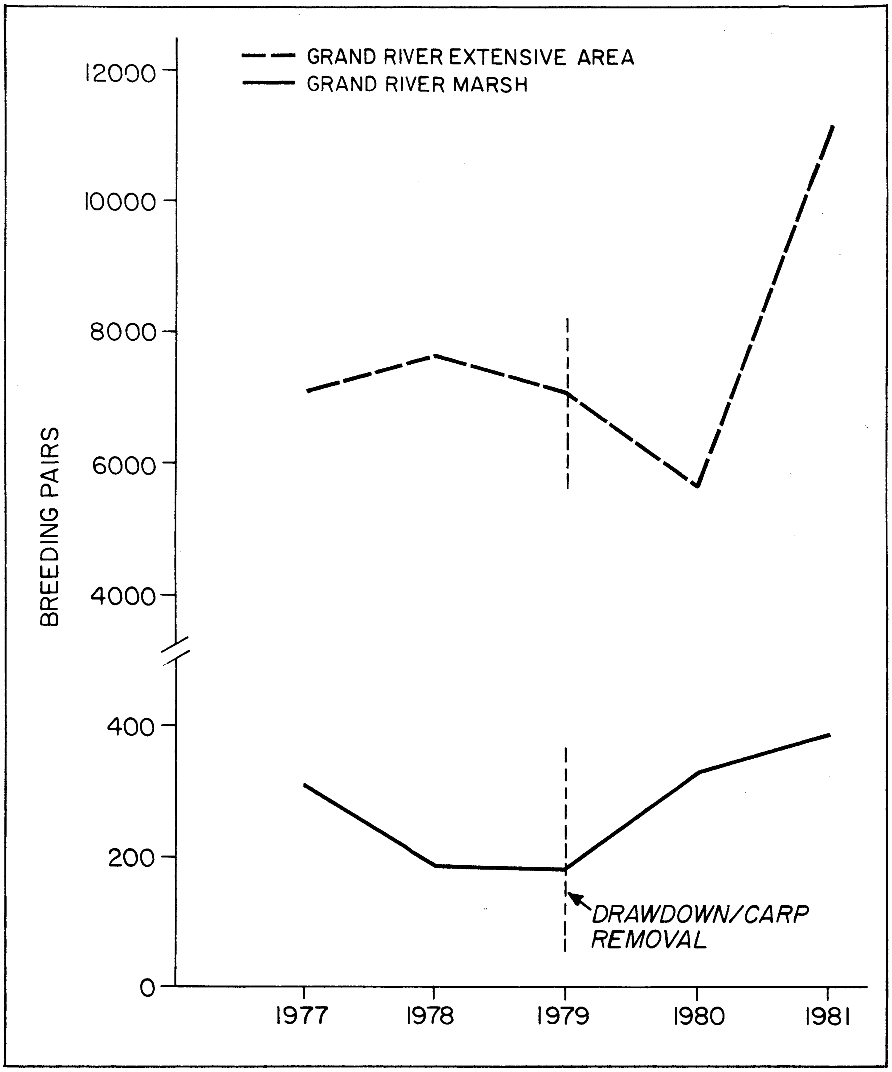


FIGURE 5. *Blue-winged teal breeding pair numbers on Grand River Marsh and the extensive study area (2,500 mile²) in relation to the 1979 drawdown on Grand River Marsh.*

TABLE 7. *Nests found on Grand River Marsh and the estimated number present, 1977-81.*

Parameter	1977	1978	1979	1980	1981	Total	Percent
Mallard	8	14	16	29	28	95	10
Blue-winged teal	93	177	135	180	183	768	84
Gadwall	7	1	3	11	15	37	4
Northern shoveler	0	1	0	4	2	7	<1
American wigeon	0	1	0	0	0	1	<1
Common pintail	0	0	0	2	2	4	<1
Green-winged teal	3	0	0	0	3	6	<1
Total	111	194	154	226	233	918	100
Estimated number of nests present on areas searched	292	267	209	490	466	1,724	
Acres searched	980	959	1,011	989	934	4,873	
Nests/acre	0.3	0.3	0.2	0.5	0.5	0.4	
Percent of available nests found	38	73	74	46	50	53	

In 4% of the blue-winged teal nests that hatched, at least 1 hatched duckling died in the nest.

The net effect was that full clutches of blue-winged teal hatched in only 61% of the successful nests and the average size of the brood leaving the nest was 1.9 ducklings less than the average full clutch size.

Thirty-nine percent of the hatched mallard nests contained at least 1 undeveloped egg (Table 12). Partial predation was not evident in hatched clutches of mallards. Some partial predation of mallard clutches was found but these nests ended in abandonment or total predation which was already taken into account when calculating nest success. No evidence of duckling death in the nest was noted at hatching mallard nests. The average size of mallard broods leaving nests was about 1 duckling less than the average full clutch size.

Cover Type and Vegetation Density. Nest success estimates of all duck species are represented in Table 13-16. (Nest success estimates of blue-winged teal are listed in Appendix C). Comparisons of nest success among cover types in individual years were hampered by small sample sizes (Table 13). There were differences ($P < 0.05$) among annual nesting success estimates for the major cover types in only 2 years.

In 1977, nest success in dry marsh types was higher than in planted cover older than 9 years and old fields. In 1981, nest success in the 4- to 8-year-old planted cover was higher than in the dry marsh and planted nest cover over 9 years old. When all years (1977-81) were pooled, the 4- to 8-year-old planted cover had higher nest success (20%) ($P < 0.05$) than the other covers studied (13-15%).

No consistent relationship between average June vegetation height-density in fields and nesting success was found (Table 14). Differences in nest success rates within vegetation density categories occurred only during 1977, 1979, and 1981, but these differences were inconsistent with each other. When years were pooled, no height-density category had a greater nesting success ($P > 0.05$). Also, there was no general trend toward increased nest success with increasing average field cover density.

Measurements of average residual cover present in nesting fields in April ranged from 0-10 cm during 1977-79 (Kirsch et al. 1978). Measurements of residual cover in 1980 and 1981 varied enough to place fields in two residual cover categories (0-10 cm and 11-20 cm). No differences ($P > 0.05$) in nest success were evident between categories in 1980 (9.5%, 6.0%) or 1981 (12.2%, 22.0%). Average residual cover of the field provided very little protection from predation.

No consistent relationship between vegetation density at nest sites and nest success was found (Table 15); no patterns of increased nest success among categories of vegetation density were found either within years or with years pooled.

As an additional test of the relationships between vegetation and nest success, vegetation height-density measurements taken when a nest was found were compared between hatched nests and those destroyed by predators (Table 16). In 3 of the 5 years (1977, 1978, 1979), vegetation at hatched nests was denser ($P < 0.05$) than at nests that were ultimately preyed upon. When years were pooled, no difference ($P > 0.05$) in vegetation density between hatched nests and those destroyed by predators was evident. The fact that differences were found in 3 of 5 years indicates a trend exists toward slightly denser vegetation at hatched nests.

Annual mean initiation dates of hatched nests destroyed by predators were not different ($P > 0.05$) during any of the five years (Append. D). Therefore, it seems no direct relationship exists between nest success and later nest initiation when cover had increased due to seasonal growth.

In summary, this study provided little evidence that the denser nesting cover available at GRM in April or June deterred predation of duck nests. A similar study at Horicon Marsh Wildlife Area indicated that denser switchgrass fields (mean height-density readings of 33.9 ± 0.9 cm) also had relatively low nest success (18%) for the same 1977-81 period (Bartelt and Vine 1982). Contrary to these findings, Duebbert and Lokemoen (1976) felt that fields of brome, wheat grass, and alfalfa (averaging 40-60 cm in height) in South Dakota provided a high degree of security to breeding hens. Duebbert (1969) also indicated dense mixtures of tall grasses and sweet clover may have deterred predators due to reduced horizontal movement of scent. It appears that factors other than nest cover density had a greater effect on nest success at GRM.

Proximity of Nest to Water. There were no differences in nest success for either mallard or blue-winged teal in relation to distances from water ($P > 0.05$). As a result, nests of all species were combined in this analysis. Nests were found from 1 to over 500 yd from water, with 70% of the nests within 300 yd of water (Table 17). Although there were some differences ($P < 0.05$) in nest success in relation to distance from water, there was no evident pattern of changing nest success with increasing distance from water for 4 of 5 years or for all years pooled. In summary, distance from water had little effect on a nest's outcome at GRM. In contrast, several authors have found nests near the water are generally less successful than those farther from wetlands (Keith 1961, Livezey 1979).

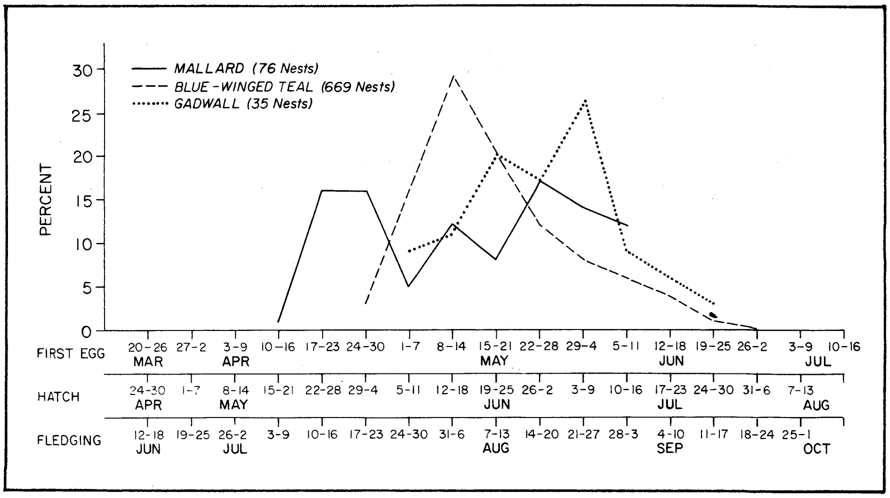


FIGURE 6. *Breeding chronology by 7-day periods for nesting mallards, blue-winged teal, and gadwalls at Grand River Marsh, 1977-81.*

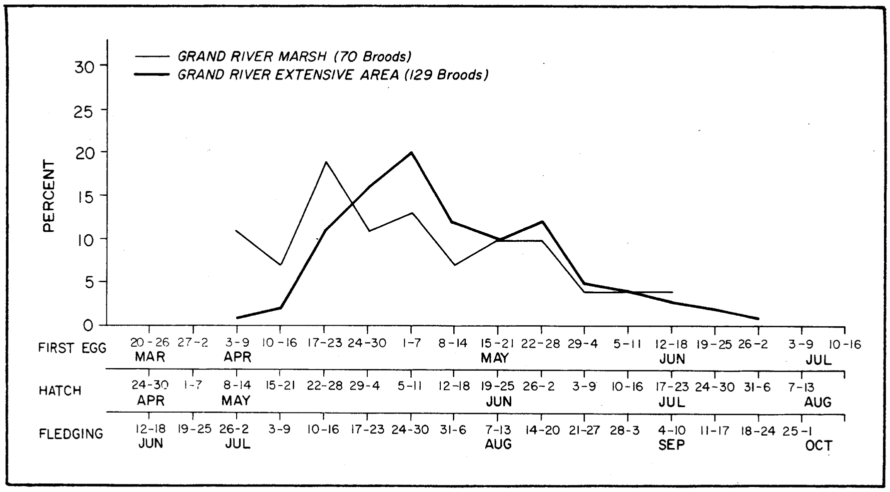


FIGURE 7. *Mallard breeding chronology by 7-day periods for the Grand River Marsh and the Grand River Extensive Area, 1977-81 (In this instance, the Extensive Area does not include Grand River Marsh).*

Mammalian predation on nests was the major factor which reduced average nest success to 17%.

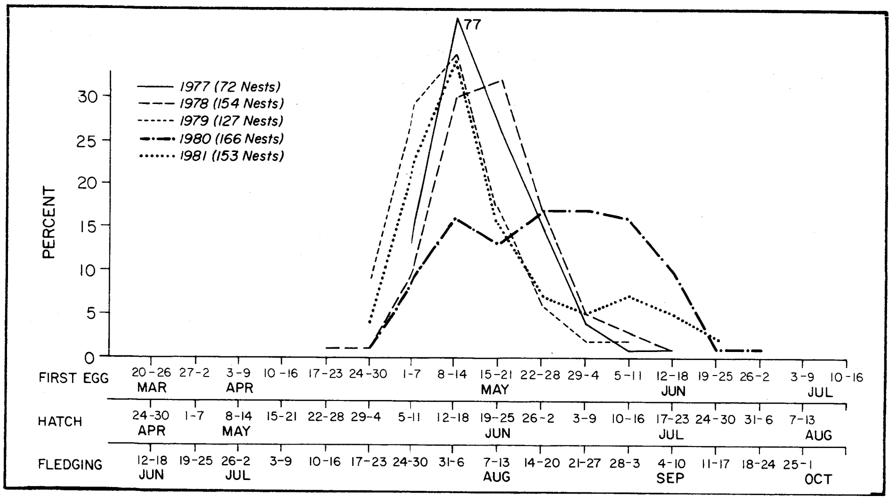


FIGURE 8. *Yearly breeding chronology by 7-day periods for blue-winged teal on Grand River Marsh, 1977-81.*

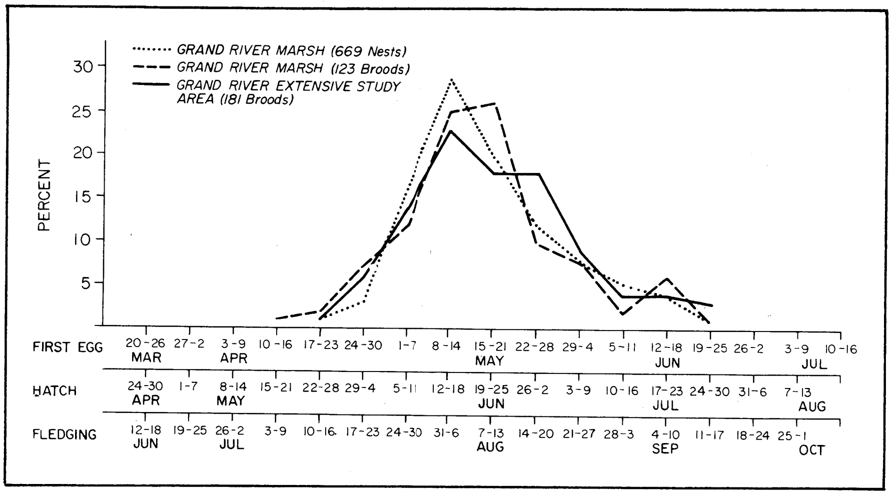


FIGURE 9. *Blue-winged teal breeding chronology by 7-day periods for the Grand River Marsh and the Grand River Extensive Area, 1977-81. (In this instance the Extensive Area does not include Grand River Marsh).*

Effect of Predator Reduction. The areas live-trapped for predators in 1978-80 were chosen for their relatively high density of nests (Figs. 10, 11). The number of animals trapped and removed ranged from 13 in 1978 to 46 in 1980 (Table 18). The amount of nest destruction by raccoons and skunks was lower ($P < 0.05$) on the trapped area than on all other nesting fields during the period (1978-80) when trapping was conducted (data for all years pooled). Although the trend was toward lower predation by skunks and raccoons on the reduction area during each year trapped, no differences ($P > 0.05$) were detected. Overall nest success on the predator reduction area was no different ($P > 0.05$) than that on all other nesting fields. During 1980, when the largest numbers of predators were removed (1/1.4 acres) the reduction area had only 8% nest success. Increases in nest success on the reduction area (1978-80) corresponded with increases on all areas and appears to be due to year effects rather than predator removal. Intensive trapping, with 1 trap/2 acres on 64 acres, from 1 April until the fate was determined for the last nest, was not effective in increasing nest success. Conversely, predator reduction on a large scale utilizing strychnine-poisoned eggs was found to double duck nest success on Agassiz National Wildlife Refuge (Balser et al. 1968). The logical conclusion is that at GRM predators were not removed in sufficient quantity (i.e., GRM may have had such a high or mobile predator population that live-trapping was not effective).

Most of the raccoons captured were males. Females or young-of-the-year were usually caught late in the nesting season (Table 19). Urban (1970) found adult females were not active on nest-

Fox snakes were also identified as a nest predator on duck nests at Grand River Marsh.

Intensive predator removal from small areas of heavily used nesting fields did not increase nesting success in these fields.

TABLE 8. *Number of duck nests found at specific stages in nesting on Grand River Marsh, 1977-81.*

	Stage When Found									
	Laying		Incubation							
Year	0-5*	6-10	11-15	16-20	21-25	26-30	31-36	Hatched	Destroyed by Predators	Total
1977	7	20	24	17	14	3	2	7	22	116
1978	23	58	24	16	9	19	2	4	22	177
1979	14	28	23	15	9	10	4	1	15	119
1980	20	66	41	38	10	5	1	6	13	200
1981	22	44	41	35	19	14	7	5	30	217
Total	86	216	153	121	61	51	16	23	102	829
Percent	10	26	18	15	7	6	2	13	12	99

*Days from first egg laid.

TABLE 9. *Mean height-density changes in vegetation over time within cover types at Grand River Marsh, 1977-81.*

Cover Type	1977	1978	1979	1980	1981
Dry marsh	35(8)*	19(14)	22(6)	30(5)	28(6)
Old fields	25(12)	14(25)	18(16)	22(18)	19(18)
Brome-alfalfa					
Pre-1975	28(16)	25(24)	31(19)	36(20)	27(21)
1975	28(3)	21[a](6)	28(6)	37(6)	21[a](6)
1976	16[b](1)	13[b](11)	33(7)	38(7)	25(7)
1977		14(13)	29[c](9)	38(10)	27[c](10)
1978			27[d](4)	22[d](4)	24[d](4)
Switchgrass**					
1977		8(2)	4(1)	14(1)	35(1)
Fallow			29(1)	34(1)	23(1)

*Sample size.

**In these cover types, stations were used as replicates; in all others, fields were replicates.

[a-d]Annual means within cover types are not different ($P > 0.05$) if means are followed by the same letter.

TABLE 10. *Nest fates and nest success for all nests found at Grand River Marsh, 1977-81.*

	Number of Nests						Nest Success (%)	
Year	Hatched	Destroyed by Predators	Deserted	Destroyed by Humans	Unknown	Total	Traditional*	Mayfield**
1977	35	68	4	3	1	111	34	12
1978	80	95	8	4	7	194	46	29
1979	47	68	34	4	1	154	41	22
1980	50	149	26	1	0	226	25	8
1981	70	145	15	3	0	233	33	15
Total	282	525	87	15	9	918	35	16
Avg.	56	105	17	3	2	184	36	17

*Number hatched divided by number hatched plus number destroyed by predators.

**Method modified by Miller and Johnson (1978), Johnson (1979).

TABLE 11. *Percent of nest predation due to specific predators, Grand River Marsh, 1977-81.*

Predator*	1977	1978	1979	1980	1981	Mean
Skunk - opossum	59	27	27	29	47	38
Raccoon	15	34	31	28	25	27
Fox	10	9	9	20	1	10
Crow	0	1	0	6	3	2
Other**	3	16	26	7	18	14
Unknown	13	13	7	10	6	11

*Nest predators identified by characteristics at the nest as described by Rearden (1951).

**Includes fox snake, Franklin's ground squirrel, badger, mink, and weasel.

TABLE 12. *Factors reducing the number of mallard and blue-winged teal young leaving successful nests at Grand River Marsh, 1977-81.*

Species/ Year	Avg. Size of Full Clutch	No. Hatched Nests	No. Hatched Nests With at Least 1 Undeveloped Egg	No. Hatched Nests: Checked 3 or >3 Times	No. Hatched Nests: Known Partial Predation	No. Nests Where Full Clutch Hatched	No. Hatched Nests Where at Least 1 Yg. Died in Nest	Avg. No. Young to Leave Nest[1]
1977-81	9.1±0.6(18)	18	7(39)*	-	0	11(61)*	0	8.2±1.6
Blue-winged Teal								
1977	9.3±0.4(27)**	31	3	7	1(14)*	22	0	8.3±1.0(24)**
1978	10.4±0.4(50)	68	15	21	8(38)	19	0	8.1±0.6(68)
1979	10.9±0.6(36)	43	10	30	3(10)	23	2	10.1±0.6(36)
1980	9.7±0.6(33)	35	8	31	8(26)	19	1	8.3±0.8(35)
1981	11.0±0.4(50)	55	7	54	6(11)	36	6	10.2±0.6(55)
Total	10.9±1.2(196)	232	43(19)	143	26(18)	119(61)	9(4)	9.0±0.4(218)

*Percent.

**Sample.

[1]No. of young based on hatched membranes left in nest bowl.

TABLE 13. *Percent duck nest success in major cover types at Grand River Marsh, 1977-81.*

Year	Dry Marsh	Old Fields*	4- to 8-Year-Old Planted Nesting Cover**	Greater Than 9-Year-Old Planted Nesting Cover*
1977	51[a,b](17)***	12[a](30)	—(3)	3[b](30)
1978	27(8)	25(84)	58(12)	31(49)
1979	25(24)	11(33)	31(8)	30(40)
1980	4(30)	8(65)	14(24)	9(65)
1981	6(39)	12[c](40)	37[c,d](40)	13[d](62)
1977-81	13[e](119)	14[f](252)	20[e,f,g](87)	15[g](246)

*Abandoned hayfield or pasture, primarily bluegrass forb.
**Planted to brome, alfalfa, timothy and clover; species present primarily brome-alfalfa.
***Number of active nests studied per cover type.
[a-g]Success figures with the same letter are significantly different ($P < 0.05$).

TABLE 14. *Percent duck nesting success in relation to the height and density of June vegetation in nesting fields at Grand River Marsh, 1977-81.*

	Visual Obstruction Measurements (cm)*						
Year	1-10	11-20	21-30	31-40	41-50	51-60	Overall
1977	35[a](9)**	5(9)	13(37)	4[a,b](19)	—	61[b](7)	12
1978	41(13)	22(65)	32(68)	45(7)	—	—	29
1979	11[c](26)	19(10)	21(37)	46[c](20)	19(12)	—	22
1980	5(37)	8(32)	8(35)	12(41)	8(36)	7(3)	8
1981	14(54)	28[d](31)	14(68)	7[d](25)	0(3)	—	15
1977-81	13(139)	18(147)	18(245)	14(112)	9(41)	34(10)	16

*Visual obstruction measurements described by Robel et al. (1970).
**Number of nests in each category.
[a-d]Success figures with the same letter are different ($P < 0.05$).

TABLE 15. *Percent duck nesting success in relation to the height and density of the vegetation at the nest sites when found on Grand River Marsh, 1977-81.*

	Visual Obstruction Measurements (cm)*						
Year	1-10	11-20	21-30	31-40	41-50	51-60	Overall
1977	10(6)**	9(26)	14(22)	20(14)	9(7)	—(1)	12
1978	4[a](7)	32[b](53)	22[c](41)	25[d](20)	69[a-d](21)	50(7)	29
1979	31[e](16)	28[f](43)	6[e-g](23)	38[g](12)	23(6)	—(1)	23
1980	6(11)	10(39)	6(51)	9(35)	9(28)	17(11)	8
1981	11(23)	19(81)	15(50)	10(14)	2(8)	—(1)	15
1977-81	13(63)	20[h](242)	12[h](187)	15(95)	19(70)	21(21)	16

*Robel et al. (1970).
**Number of nests in each category.
[a-h]Success figures with the same letter are different ($P < 0.05$).

TABLE 16. *Height and density of nest site vegetation at hatched nests and those destroyed by predators on Grand River Marsh, 1977-81.*

	Visual Obstruction Measurements (±95% C.I.)*	
Year	Hatched Nests	Nests Destroyed by Predators
1977	27.9±**4.3(35)***,[a]	20.0±2.7(71)[a]
1978	31.0±3.3(80)[b]	25.8±2.7(97)[b]
1979	23.2±3.9(48)[c]	16.3±2.5(72)[c]
1980	30.5±4.0(48)	27.1±2.2(155)
1981	21.3±2.7(70)	22.9±2.1(147)
Mean	26.8±12.0(281)	22.4±12.1(542)

*Robel et al. (1970).
**95% C.I.
***Number of nests.
[a-c]Vegetation readings with the same letter are different ($P < 0.05$).

ing areas on dikes in Ohio during the period females were having their young (15 March - 1 June). Adult males at GRM appear to be the greatest threat to nesting ducks as females with young apparently were not active in nesting fields until late in the nesting season, after the bulk of the nests were terminated. Adult males are known to have larger home ranges than adult females and young of either sex (Fritzell 1978a, Lehman 1977, Greenwood 1982). Removal trapping of territorial males may have caused an influx of males taking their place. Fritzell (1978b) reported such shifting of an adult male to the former home range of another male which had died.

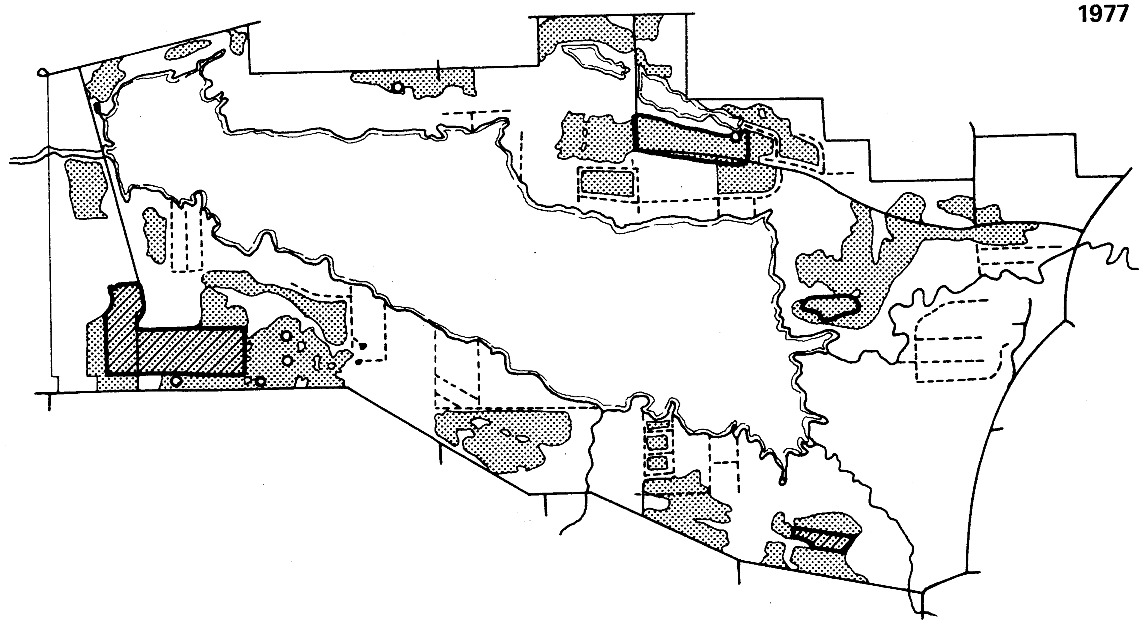
Twenty-eight percent of the males and 55% of the females caught were older than 3 years. This appears quite high for a heavily hunted and trapped population. Raccoons older than 3 years made up only 10% of a population of raccoons in Indiana subject to harvest (Lehman 1977).

Renesting

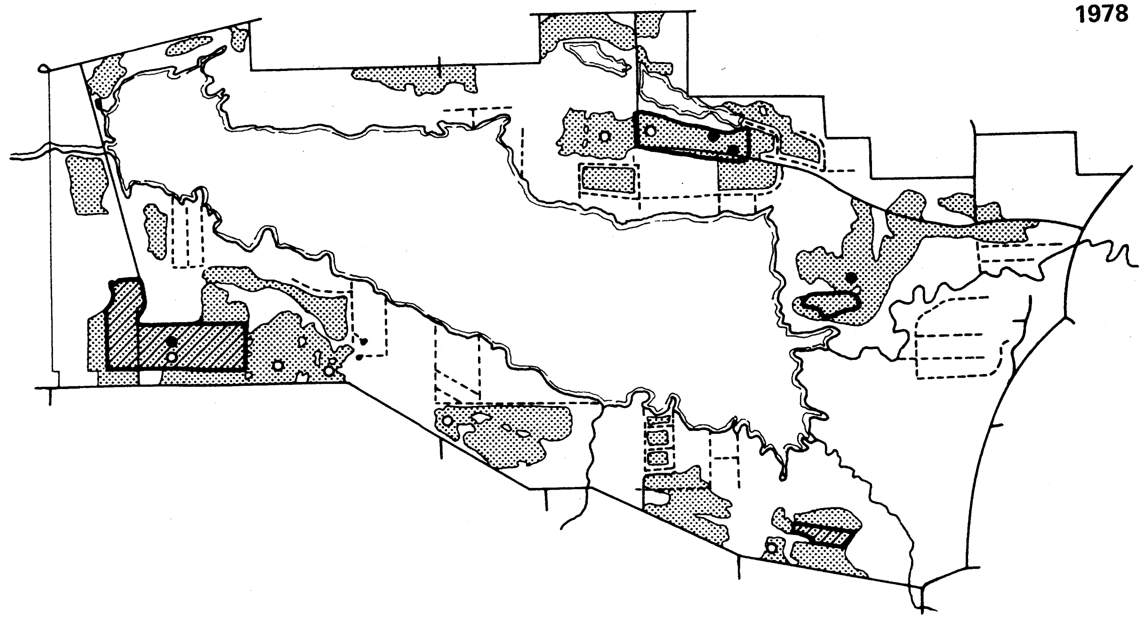
Little information was obtained on renesting at GRM. When trapping of hens began in 1979, we hoped to collect data on both renesting and brood survival, so hens were trapped in early incubation. When this resulted in high rates of abandonment, jeopardizing data on brood survival, a decision was made to put more emphasis on studying broods. Most hens were marked in late incubation in 1980-81, and as a result these were most often successful nests, leaving few unsuccessful hens to monitor for renesting.

The number of nesting hens marked in 1979-81 totaled 46 nasal-saddled and 57 radio-equipped blue-winged teal, and 3 nasal-saddled and 27 radio-equipped mallards. Some mortality of radio-marked hens (Table 20) plus high hatching success of nasal-saddled and radio-marked hens left only 31 marked birds available to renest (Table 21). Two of 17 mallards renested (12%) but none of the 14 blue-winged teal hens renested. Sowls (1955) indicated only 1 of 20 unsuccessful (5%) mallards renested at Delta, Manitoba. In Vermont 53% of the mallard hens marked by Coulter and Miller (1968) were known to renest, although they felt this was a minimum estimate. Keith (1961) felt all unsuccessful mallard hens on his Alberta study area renested at least once. Higher rates of renesting by blue-winged teal were reported for Horicon National Wildlife Refuge, Wisconsin (22%) and Dewey's Pasture, Iowa (35-40%) by Carlson (1981) and Strohmeyer (1967), respectively. Sowl's and Carlson's estimates may not be directly comparable since

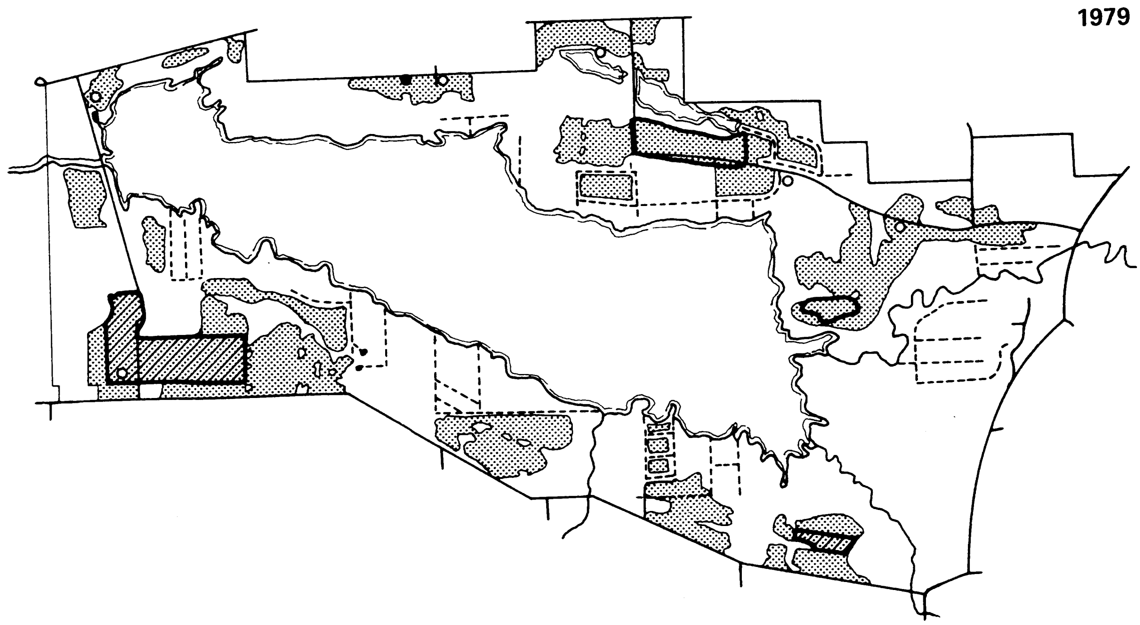
1977



1978



1979



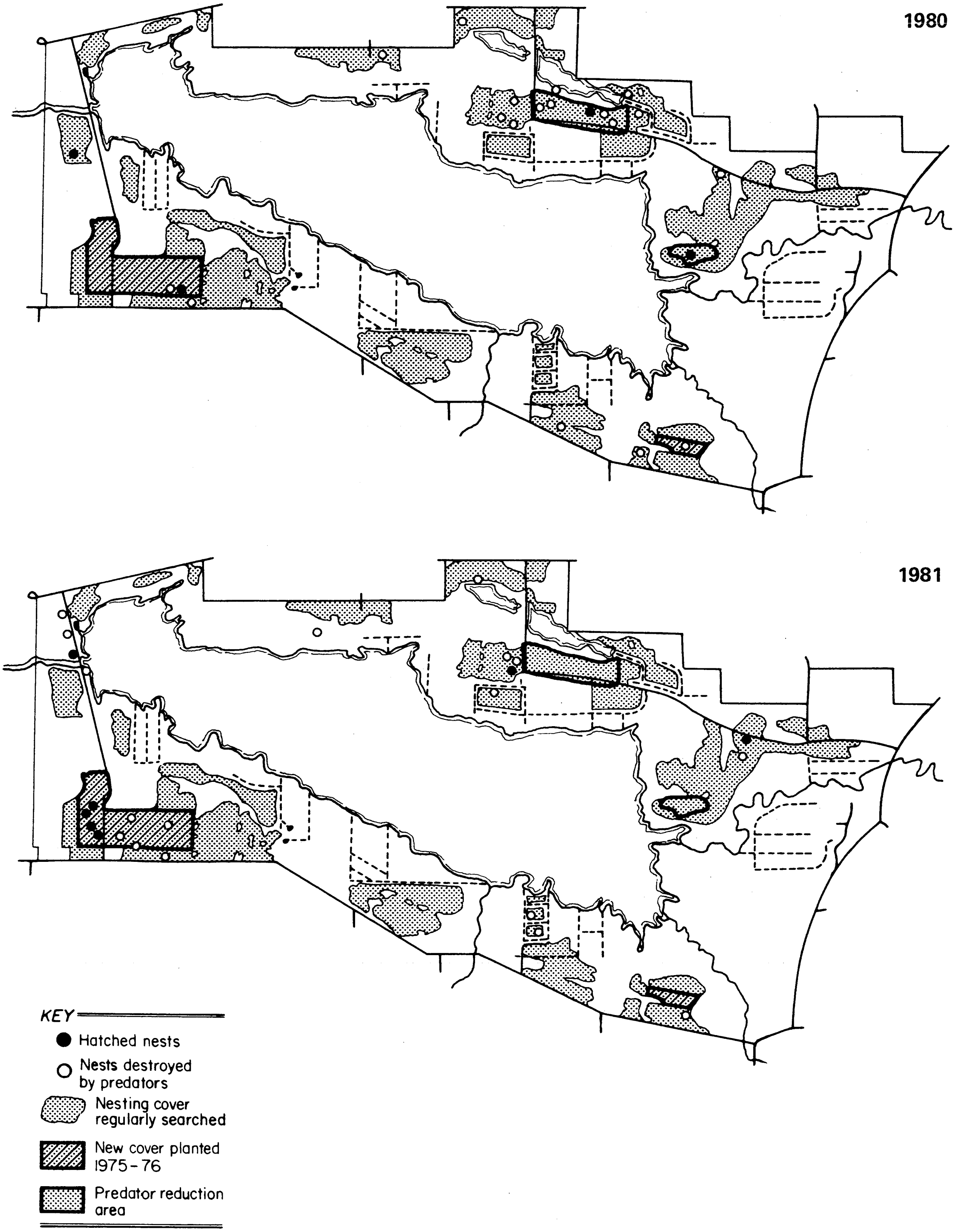
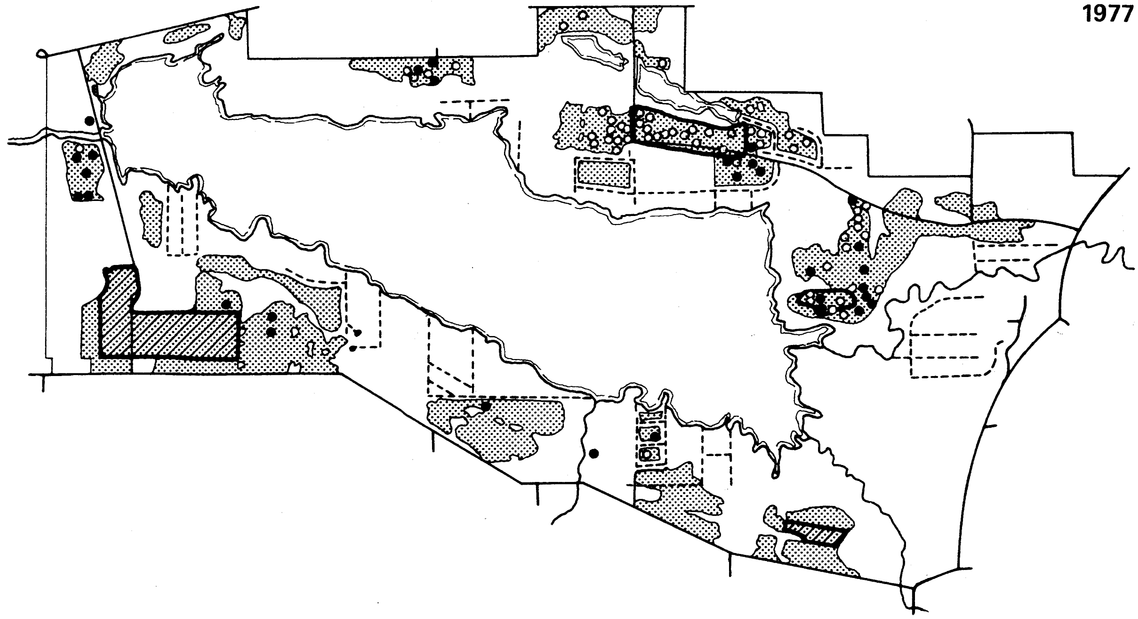
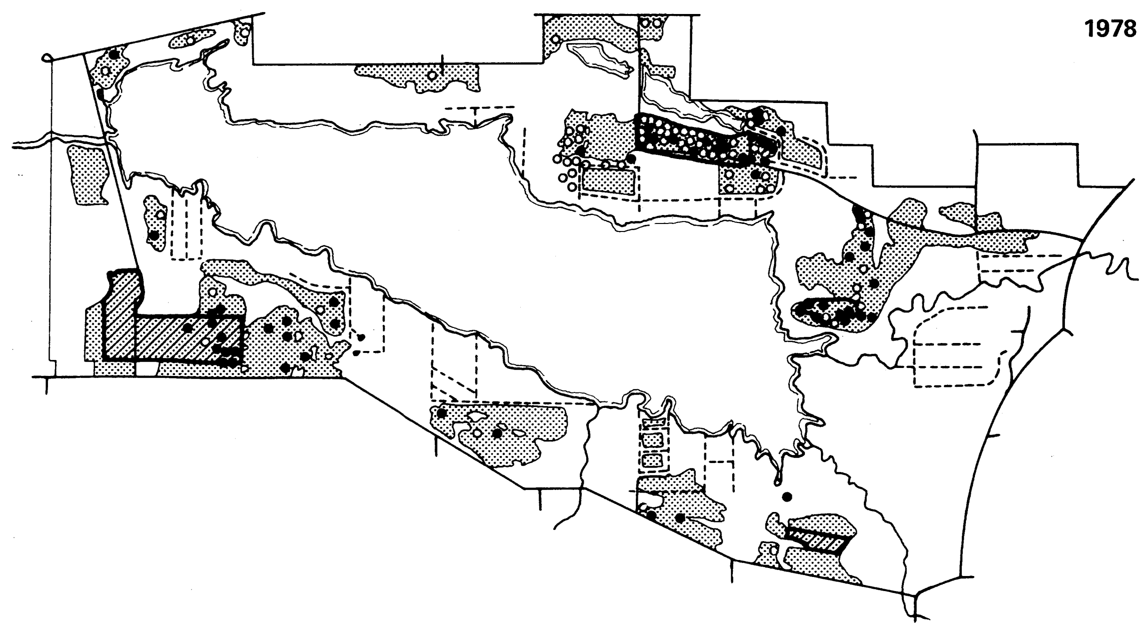


FIGURE 10. *Mallard nest locations on Grand River Marsh, 1977-81.*

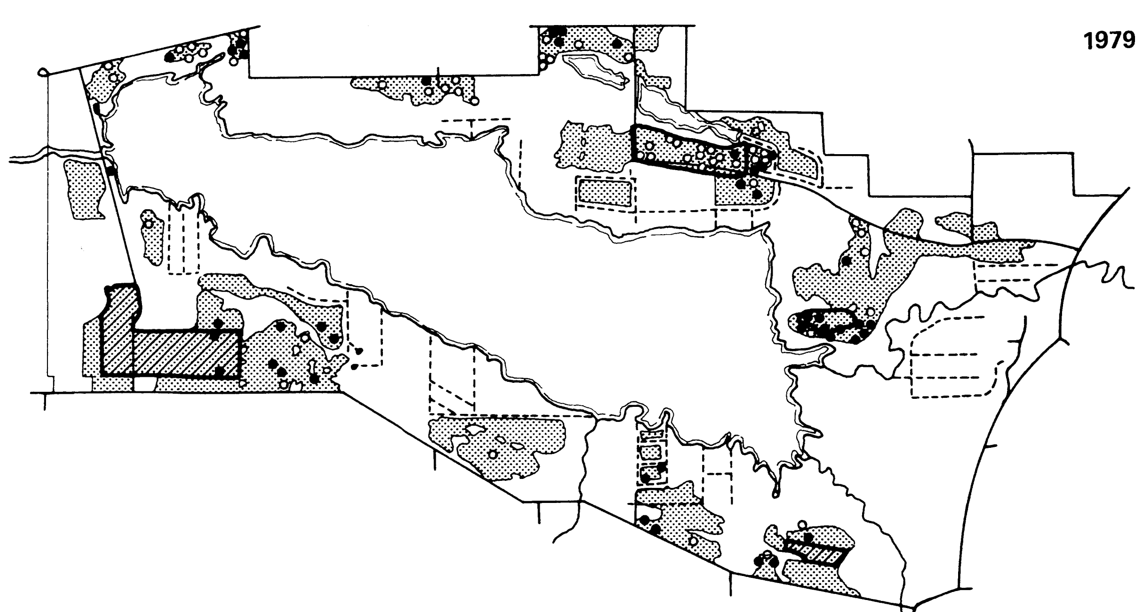
1977



1978



1979



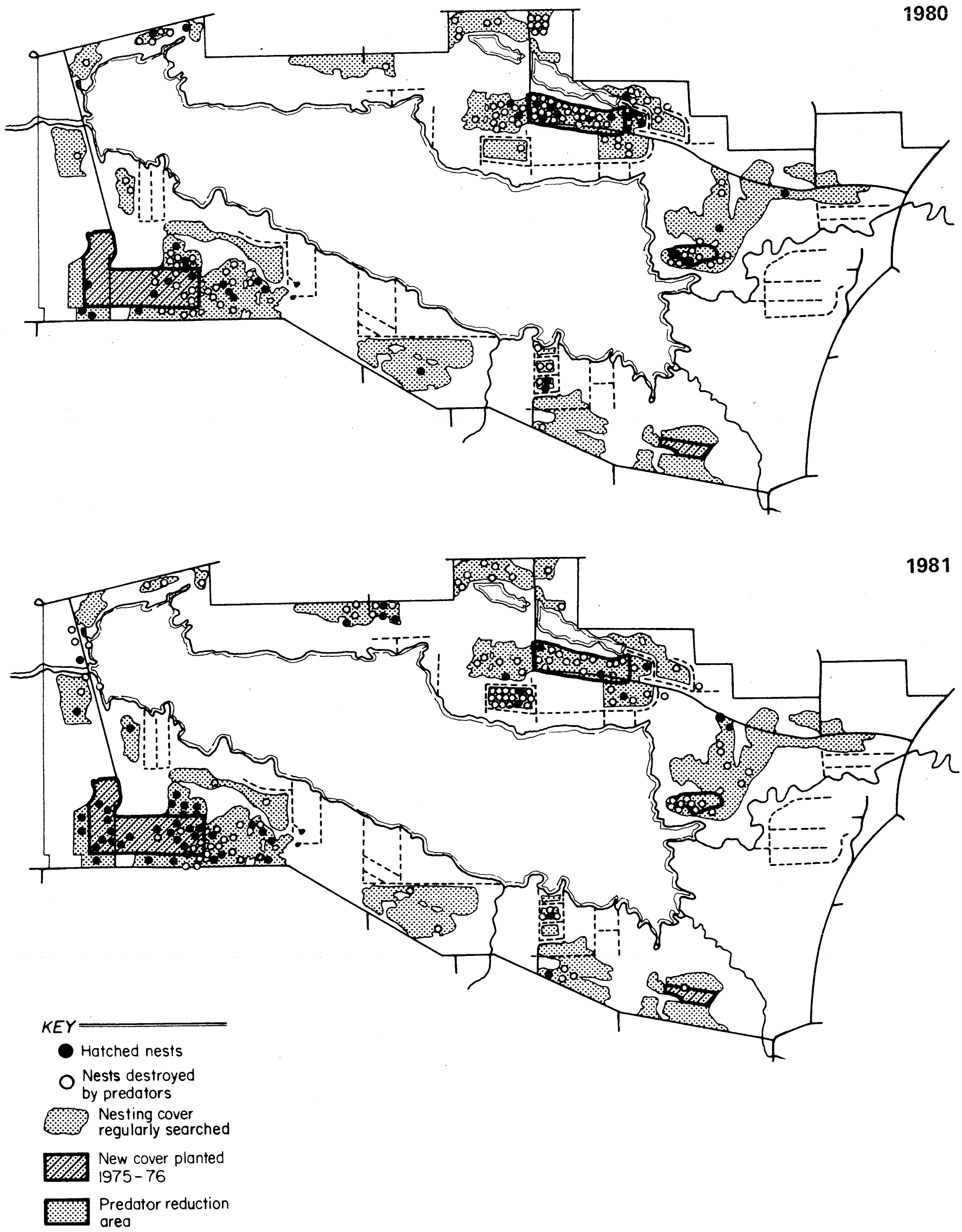


FIGURE 11. *Blue-winged teal nest locations on Grand River Marsh, 1977-81.*

TABLE 17. *Percent duck nesting success in relation to the distance nests were located from water on Grand River Marsh, 1977-81.*

Year	Distance to Nearest Water (yd) 1-50	51-100	101-200	201-300	301-500	500	Overall
1977	18(15)*	18(13)	16(19)	5(20)	17(4)	6(0)	12
1978	82(9)[a-d]	58(16)[e,f,g]	42(36)[a,h,i,j]	15(28)[b,e,h]	15(27)[c,d,f,i]	16(25)[d,g,j]	28
1979	22(28)[k]	16(20)[l]	36(23)	11(17)[m]	9(9)	69(8)[k,l,m]	22
1980	10(38)	4(39)[n]	7(42)	5(16)	8(18)	17(31)[n]	8
1981	6(29)[o,p]	7(22)[q,r]	6(33)[s,t]	3(11)[q]	34(27)[o,s]	28(59)[p,r,t]	15
1977-81	15(119)	12(110)	18(153)[u,v]	8(92)[u]	17(85)	22(133)[v]	16

*Number of nests.
[a-v]Success figures with same letter are different (P < 0.05) within years or total.

TABLE 18. *Effects of predator reduction on nesting success of ducks on Grand River Marsh, 1977-81.*

	Predator Reduction Areas: No. Predators Removed					Percent Nest Destruction by Skunks/Raccoons		% Nest Success	
Year	Skunk	Raccoon	Opposum	Gr. Squirrel	Badger	Reduction Area	All Other Areas GRM	Reduction Area	All Other Areas GRM
1977**	—	—	—	—	—	82	86	4(20)*[b]	17(60)[b]
1978	4	6	0	3	0	43	80	22(39)	32(114)
1979	7	22	0	1	0	40 } 43[a]	66 } 70[a]	28(21)	19(84)
1980	5	34	4	1	2	43	67	8(37)	8(147)
1981**	—	—	—	—	—	63	78	2(19)[c]	17(162)[c]

*Number of nests in sample.
**No predator trapping in these years.
[a,b,c]Success and destruction figures with the same letter are significantly different (P < 0.05), within years.

they removed eggs to simulate predation. Since most hens were trapped during incubation at Grand River, a comparison of unsuccessful incubating hens would be more appropriate. Renesting rates reported for hens whose nests were destroyed during incubation were found to be 18%, 7% and 0% by Strohmeyer (1967), Carlson (1981), and this study, respectively. Since renesting appears to be a function of body condition (Krapu 1981) the potentially stressing effects of radios on hens may have suppressed the GRM renesting rate.

Attempts to identify renesting of mallards and teal from chronology curves of overall nest initiation are of questionable value. Sowls (1955) set arbitrary dates after which all nests initiated were considered renesting, even though he found evidence at the nest unreliable in classifying renests or identifying these break-off dates. Strohmeyer (1967) and Carlson (1981) documented renesting during the first peak of nest initiation (2nd week of May), long before Sowls' (1955) cut-off date of 24 June.

The sharp peaks in nest initiation by bluewings in 1977-79, and 1981 (Fig. 8), and the absence of secondary peaks also support the lack of renesting evidenced by marked blue-winged teal hens at GRM. In 1980, the year of lowest nest success (8%), nest initiation

TABLE 19. *Ages of trapped raccoons, Grand River Marsh, 7 April-15 July 1980.*

SEX	Age in Months 3	4-14	15-38	39-57	58-86	>86	Total
Males		6	7	4	0	1	18
Females	1	2	2	4	1	1	11
Unknown	3						3
Total	4	8	9	8	1	2	32

TABLE 20. *Fate of nests of radio-marked hens on Grand River Marsh, 1979-81.*

Species and Nest Fate	1979	1980	1981	Total
Mallard (27)*				
Hatched	1	2	4	7 (26%)
Destroyed by predators	2	6	3[1]	11 (41%)
Abandoned**	4	4	1	9 (33%)
Human disturbance	4	2	0	6 (22%)
Hen killed by predator	0	2	1	3 (11%)
Partial predation of nest	0	0	0	0 (0%)
Blue-winged teal (57)*				
Hatched	7	11	10	28 (49%)
Destroyed by predators	2	1	3	6 (11%)
Abandoned**	6	10	9	23 (40%)
Human disturbance	4	2	5	11 (19%)
Hen killed by predator	0	6	3	9 (16%)
Partial predation of nest	0	2	1	3 (5%)

*Total number radio-equipped hens that nested.
**Traditionally, abandoned means any nest left by the hen, for any reason. These nests are not included in calculations of nest success by the Mayfield method.
[1]Believed destroyed by plow prior to predation.

TABLE 21. *Renesting by color-marked and radio-equipped hens on Grand River Marsh, 1979-81*.*

Species Marked	1979 Available to Renest**	1979 Renested	1980 Available to Renest**	1980 Renested	1981 Available to Renest	1981 Renested	Total Available to Renest	Total Renested
Mallard								
Nasal saddled	1	0	0	—	0	—	1	0
Radio-equipped	5[a]	1	8[b]	1	3	0	16	2
Total	6	1 (17%)	8	1 (13%)	3	0	17	2 (12%)
Blue-winged Teal								
Nasal saddled	0	0	1	0	1	0	2	0
Radio-equipped	5	0	3	0	4	0	12	0
Total	5	0	4	0	5	0	14	0

*All marked and radio-equipped hens represented here had full clutches and had begun incubating before capture.
**Unsuccessful hens due to nest predation or abandonment.
[a]Two hens' nests destroyed by predators late in season 15 June, 20 June.
[b]Five hens' nests destroyed by predators late in season 16-18 June.

TABLE 22. *Mean brood size by age class on Grand River Marsh and the Grand River Extensive Area, 1977-81.*

Species/Area	Age Class I	II	III
Mallard			
GRM	7.4±0.8*(34)[1]	6.2±1.0(30)	5.1±1.6(11)
GREA**	7.0±0.1(30)	5.8±0.7(43)	5.7±0.8(47)
Total	7.2±0.6(64)	5.9±0.6(73)	5.6±0.7(58)
Blue-winged teal			
GRM	7.1±0.6(76)	6.7±0.8(43)	6.0±2.0(9)
GREA**	6.9±0.8(50)	7.0±0.6(79)	5.6±1.3(31)
Total[2]	7.0±0.5(126)	6.9±0.5(122)	5.7±1.1(40)

*95% confidence limits at $P < 0.05$.
**In this instance, the Extensive Area does not include Grand River Marsh.
[1]Number of broods (sample size).
[2]There were no differences ($P > 0.05$) between mean brood sizes within age classes for Grand River Marsh and the rest of the Grand River Extensive Area, so the observations were combined to produce a total.

TABLE 23. *Summary of statistics on radio-marked mallard and blue-winged teal hens, Grand River Marsh, 1979-81.*

Number of Hens	Mallard 1979*	1980	1981	Total	Blue-winged Teal 1979*	1980	1981	Total
Radio-equipped	7	15	13	35	14	26	22	62
With nests	7	12	8	27	14	21	22	57
With hatched nests	1	2	4	7	6	10	9	25
Renested	1	1	0	2	0	0	0	0
With broods to follow	1	1	5**	7	4	10	8	22
Killed by predators	0	3	1	4	2	7	9	18
Radio failed	0	0	0	0	0	2	2	4
Slipped radio[1]	1	5	2	8	0	3	2	5
Known to molt on GRM	0	4	8	12	0	4	8	12
Lost signal-unknown reason	7	0	0	7	-	-	-	-

*Main impoundment was drawn down eliminating much molting habitat.
**Includes one hen radio-equipped when captured with a brood on the water.
[1]Includes all hens whose radios were found detached, with no signs to indicate whether the hen was killed or injured. This category may or may not include additional birds killed by predators or which died of other causes and were scavenged.

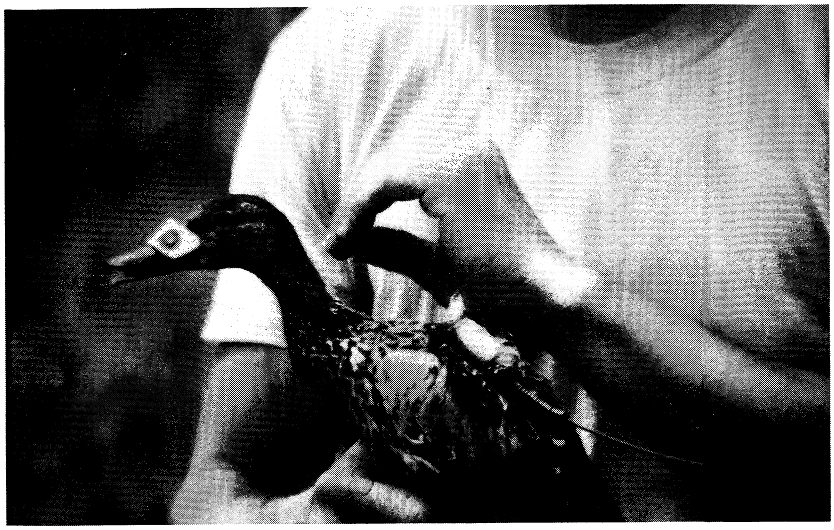
was spread out more evenly over time. This may be explained by: (1) higher predation induced more renesting in late May and June, or (2) the late spring and exceptionally cold weather in April and early May of 1980.

In summary, renesting by blue-wings, the primary nester at GRM, appears very low and cannot be compensating for the low success rates which ranged from 8-29% (Mayfield—40% estimate), renesting included. Keith (1961) felt a hatch rate of 42% (traditional mean percentage hatched) and renesting rates of 55% for blue-winged teal in Manitoba were adequate to maintain population levels.

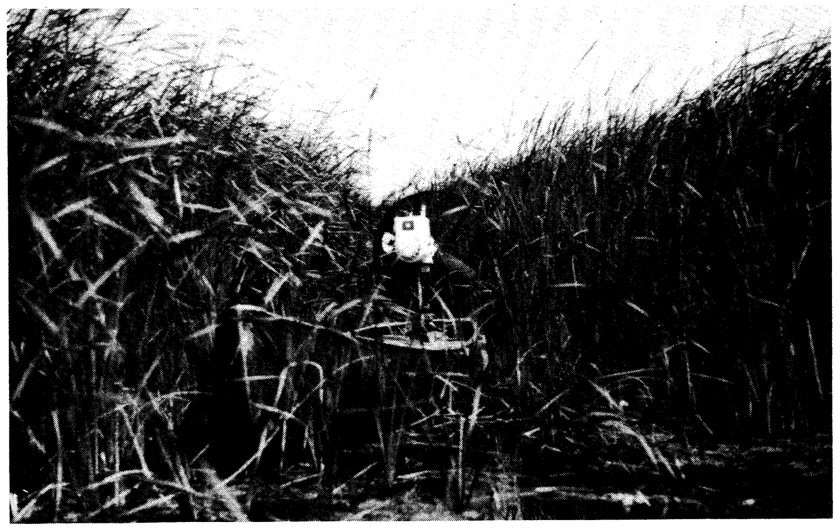
Duck Brood Characteristics

Mean Brood Sizes. Mean brood sizes in all age classes of mallards and blue-winged teal at GRM were not different ($P > 0.05$) than those from the surrounding GREA (Table 22). Brood sizes of class III mallards on GRM (5.1) and on the GREA (5.7) are smaller ($P < 0.05$) than those found in previous studies in southeastern Wisconsin (7.0±0.6, Jahn and Hunt 1964). Mean brood sizes of 6.5±0.4 and 6.3±0.8 were also calculated for the same general area by March (1976) and Wheeler and March (1979); however, they were not significantly different from those recorded in the present study ($P > 0.05$).

Class III blue-winged teal brood sizes at GRM (6.0) and GREA (5.6) indicate a similar trend toward smaller broods when compared to mean class III brood sizes of 6.9±0.8, 6.3±0.4 and 6.2±0.8 reported by Jahn and Hunt (1964), March (unpubl.) and Wheeler and March (1979), respectively. They are not significantly smaller ($P > 0.05$), however. De-



Radio tracking of broods indicated most loss of ducklings occurred after they reached water.



Dense brood cover made observations of radio-tracked broods extremely difficult.

creasing average regional brood sizes may indicate a long-term decline in duckling survival in southeastern Wisconsin.

Brood Mortality. Brood sizes of class I mallards and blue-winged teal (Table 22) observed on the water at GRM were smaller by 0.8 and 1.9 young, respectively, than mean brood sizes at the nest (Table 11). This would indicate a reduction in brood size of 10% for mallards and 21% for blue-winged teal during overland travel to water and through the first 13-18 days after hatch.

During 1979-81, 35 mallard and 62 blue-winged teal hens were equipped with radios to allow monitoring of brood movements and attrition. High nest loss and hen mortality, coupled with the loss of radio transmitters or signals, reduced the number of broods monitored to 7 and 22, respectively, for mallard and blue-winged teal (Table 23).

Five blue-winged teal and 3 mallard broods were closely observed on the day of hatch to get complete counts of duckling loss between nest and water (Table 24). All 7 broods made it to water when moving less than 0.7 mile from nest to water. One blue-winged teal hen moving a distance of 0.9 mile from nest to water lost 1 duckling. Since most movements to water at GRM occurred at midday when mammalian predators are least active, mortality may more likely be due to fatigue of ducklings or the physical separation of ducklings during movements. One other mallard brood not included in this summary was killed by haying operations as it moved off GRM onto an adjacent private hay field in 1979. The mortality rate of 1% (1/71 ducklings) during the exodus from nest to water does not appear to be a major component of total mortality from egg to flighted juvenile.

Observing broods by foot, canoe, airboat or combinations of all three was very difficult in the dense cattail marshes at GRM; only 20% and 9% of the attempts to observe mallard and blue-winged teal broods while pursuing them in wetland cover, respectively, ended successfully in complete brood counts (Table 25). Broods were usually able to outmaneuver observers and in several instances hens would leave the brood. The best way to observe radioed broods was to quietly observe open water areas in the vicinity of a hen's radio location, just before sunset.

During 1979-81 only 4 and 9 broods of mallards and blue-winged teal, respectively, yielded counts of ducklings during the period between the broods reaching water and fledging (Table 26). Two of 4 mallard broods survived intact on the water approximately 10 days. One brood was intact and one hen lost 2 of 9 ducklings by approximately 15 days after entering the marsh. Three of the hens were known to lose 88% of their total ducklings after 35 days in the marsh. Two of the four mallard hens lost all their ducklings by 36 days.

Blue-winged teal hens began losing ducklings almost immediately once they reached water, as four hens lost 25% of their ducklings during the first five days. Broods observed at 7-11 days after hatch were reduced by 46%. Data on broods after 12 days on the water is very sketchy; however, a minimum of 4 of 12 radioed hens lost their entire brood by 27 days after hatch.

A minimum estimate of brood attrition can be calculated by traditional means (Jahn and Hunt 1964, Stoudt 1971) from Table 22. The difference in observed brood sizes of class I and class III broods indicates between-class brood mortality of 31% and 15% of the ducklings for GRM mallards and bluewings, respectively. Both estimates for the GREA were 19%. These losses are not different ($P > 0.05$) than the 13% for both mallards and bluewings in southeastern Wisconsin during 1973-75 (Wheeler and March 1979). These estimates are minimal since they exclude any downward adjustment for complete brood loss which surely occurs.

Temporary absence of females from their broods has been documented by Beard (1964) and more recently for the mallard (Haland 1983, Talent et al. 1983) and black duck (Ringleman and Longcore 1982). This was observed in several instances on GRM. Four mallard hens were seen loafing and preening without their broods at 3, 9, 20, and 33 days after hatch, indicating that ducklings were left unattended. Three of these were later observed with their broods, while marked ducklings from the fourth hen's brood were later captured. Two blue-winged teal were noted to flush, when pursued in cover, exhibiting no broody reactions and to leave the area, but later were known to have broods. One instance of brood-mixing was also documented. Sixteen days after hatch a color-marked blue-winged teal hen was captured with a brood of 6, containing 4 web-tagged ducklings from her brood and 2 web-tagged ducklings from a different brood. None of the radio-equipped hens were known to have assembled gang broods.

In summary, only after close and careful monitoring can duckling mortality or loss of ducklings from the brood be confirmed. The only sure way of assessing brood mortality would be to monitor individually marked duck-

TABLE 24. *Brood size changes in relation to time and length of movement from nest to water, Grand River Marsh, 1979-81.*

Species	Distance to Water (Mile)	Total Time of Move (hours)	Brood Size at Nest	Brood Size at Water	Lost
Mallard	0.1	0.50	9	9	0
	0.6	—	10	10	0
	0.7	2.00	10	10	0
Blue-winged teal	0.1	—*	8	8	0
	0.2	2.75	6	6	0
	0.2	—	9	9	0
	0.5	2.50	12	12	0
	0.9	—	7	6	1

*Not timed.

TABLE 25. *Observations of broods of radio-equipped hens on Grand River Marsh, 1979-81.**

Brood Observations	Mallard No.	Mallard Percent	Blue-winged Teal No.	Blue-winged Teal Percent	Total No.	Total Percent
Complete brood count	4	20	3	9	7	13
Incomplete brood count	7	35	10	29	17	31
Only hen observed	7	35	10	29	17	31
No hen or brood observed	2	10	11	32	13	25
Total	20	100	34	100	54	100

*Observations made by following radio signals of hen into wetland cover on foot or by canoe.

TABLE 26. *Brood attrition of radio-tracked mallard and blue-winged teal ducklings at Grand River Marsh, 1979-81.*

Brood No.	No. Ducklings at Nest	No. That Reached Water*	No. Alive After Period of Days on Water: 2-6	7-11	12-16	17-21	22-26	27-31	32-36
Mallard									
879	9	—	—	—	7	—	—	—	3
057	10	10	10	—	10	—	—	—	—
314	7	7	—	7	—	—	0		
342	9	9	—	9	—	—	—	7	0
		(100)**	(100)	(100)	(89)	—	(0)	(78)	(17)
Blue-winged teal									
070	6	6	—	—	—	—	—	—	—
073	12	12	—	—	—	—	—	—	—
133	8	8	—	—	—	—	—	—	—
266	7	6	6	—	0				
373	9	9	5	5	—	—	—	—	—
276	11	—	8	8	—	—	0		
923	8	—	—	—	—	1	—	—	—
297	3	—	2	—	—	—	—	0	
909	12	—	—	0					
955	10	—	9	—	—	—	—	—	—
101	10	—	—	7	—	—	—	—	—
102	8	—	—	7	6	—	—	—	—
		(98)**	(75)	(54)	(40)	(13)	(0)	(0)	—

*Average distance from nest to water: mallard, 0.5 mile, blue-winged teal, 0.4 mile.
**Percent (number of ducklings of all broods observed this period divided by number of ducklings same broods contained at nest).

Nests in cover with the best height-density measurements hatched no better than those in cover with poor readings.

fencerows, rock piles, and old foundations occur in many places. Indirect predator control through management of their critical habitat components has not been studied, to determine its effects on duck production in Wisconsin.

The establishment of dense cover to protect nests from predation has been studied at two sites in Wisconsin. On the Horicon Marsh Wildlife Area during 1977-81, average nest success in dense switchgrass fields (18%) was higher ($P < 0.05$) than that in alfalfa (7%) and forb-grass type fields (9%), but not higher ($P > 0.05$) than nest success in brome grass (13%) or bluegrass (13%)(Bartelt and Vine 1982). On Schoeneberg's Marsh Waterfowl Production Area (Columbia Co.), nest success in 3 dense switchgrass fields totalling 40 acres has varied from 14-37% over 3 years (Petersen 1982). The effectiveness of dense nesting cover is still under investigation in Wisconsin and elsewhere. These ongoing studies should provide additional information regarding the amount of security for nesting ducks provided by dense nesting cover and switchgrass in particular.

lings which could be relocated at death or individually identified if still living.

Duck Production Estimates

The estimated annual production by upland nesting species of ducks on GRM averaged 872 ducklings (Table 27) or 1 young/3 acres of grassy nesting cover. This also calculates to 1 duck/4 acres of permanent water. The highest production years were 1978 and 1981 when approximately 1 duck/2 acres of cover or 1 duck/3 acres of permanent water were produced. In 1978 only half as many pairs were attracted to GRM compared to 1981, but nest success was twice as high, resulting in similar production estimates.

Annual objectives in the Grand River Wildlife Area Master Plan (Hansen et al. 1982) call for production of 1 duck/1.3 acre of permanent water (2,350 ducks). A nest success of 32% during the years of highest duck pair use and nest densities (1980 and 1981) would have achieved this goal. Nest success rates of 53%, 56% and 75% would have been required in 1977, 1978 and 1979, respectively, to attain the goal.

Adequate water for both pairs and broods was available in years of low carp populations, but the primary restrictions to better duck production were the high predation of upland nests and brood mortality. The quality (height and density) of the cover was not found to influence nest success within the range of densities at GRM. At present, reduction or exclusion of predators from nesting fields seem the most likely alternatives to increase nest success and duckling production. Direct predator reduction on a small scale in this study, aimed at specific high density nesting fields, did not result in increased nest success. Large-scale predator removal has been successful in other areas. Chesness et al. (1968) were able to increase pheasant nest success by intensive trapping and gassing predator dens. The use of poison egg baits (strychnine) to reduce predators doubled duck nest success on Agassiz National Wildlife Refuge, Minnesota (Balser et al. 1968). Also, reduction of fox, skunk, and badger in South Dakota by year-round poisoning, shooting, and trapping resulted in 92% and 85% duck nest success on high and low quality habitats (Deubbert and Kantrud 1974).

Exclusion of predators from nesting fields has been tested using electric fences. Higher hatch rates (65%, 55%) within fenced areas in comparison to unfenced areas (55%, 12%) were reported from North Dakota and Minnesota, respectively (Lokemoen et al. 1982). Hatch rates of as high as 79% have been achieved with electric fences in Wisconsin (Petersen 1982). GRM contains a considerable amount of habitat suitable for predators. Timber occupies over 600 acres and wooded

FALL DUCK POPULATIONS AND HARVEST CHARACTERISTICS

Early Fall Duck Concentrations

During August and September, waterfowl begin congregating on Rush Lake, Lake Maria, Buffalo Lake, Mud Lake Wildlife Area, GRM, and to a lesser degree on other large marshes within the GREA (Fig. 1). GRM became of particular interest when it began attracting thousands of ducks in August and banding crews could easily trap and band 500 to 1,000 mallards prior to the hunting season. These concentrations continue to build on the refuge area of GRM until peaks of 10,000 to 20,000 ducks have been observed in October.

During 1977 and 1978, fall concentrations of ducks on GRM were lower than the numbers previously counted (Fig. 12), and were also low in relation to numbers on other wetlands in the GREA (Table 28). Following the drawdown and removal of carp in 1979, the GRM concentrations of ducks again increased in 1980 and 1981. Large expanses of moist soil plants resulting from the drawdown provided both food and roosting cover for these larger waterfowl concentrations.

TABLE 27. *Estimated production of ducks in upland fields at Grand River Marsh, 1977-81.**

Year	No. Successful Nests Found	Mayfield Nest Success Estimates	No. Acres Searched	Estimates for Total Upland Area (2,500 acres) Total Nests**	Hatched Nests	Ducklings Produced[1]
1977	35	0.12	980	743	89	534
1978	80	0.29	959	719	209	1,254
1979	47	0.22	1,011	528	116	696
1980	50	0.08	989	1,580	126	756
1981	70	0.15	934	1,249	187	1,122
Mean	56	0.17	975	964	145	872

*Based on 84% blue-winged teal, 10% mallard, 4% gadwall, 2% shoveler, wigeon, pintail, and green-winged teal nests.
**(Number of successful nests found X total nesting acres)/(Mayfield nest success estimated X number of acres searched.)
[1]Class III brood size.

TABLE 28. *A comparison of September duck numbers on Grand River Marsh and other primary fall concentration areas, 1977-81.*

Species/Area	1977	1978	1979*	1980	1981	5-Year Mean
Mallard						
Grand River Marsh	128	54	70	596	1,048	379 ± 541
Study area lakes and management areas	1,939	6,395	4,781	1,617	1,046	3,156 ± 2,873
Blue-winged teal						
Grand River Marsh	0	38	40	221	160	92 ± 117
Study area lakes and management areas	415	553	1,124	253	127	494 ± 481
All other species**						
Grand River Marsh	200	1,534	0	2,349	2,092	1,235 ± 1,340
Study area lakes and management areas	4,479	17,847	18,798	3,989	2,606	9,544 ± 9,994

*Grand River Marsh drawn down, carp removed and marsh reflooded by late October.
**Wigeon, green-winged teal, gadwall, pintail, redhead, black duck, ruddy, wood duck (90% wigeon).

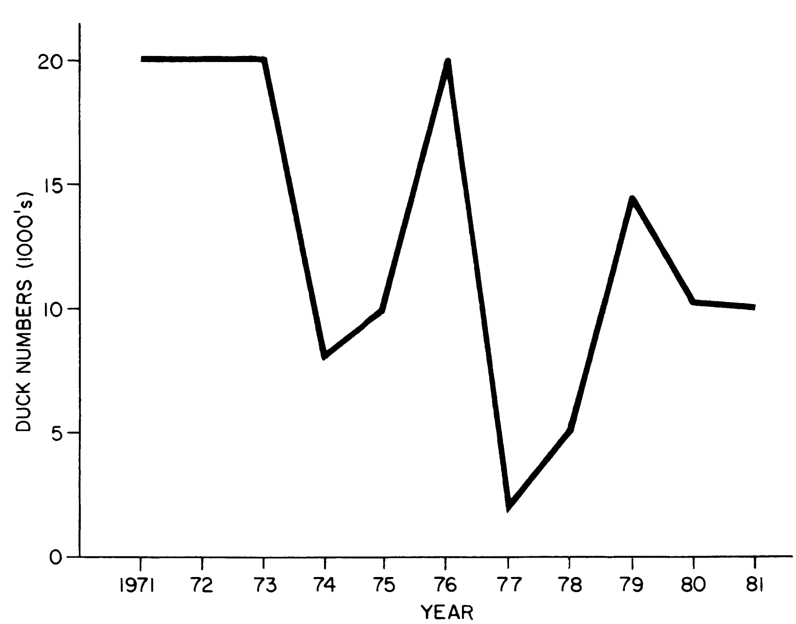


FIGURE 12. *Peak duck numbers in September-October at Grand River Marsh, 1971-81 (T. Hansen pers. comm.).*

Movements of Locally Produced Ducklings

The total numbers of mallard, blue-winged teal, and wood duck ducklings nightlighted and marked on the GREA were 967, 2,679, and 320, respectively. Resightings, recaptures, and hunting season recoveries were used to determine early fall movements prior to the Wisconsin hunting season.

The number of marked blue-winged teal on the GREA began to decrease in August and by early September very few were being observed (Table 29). By late September, blue-winged teal from the GREA were recovered as far east as Quebec and as far south as the Texas Coast (Fig. 13). Sixty-two percent of the 22 teal marked and shot on the GREA were recovered before 6 October. A few local blue-winged teal did, however, remain until 17 October.

Observations on the GREA indicated that local mallards marked as ducklings were also moving off the study area by early September (Table 29). These mallards moved considerable distances within the area studied (Fig. 14) to feed in harvested pea and sweet corn fields as early as 16 August. Other marked mallards were observed as far south as Milwaukee and Kenosha counties by 27 August and 15 September, respectively. Fall cannon-netting of approximately 1,000 mallards annually at GRM indicated most marked mallard ducklings were gone from the marsh by August and September (Table 30). The greatest number of marked birds recaptured per year was 12 (22%) in 1979. Trapping during other years recovered 2-5% of the mallards marked as ducklings annually on GRM.

There was little evidence that mallard ducklings reared within 25 miles of GRM were adding significantly to the early fall concentrations at GRM. Of 709 ducklings marked in the GREA only 8 (1%) were retrapped at GRM, during 1 August through 20 September (Table 30).

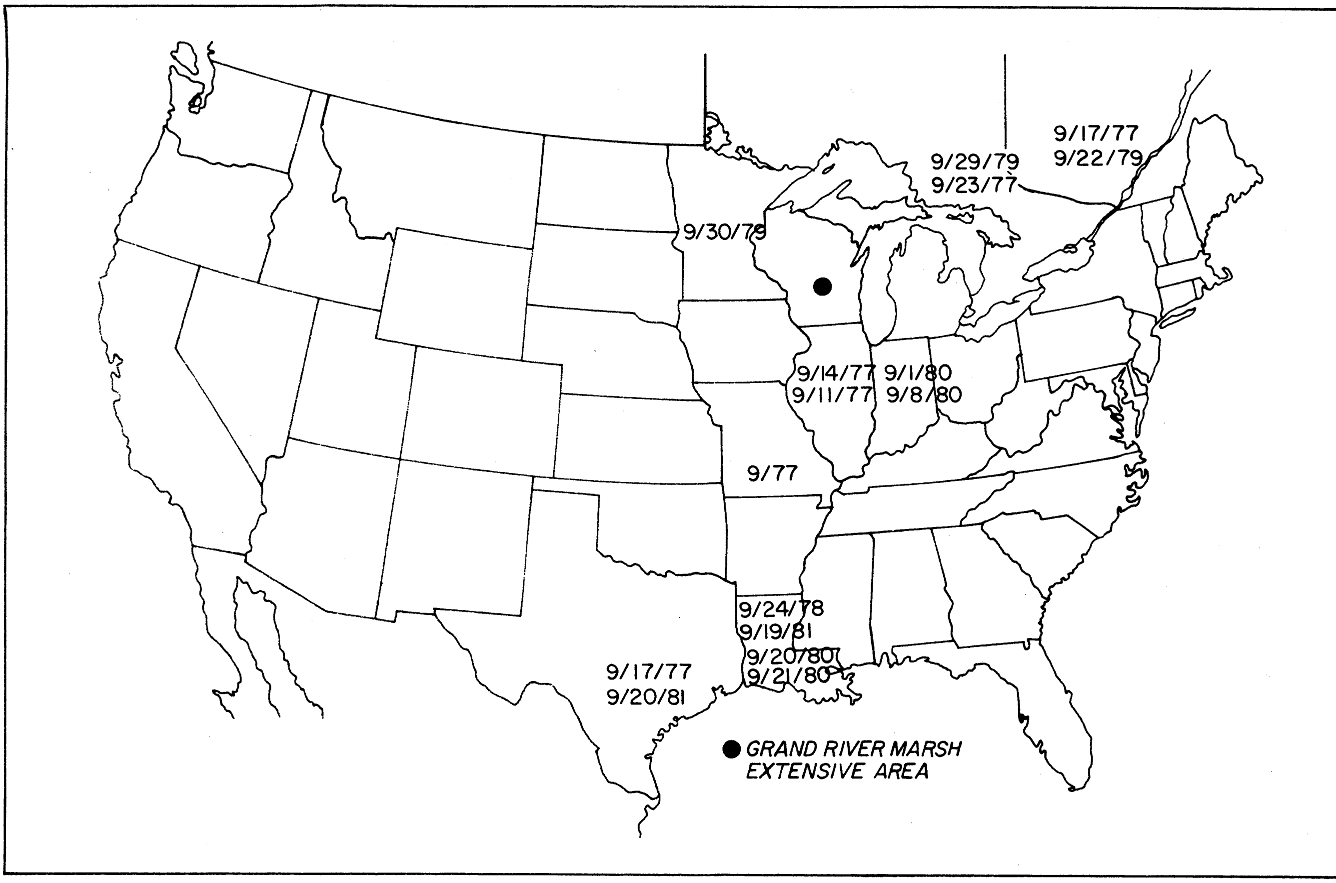


FIGURE 13. *Areas and earliest known dates for fall dispersal of blue-winged teal from Grand River Marsh, 1977-81.*

Banding sites which were sources of marked mallards retrapped at GRM are shown in Figure 15. These retrapped birds (except for one local marked in St. Croix County) were all marked as flying young or adults only days earlier and they may have already traveled considerable distances prior to being banded. Little or no banding has been done on many of the other breeding grounds that may contribute mallards to the GRM fall concentrations. Virtually all of northern Canada and western and northern Ontario lack banding data for any age or sex group (Anderson 1975). March and Hunt (1978) suggested that these areas (northern Saskatchewan, northern Manitoba and Ontario) supply the major flight of migrants entering Wisconsin. Analysis of recoveries (1,002) from this area indicated Wisconsin derives 20% or more of its mallard harvest from there, although the banding distribution was felt to be too heavily concentrated on the area's southern margin to be representative of the total area (Munro and Kimball 1982). The same authors found that the main source of banded mallards in the Wisconsin harvest were those banded preseason in the Great Lakes major reference areas (Wisconsin, Minnesota, Michigan, Iowa, Illinois, Indiana). The lack of banding in northern Wisconsin also leaves a major gap in information on possible sources of birds entering fall concentrations at GRM.

Harvest of Locally Produced Ducks

Although some blue-winged teal marked on GRM remained within the GREA, only a few of the 1,300 marked ducklings became part of the hunter's bag at GRM. From an estimated harvest of 1,168 blue-winged teal (1977-81), only 5 direct (first year) recoveries and one indirect (second year) recovery were obtained from locals banded at GRM (Table 31). Locally nesting adult females were recovered on GRM at only a slightly higher rate than ducklings, with 3 of 115 recovered in 1980 and 1 of 129 recovered in 1981. Although 369 adult males were marked at GRM, none were harvested there (1979-81). Marked locals represented only 0.5% of the GRM blue-winged teal harvest over the 5 years.

Blue-winged teal from the surrounding wetlands (GREA) were not recovered at GRM in any appreciable proportion either. Although 1,579 blue-winged teal, including 1,380 local ducklings, were marked within the GREA, only 2 of these locals were recovered on GRM in the 5 years (Table 31).

GRM was not a concentration or staging area for local bluewings either prior to or during the hunting season. Hunting at GRM, therefore, had little effect on locally produced blue-winged teal.

Blue-winged teal produced on the GREA did provide hunting opportunity elsewhere in Wisconsin (Fig. 16), with 46% (38 of 82) of the recoveries reported within the state. Nearly one-half of the Wisconsin recoveries were within the GREA, the same region where they were banded. A larger proportion of males compared to females were recovered outside of Wisconsin. Over half of the out-of-state recoveries were from southeastern Atlantic and gulf coast states or farther south.

Mallards hatched on GRM added little to the harvest there (Table 32). Although only 3 of the 260 marked ducklings (1.2%) were shot on GRM, marked locals were recovered in the GREA as late as 24 November. Marked locals only added 0.1% to the estimated five-year bag of 4,089 mallards at GRM. From these data it ap-

TABLE 29. *Chronology of observations and hunting recoveries of color-marked ducklings reared and encountered on the Grand River Extensive Area, 1977-81.*

	No. Observed		No. Shot										
			Oct							Nov			
Species	Aug	Sep	1-5	6-10	11-15	16-20	21-25	26-30	31-4	5-9	10-14	15-19	20-24
Mallards (967)*	46	37	9	8	4	6	5	0	1	0	1	0	1
Blue-winged teal (2,679)	28	6	16	8	1	1							

*Total number marked.

TABLE 30. *Summary of recaptures of banded mallard ducklings from fall preseason concentrations (1 Aug-20 Sept) on Grand River Marsh, 1977-81.*

	Ducklings Marked at GRM						Ducklings Marked Off GRM But Within 25 Miles						
	No. Marked			No. Recaptured at GRM			No. Marked			No. Recaptured at GRM			Total No.
Year	Nasal Saddled	Web Tagged	Total	Nasal Saddled	Web Tagged	Total	Nasal Saddled	Web Tagged	Total	Nasal Saddled	Web Tagged	Total	Trapped at GRM
1977	42	—	42	1	—	1	186	—	186	4	—	4	1,199
1978	0	—	0	—	—	—	67	—	67	0	—	0	1,065
1979	39	16	55	7	5	12	277	36	313	3	0	3	1,214
1980	47	16	63	1	0	1	61	2	63	0	0	0	328
1981	60	40	100	2	3	5	78	2	80	1	0	1	1,955
Total	188	72	260	11	8	19*	669	40	709	8	0	8	5,761

*Only 2 ducks marked as ducklings were recaptured the year following marking (both females).

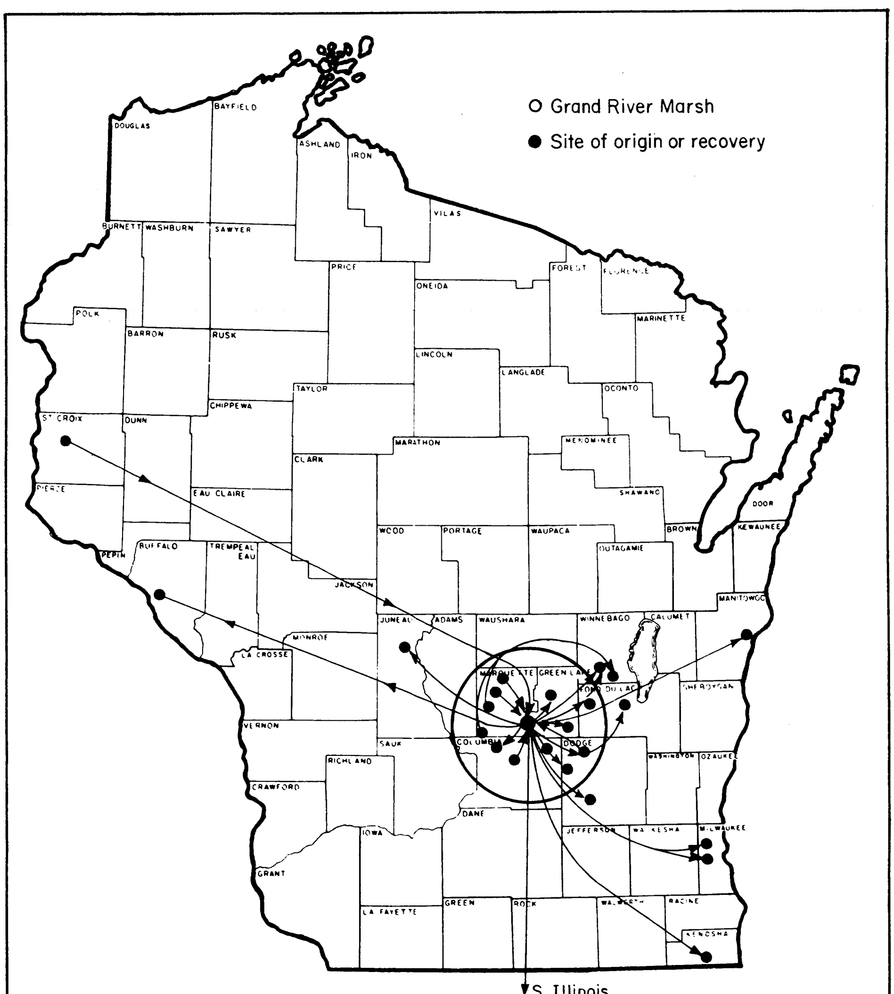


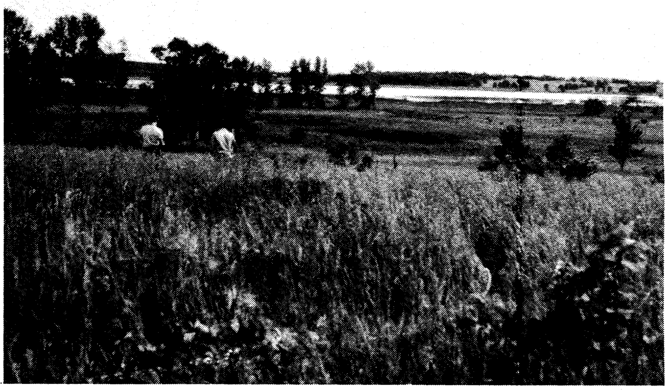
FIGURE 14. *Movements of mallard ducklings associated with Grand River Marsh prior to the opening day of hunting, 1977-81.*

pears hunting on GRM did not overharvest locals on their natal marsh. The GRM refuge was known to provide roosting sites for locals but most recoveries appeared to be from field feeding areas and did not come from the public hunting area on GRM (Fig. 17).

GRM did not concentrate local mallards hatched in the GREA. Only 8 GREA locals were recaptured prior to the season on GRM and none of the 709 locals banded and marked in the GREA were shot on GRM (Tables 30 and 33). Within an estimated harvest of over 1,300 immature mallards only 3 locals marked at GRM were reported shot there and none from those marked within the GREA.

Seventy-seven percent of the 125 direct recoveries of local mallards produced within the GREA occurred in Wisconsin. This rate was higher than the 56% March and Hunt (1978) reported for locals banded and recovered in Wisconsin during 1961-72. The 77% is not different ($P > 0.05$) from the 70% rate for direct recoveries of fall-banded immatures occurring in Wisconsin (Fig. 20) found in this study. Thirty-eight percent of the direct recoveries of locals in Wisconsin were within the GREA (Fig. 17). Most out-of-state recoveries occurred south of Wisconsin in the Mississippi Flyway; however, some locals were also recovered in Michigan and Minnesota.

Two of the 47 local wood ducks from GRM and 1 of the 152 from the GREA were recovered on GRM (Table 34). Wood duck recoveries from bandings



Blue-winged teal nest sites were often nearly 1 mile from the nearest water.

Trapping and banding indicated few locally raised ducklings were present in the large fall concentration of ducks on Grand River Marsh Wildlife Area.

on the GREA and GRM combined accounted for only 4% of the estimated wood duck harvest on GRM. Although only 9% of 199 banded wood ducks were recovered, 65% of these recoveries were in Wisconsin and 53% were within the GREA (Fig. 18). The implication is that most wood ducks are leaving prior to the Wisconsin hunting season, but those that stay are being heavily harvested.

Distribution of the Harvest and Fall Duck Movements

Mallard concentrations at GRM seemed to be a continually mixing group. Fall banded mallards moved off GRM in all directions between mid-August and 1 October (Fig. 19). During the same period, birds that were banded only days before in Wisconsin, Michigan, and Ontario moved onto GRM. Other birds also moved between GRM and banding sites at Collins Marsh Wildlife Area, Eldorado Marsh Wildlife Area, Mead Wildlife Area, Horicon National Wildlife Refuge, and Necedah National Wildlife Refuge.

Immature and adult mallards fall-banded on GRM were recovered at a higher rate ($P < 0.05$) on GRM than locals raised on GRM (Figs. 20, 21). The percent of all recoveries which occurred on GRM were 2%, 12% and 20%, respectively, for locals, immatures and adults. Mallards which initially arrived at GRM in August and September were more heavily shot on GRM than the locals hatched there, probably because most of the locals had already left the area prior to the opening of the hunting season. Immature females were recovered on the

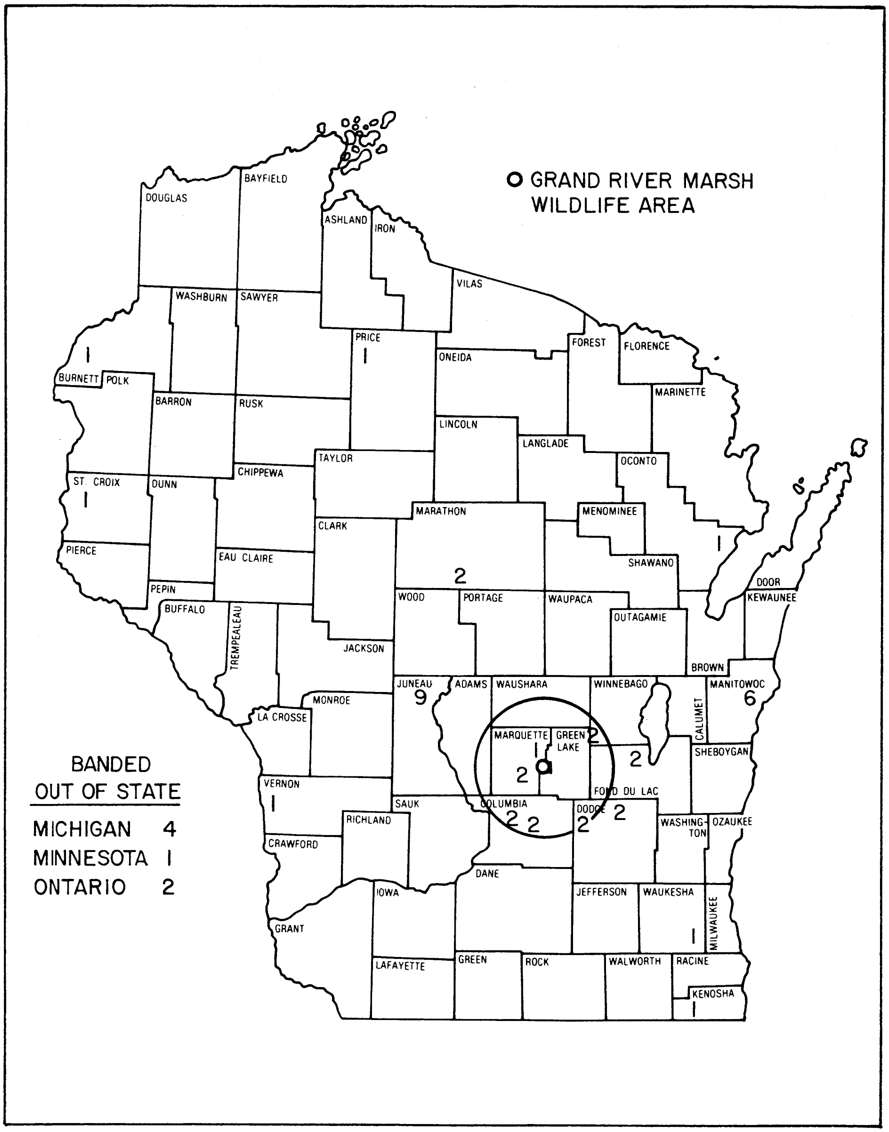


FIGURE 15. *Foreign banding sites of mallards retrapped in cannon nets at Grand River Marsh, 1977-81 (N=46).*

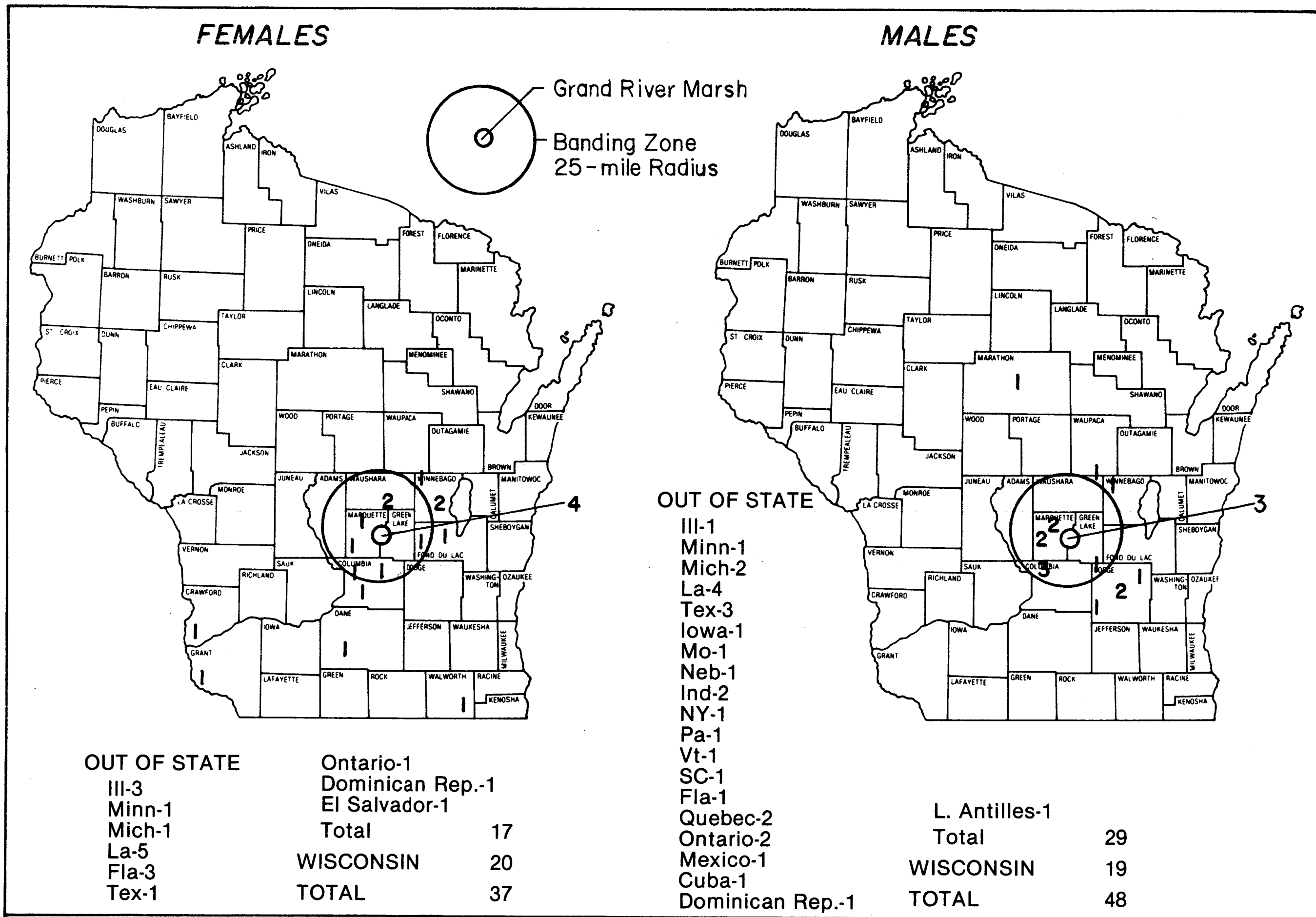


FIGURE 16. *Distribution of direct recoveries from blue-winged teal banded as flightless ducklings on the Grand River Extensive Area, 1977-81 (2,679 banded).*

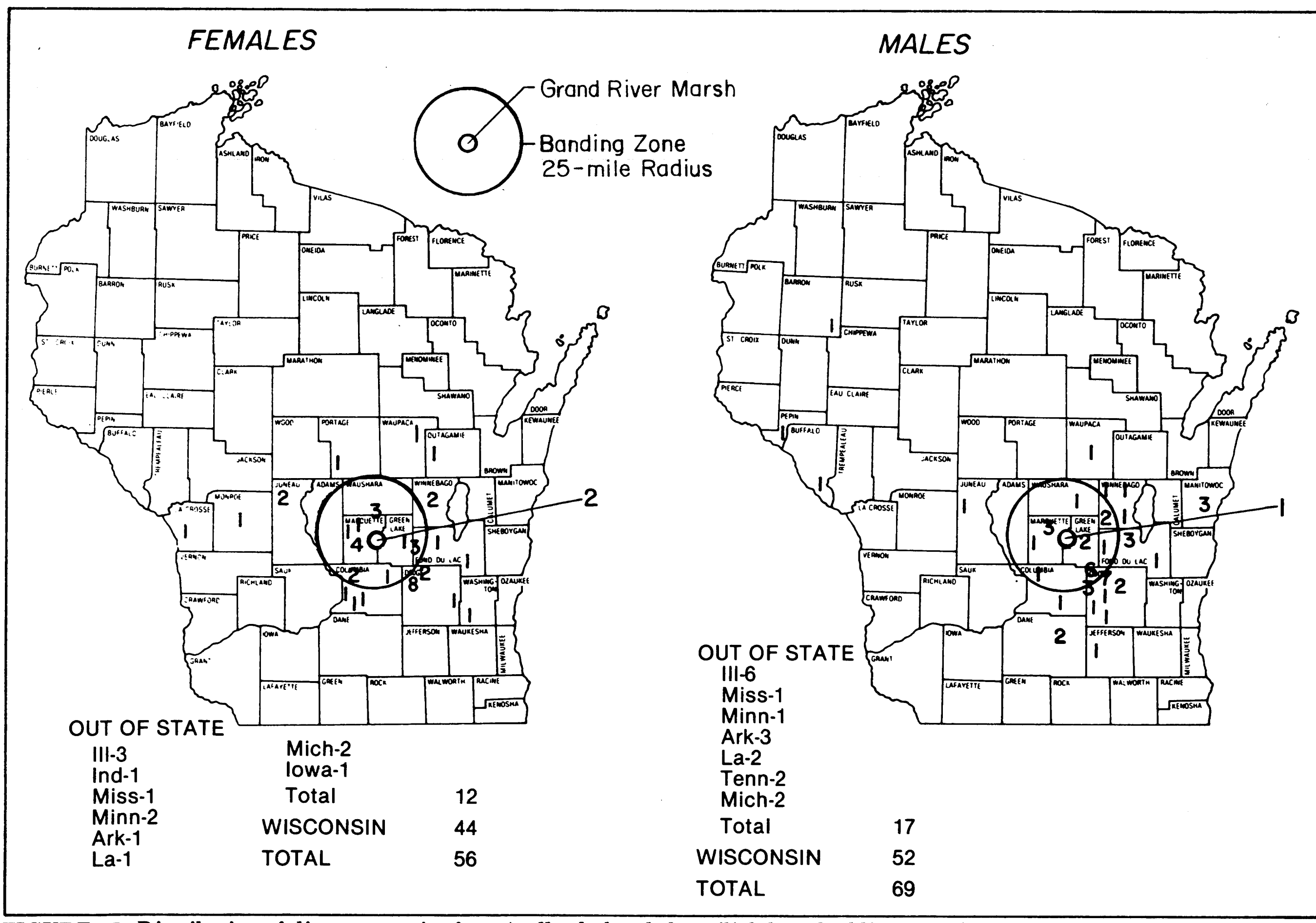


FIGURE 17. *Distribution of direct recoveries from mallards banded as flightless ducklings on the Grand River Extensive Area, 1977-81 (709 banded).*

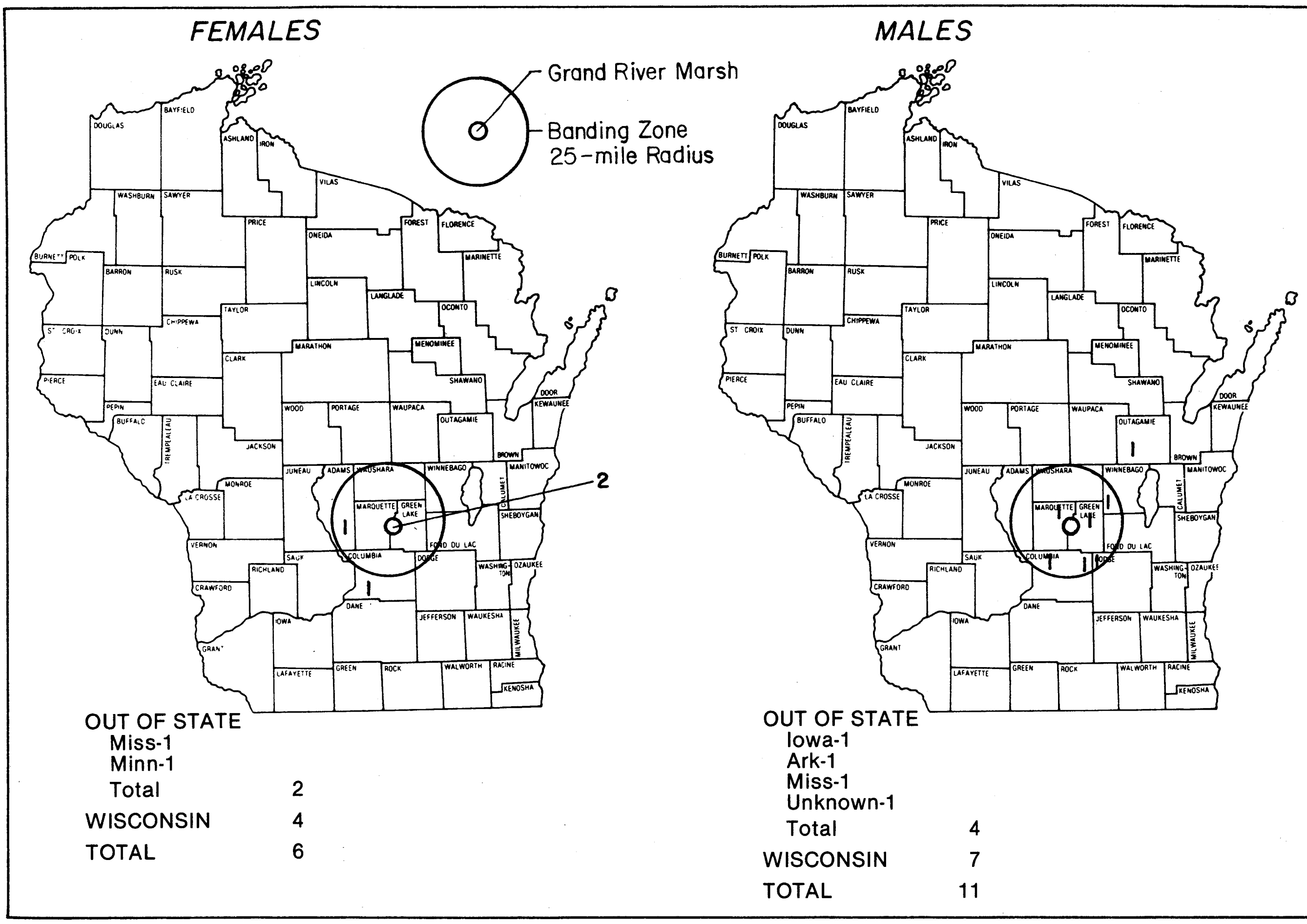
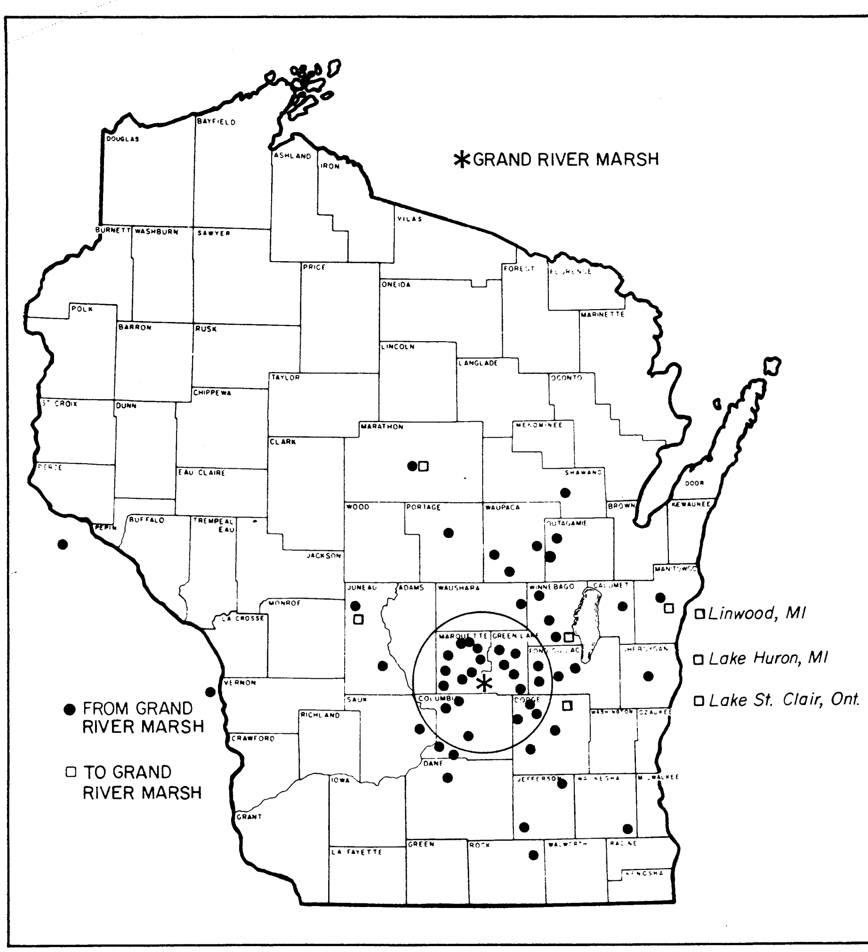


FIGURE 18. *Distribution of direct recoveries from wood ducks banded as flightless ducklings on the Grand River Extensive Area, 1977-81 (199 banded).*

FIGURE 19. *Movements of mallards associated with Grand River Marsh prior to opening day of the season. Represents mallards which were banded between 18 August and 14 September at Grand River Marsh 1977-81 (5,164) plus those banded elsewhere and trapped at Grand River Marsh.*



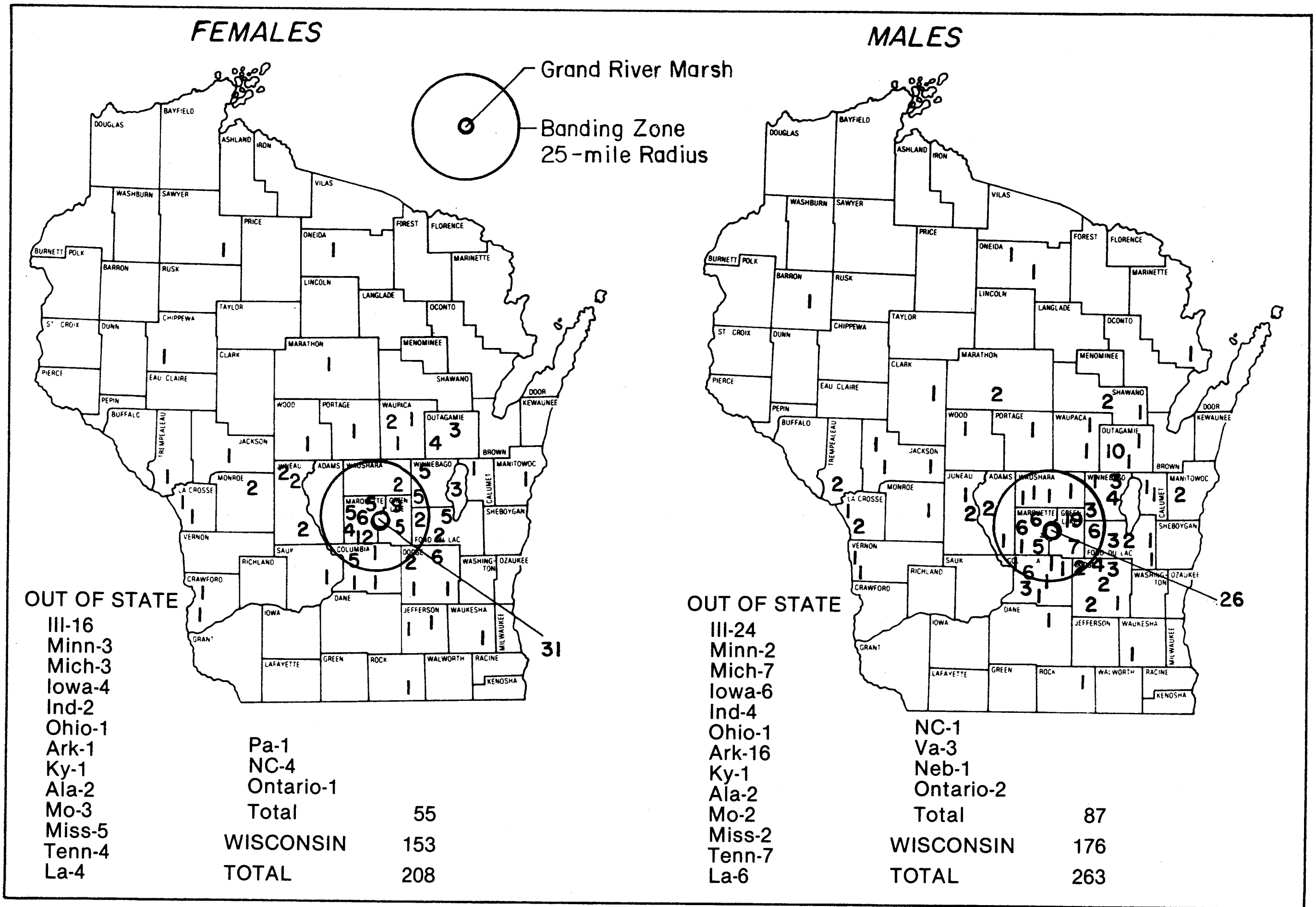


FIGURE 20. *Distribution of direct recoveries from immature mallards banded between 18 August and 14 September at Grand River Marsh, 1977-81 (3,648).*

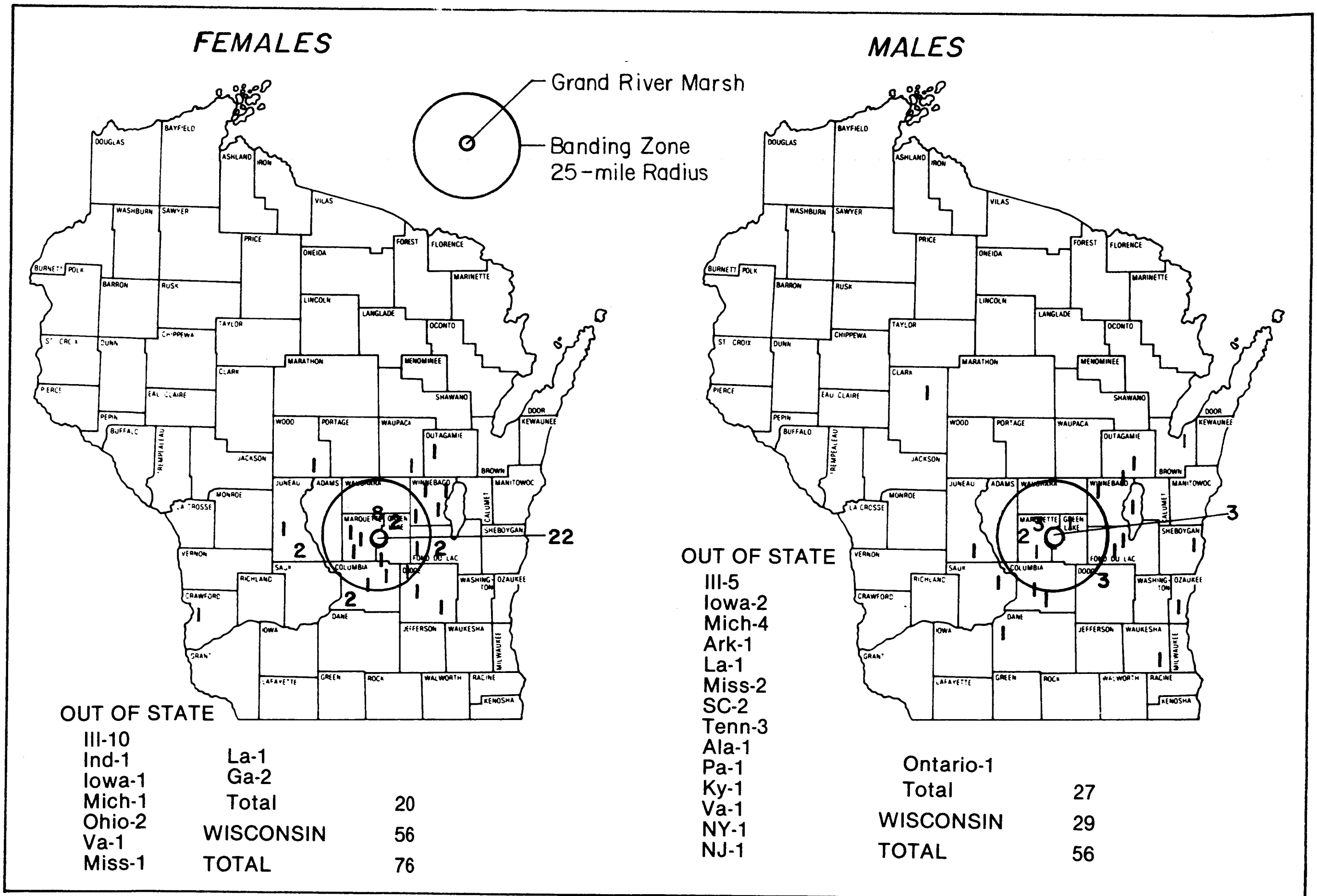


FIGURE 21. *Distribution of direct recoveries from adult mallards banded between 18 August and 14 September at Grand River Marsh, 1977-81 (1,460 banded).*

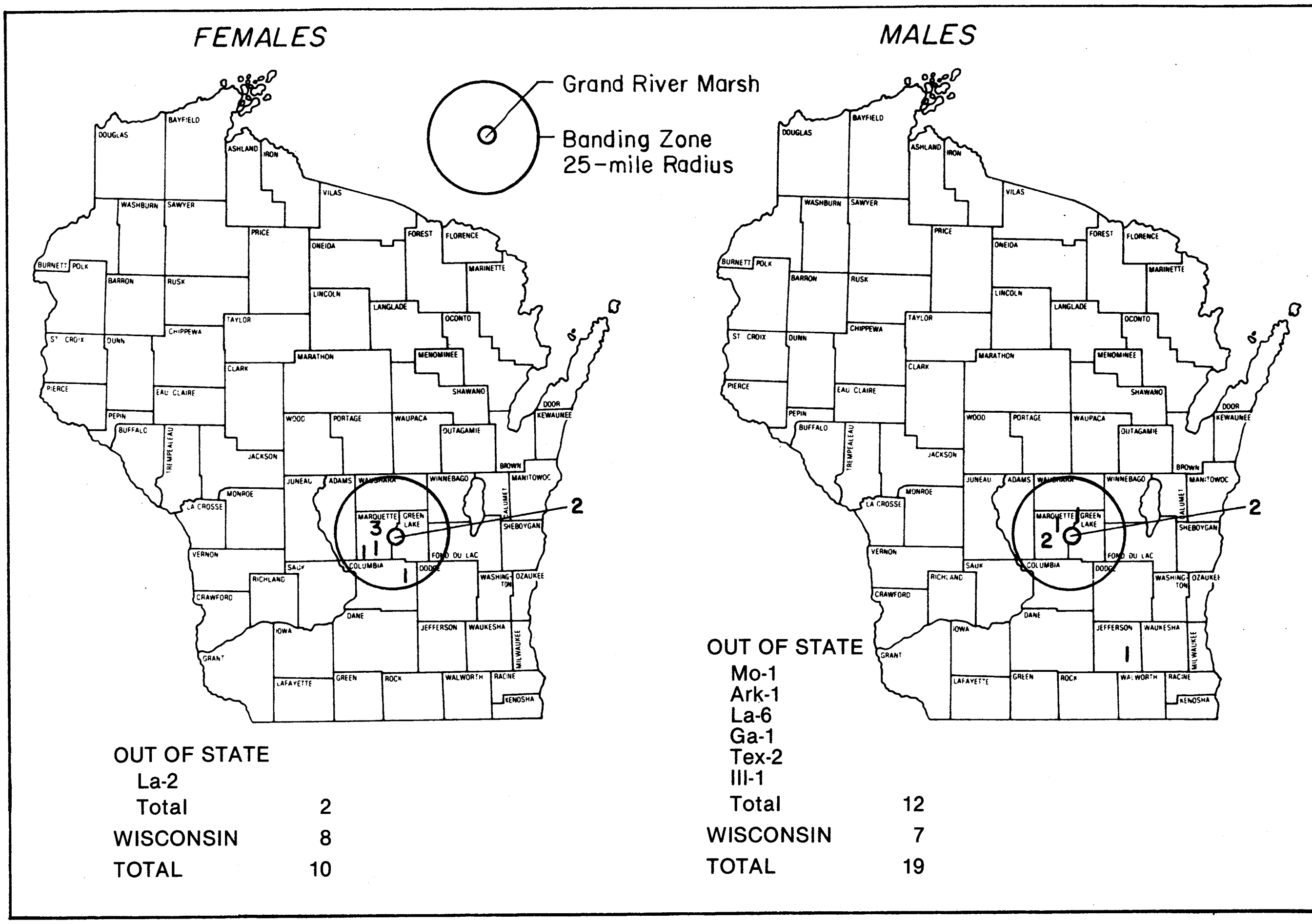


FIGURE 22. *Distribution of direct recoveries from wood ducks banded as adults and flying young on the Grand River Extensive Area, 1977-81 (448 banded).*

GREA at a higher rate than were immature males (45% vs. 31%):(P < 0.05). A higher proportion of immature females (74%) than immature males (66%) were also recovered in Wisconsin; however, this difference was not significant (P > 0.05). March and Hunt (1978) also reported that female mallards of all age categories had a greater tendency than males of the same categories to be recovered within Wisconsin. For some reason, immature females appear to be more vulnerable to hunting in Wisconsin. The same condition was true of adult mallards, with females being recovered in higher proportions than males on GRM, the GREA and in Wisconsin. The dispersal of both age groups of mallards seems quite similar with no large concentrations of recoveries in any one spot with the exception of adult females. For adult females, GRM stands out as a recovery site. Twenty-nine percent of the adult females banded at GRM were recovered there as compared to 5% of the adult males. During the 5 years, a minimum of 13% of the adult females banded had not molted at the time of capture and may very likely have remained on GRM to molt. If so, a good proportion of the adult females would have only recently gained flight by the time the hunting season opened or shortly thereafter. The stress of molt and reproduction may have caused them to spend more time feeding in the marsh or in nearby fields prior to migration to rebuild weight losses, making them more vulnerable to shooting locally.

The proportions of direct recoveries from GRM banded mallards (both sexes) within the GREA were 37% for immatures and 38% for adults vs. only 29% for locals (Figs. 17, 20, 21). A greater recovery of immature mallards near banding sites (49%) was reported by Hunt et al. (1958) for mallards banded on Horicon Marsh and shot within a 20-mile radius.

The proportions of total mallards recovered in Wisconsin, from preseason trapping at GRM were 70% and 64% for immatures and adults, respectively. Comparable percentages of 73% and 54% were found for immature and adult mallards banded statewide and recovered in Wisconsin in 1961-72 (March and Hunt 1978). In summary, the distribution of recoveries from preseason banded mallards at GRM (1977-81) seems quite similar to previous findings for preseason mallards banded statewide, with the exception of adult females. GRM preseason banded adult females were recovered at a much higher rate in the vicinity of the banding site than adult females in previous studies.

Only 29 recoveries were reported from 448 wood ducks banded preseason at GRM (Fig. 22). Although the sample of recoveries is small, 52% of all recoveries occurred in Wisconsin with 38% recovered within the GREA plus 14% on GRM. Folley (1978) found that 48% of Wisconsin banded wood ducks were recovered in-state. Ninety-three percent of the 29 Wisconsin recoveries from wood ducks banded on the GREA occurred on the GREA indicating little movement about the state and heavy harvest near the banding site.

Fall Staging

GRM is a major fall mallard concentration site with duck numbers reaching 20,000 or more in some years. Recaptures of previously marked mallards were few in number and indicate that few birds return to the area year

TABLE 31. *Blue-winged teal marked on Grand River Marsh and within 25 miles of the marsh and shot on Grand River Marsh, 1977-81.*

	No. Marked							No. Shot**		Est. Kill
	Adult		Immature		Local*					
Year	Male	Female	Male	Female	Male	Female	Total	Same Year as Marked	After One Year	on GRM
Marked on GRM										
1977	0	5	16	14	44	46	125	1 LF, 1 LM	0	184
1978	0	0	0	0	0	0	0	0	0	387
1979	60	65	0	0	171	145	441	1 LF	0	51
1980	188	115	0	0	179	136	618	1 LM, 3 AF	1 LF	407
1981	121	129	115	103	301	277	1,046	1 LF, 1 AF	0	139
Total	369	314	131	117	695	604	2,230	9	1	1,168
Marked within 25 miles of GRM										
1977	4	12	43	58	192	148	457	1 LF	0	184
1978	2	1	13	7	98	124	245	0	0	387
1979	6	16	0	0	227	242	491	0	0	51
1980	9	18	0	0	87	83	197	1 LM	0	407
1981	4	2	3	1	96	83	189	0	0	139
Total	25	49	59	66	700	680	1,579	2	0	1,168

*Includes nasal-saddled and web-tagged ducklings.
**LM = local male, LF = local female, AF = adult female.

TABLE 32. *Mallards marked and shot on Grand River Marsh, 1977-81.*

	Adult		Immature		Local					
Year/Status	Male	Female	Male	Female	Male Nasal Saddled	Female Nasal Saddled	Unknown Web Tagged	Total	Total Marked	Estimated Mallard Kill on GRM**
No. marked										
1977	106	284	316	292	18	24	—	42	1,040	565
1978	115	136	305	387	0	0	—	0	943	452
1979	99	75	442	493	18	21	16	55	1,164	719
1980	15	84	143	92	24	23	16	63	397	1,368
1981	257	335	578	600	29	31	40	100	1,870	985
Total	592	914	1,784	1,864	89	99	72	260	5,414	4,089
No. shot										
1977-81	3	22	26	31	1	2	0	3	85(2.1)*	
Percent shot										
1977-81	0.5	2.4	1.4	1.7	1.1	2.0	0	1.2	1.5	

*Percent of mallard kill at GRM (1977-81) banded at GRM.
**Marked and unmarked birds.

TABLE 33. *Mallard ducklings marked within 25 miles of Grand River Marsh and shot on Grand River Marsh, 1977-81.*

	No. Marked					
Year	Male Nasal Saddled	Female Nasal Saddled	Unknown Web Tagged	Total	No. Shot on GRM	Estimated Kill of Immature Mallards on GRM
1977	97	89	0	186	0	189
1978	19	48	0	67	0	130
1979	136	141	36	313	0	296
1980	27	34	2	63	0	513
1981	42	36	2	80	0	227
Total	321	348	40	709	0	1,355

TABLE 34. *Wood ducks marked on Grand River Marsh and within 25 miles of the Marsh and shot on Grand River Marsh, 1977-81.*

	No. Marked*							No. Shot**			
	Adult		Immature		Local						
Year	Male	Female	Male	Female	Male	Female	Total	Same Year as Marked	After One Year	Total	Est. Kill on GRM
Marked on GRM											
1977	9	13	2	1	1	3	29	1 AM	0	1	69
1978	119	8	26	13	0	0	166	0	0	0	47
1979	12	0	2	1	1	3	19	1 LF	1 AM	2	10
1980	14	4	0	0	7	6	31	1 AF	0	1	23
1981	58	16	6	5	8	18	111	1 LF, 1 AM	1 LF	4	33
Total	212	41	36	20	17	30	356	5	2	7	182
Marked within 25 miles of GRM.											
1977	15	9	30	18	3	8	83	0	0		69
1978	4	4	4	8	30	8	58	0	0		47
1979	14	2	0	0	35	19	70	0	0		10
1980	16	7	0	0	17	23	63	0	0		23
1981	7	1	0	0	6	3	17	0	1 LF		33
Total	56	23	34	26	91	61	291	0	1		182

*Leg bands only.
**LM = local male, LF = local female duckling, AM = adult male, AF = adult female, IF = immature female, IM = immature male.

TABLE 35. *Summary of recaptures of previously banded adult and immature mallards from fall preseason concentrations (1 Aug - 20 Sep) on Grand River Marsh, 1971-81.**

		No. Retrapped at GRM Originally Banded at GRM			No. Retrapped at GRM Originally Marked Elsewhere				
						U.S.			Total No. Mallards
Year	No. Banded	Same Year as Marked	1 Year Earlier	1+ Years Earlier	Wis.	Outside Wis.	Canada	Total No. Mallards Trapped at GRM	Retrapped 1+ Years After Banding at GRM
1971**	514	2	0	0	1	1	0	518	—
1974	846	64	0	0	1	2	0	913	0
1975	726	55	2	0	1	1	0	785	2
1976	545	61	5	0	2	0	0	613	5
1977	991	196	7	0	10	1	1	1,206	7
1978	943	112	4	0	2	4	1	1,066	4
1979	1,088	124	0	1	3	3	3	1,222	1
1980	322	0	1	4	0	0	2	329	5
1981	1,767	175	1	6	11	4	1	1,965	7
Total	7,742	789	20	11	31	16	8	8,617	31

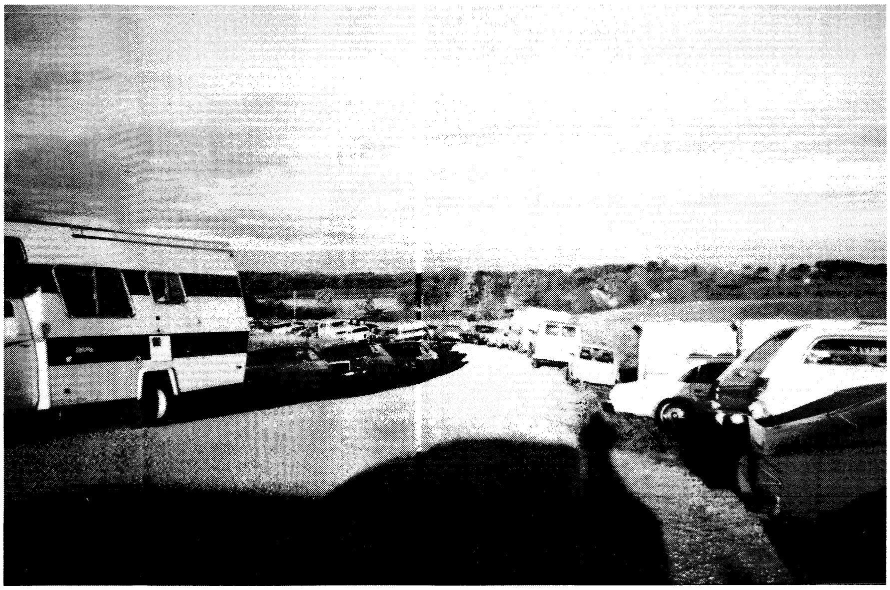
*Does not include recaptures of mallards banded as flightless ducklings.
**No mallards banded at GRM prior to 1971 or during 1972 and 1973.

after year. A total of 8,617 mallards was trapped on GRM during the period 1971-81, yet only 31 were known to return to the marsh after the initial year of banding (Table 35). Only 10 were known to return more than 1 year after banding. This indicates buildups of mallards on GRM probably had little to do with their returning to the area as a traditional fall concentration site. More likely, the birds were reacting to the available food and protection provided by the 3,000-acre undisturbed refuge area on GRM and the surrounding food supplies in grain fields. Recaptures totalled 84; 36% were from Grand River, 36% were from other preseason banding sites in Wisconsin, 19% were from other states, and 10% were from Canada. Again, this illustrates the mix of birds on the GRM but returns are not adjusted by the proportions banded at various points of origin. These recaptures do not, however, necessarily indicate the origin of these birds since the majority of all foreign recoveries were also marked during fall migration as both immatures and adults.

Duck Hunter Use Characteristics

An estimated 6,800 hunters/year hunted ducks on GRM, with a maximum of 9,000 in 1978. More than 4,000 hunters/year were checked and interviewed (Table 36). Car counts and interviews indicated an average of 2 hunters/car/trip. An average of 63% of the hunters hunted ducks during the morning hours only, 24% during afternoons only, and 12% spent all day hunting ducks. Lower Canada goose harvest quotas, uncertain marsh conditions following the drawdown, and a general decrease in the number of hunters afield may have reduced hunter numbers after 1979. Higher gasoline prices may have increased the number of hunters making a full day out of their trip and taking less trips during 1980-81.

The estimated number of hunters pursuing waterfowl, including geese, averaged over 11,000/year, peaking at nearly 17,000 in 1978. A reduction of Canada goose harvest tags from 3/year in 1977 to 1/year by 1980 and 1981 probably was a principal cause of the decline in overall hunter numbers.



Grand River Marsh Wildlife Area attracts large numbers of waterfowl hunters.

The gauges of guns used to hunt waterfowl at GRM (Table 37) changed over the period studied in relation to increasingly stringent steel shot requirements (Append. E). It is evident that hunters switched to the use of more 10- and 20-gauge guns during 1977-79 to avoid the use of steel shot. Several reasons were given for avoiding steel shot, with these three being the major complaints: (1) cost of steel shot, (2) lack of confidence in the killing power of steel, and (3) fear of damage to older or favorite guns. When the steel shot rules were dropped in 1980, hunter preference for 12-gauge guns soon re-emerged as their use jumped from 73% to 87%. In 1981, when steel shot became mandatory in all gauges, the percent of hunters using the 12-gauge gun increased again to 93%. The high cost of 10-gauge steel shot, the unavailability of steel in 16-gauge, and the short supply of 20-gauge steel ammunition all played a part in the return to predominantly 12-gauge guns.

Hunting pressure on GRM was heaviest in the first week of the season with an average of 30% of all hunter trips occurring during that period (Table 42). The opening day and the second opening day during years of split seasons each averaged about 7% of the total annual hunting pressure. After the second opening, pressure dropped drastically, spreading 63% of the hunter trips over the remainder of the season (38-43 days).

Daily hunting pressure averaged 489 duck hunters on the opening day of the duck season during 1977-81 (Table 38). Second opening days during split seasons were equally crowded with an average of 512 duck hunters using the approximately 1,100 acres of wet marsh accessible to duck hunters (2 acres/hunter). Weekends, excluding opening days, averaged 270 hunters/day, while normal weekdays averaged 106 hunters/day.

Duck Harvest Estimates

The estimated annual retrieved harvest on the GRM averaged 2,103 ducks (Table 39) with a peak of 3,394 ducks in 1980. The two major breeding species at Grand River, mallards and blue-winged teal, averaged 818 and 233 in the annual harvest, respectively. The age ratio in the mallard harvest at GRM averaged 0.5 young/adult. This age ratio is low compared to the 1961-75 average age ratio in the Wisconsin harvest of 4.0 young/adult (Martin and Carney 1977). The main cause of this difference appears to be the presence of large numbers of adult females which averaged 34% of the GRM mallard harvest estimate in 1977-81.

The percent of adult females in the total Wisconsin harvest for the same period averaged 15% (Sorenson et al. 1982). Although use of the point system for determining bag limits (Append. C) with high point values for hen mallards (70-100 points each) is designed to protect this cohort, it apparently was not as effective as expected. Few hunters appear to be selectively shooting drakes. Only during the opening week was there much opportunity to be selective. The number of ducks per hunter averaged only 1.0/hunter on opening day and 0.3/hunter during the total season (1977-81). Few hunters apparently passed up the opportunity to shoot at any duck which came within range.

The age ratio of the blue-winged teal harvest at Grand River averaged 1.2 young/adult. Like the mallard bag, adult female bluewings averaged over 30% of the bag and reached 46% of the bag in 1977. Again, it appears the attraction of the area for adult females greatly affects the observed young per adult ratio in the harvest. Therefore, care must be taken when examining harvest age ratios as an index to annual production on known molting areas such as GRM.

The species composition of the harvest at Grand River is presented in Table 40. During normal years, 22-39% of the annual bag was mallards. The late reflooding of the marsh following the summer drawdown in 1979 reduced early season hunting opportunity and resulted in mallards making up a larger proportion of the harvest (62%).

During seasons with normal water conditions and opening dates near 1 October (Append. E), the bag was comprised of 15-19% blue-winged teal. Late flooding caused a decline in bluewings in the harvest in 1979 and a late (4 Oct) opening in 1981 had the same effect, as most bluewings had already left the area.

Green-winged teal and wigeon made up over 20% of the bag in some years. The other species known to make up at least 5% of the bag were wood duck, pintail, gadwall and ring-necked duck. In 1978, wigeon made up a larger percent of the harvest than mallards (24%). Ring-necked ducks made up an unusually high percent of the bag in 1980 (16%).

TABLE 36. *Duck hunter statistics from 1977-81 bag checks at Grand River Marsh.*

Year	Hunters Checked	Hunters/ Car	Percent Hunting Morn.	Aft.	All Day	Est. No. Duck Hunters	Est. No. Hunting Ducks, Geese, or Both
1977	6,721	2.0	68	23	9	8,697	14,994
1978	5,367	2.0	71	22	6	9,062	16,640
1979	2,119	2.0	62	30	8	4,164*	7,017*
1980	3,722	1.9	60	25	14	6,859	8,574
1981	3,147	2.0	53	22	25	5,563	8,032
Avg.	4,215	2.0	63	24	12	6,869	11,051

*Drawdown of marsh for first half of the waterfowl season made area less attractive to ducks and hunters.

TABLE 37. *Gauges of shotguns used for waterfowl hunting at Grand River Marsh, 1977-81.*

Year	No. Hunters	Hunters' Gun Use (%) 10	12	16	20	410	28	Muzzle Loader
1977*	6,721	6	75	4	14	tr[3]	tr	0
1978*	5,367	10	72	4	14	tr	0	tr
1979**	2,119	11	73	3	13	tr	0	0
1980[1]	3,722	5	87	2	7	tr	0	0
1981[2]	3,147	3	93	0	4	0	0	0

*Steel shot required on wetlands in 12 gauge only.
**Steel shot required on all hunting areas (marsh and uplands), in 12 gauge only.
[1]Steel shot requirements dropped (lead legal on all areas, all gauges).
[2]Steel shot required on all hunting areas with all gauges.
[3]tr = trace (< 1%).

TABLE 38. *Daily duck hunter numbers on Grand River Marsh, 1977-81.*

Year	Opening Day	2nd Opening Day	Weekend Days* (mean)	Week Days** (mean)
1977	519 (Sat)	607 (Sat)	302	122
1978	651 (Sat)	561 (Sat)	339	132
1979	89 (Mon)	240 (Sat)	155	68
1980	258 (Mon)	—	256	85
1981	529 (Sun)	369 (Sat)	184	84
Mean[1]	489	512	270	106

*Excludes opening weekend days.
**Excludes openings on week days.
[1]Excludes 1979, main flowage drawdown until late October.

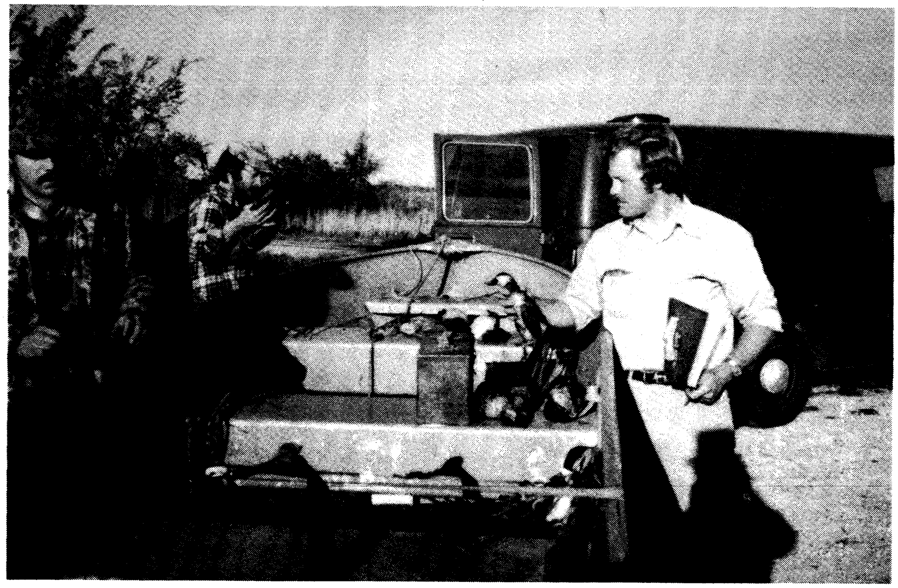
TABLE 39. *Harvest statistics from Grand River Marsh, 1977-81.*

Year	Ducks Checked	Ducks/Ducks Hunter	Total Est. Duck Harvest	Mallard Harvest Est. No.	Age Ratio (yg/ad)	Percent Ad. Females	Blue-winged Teal Harvest Est. No.	Age Ratio (yg/ad)	Percent Ad. Females
1977	995	0.2	1,488	565	0.5	41	184	0.8	46
1978	1,193	0.2	2,049	452	0.4	41	387	1.5	31
1979*	414	0.3	1,092	719	0.7	25	51	1.9	13
1980	2,113	0.5	3,394	1,368	0.6	27	407	1.1	31
1981	1,087	0.4	2,491	985	0.3	38	137	0.9	44
Mean	1,160	0.3	2,103	818	0.5	34	233	1.2	33

*Due to a summer drawdown, little duck kill occurred prior to 20 October when water levels reached normal fall levels.

The total harvest on GRM averaged 2,103 (Table 41). The reported unretrieved kill (cripples) averaged over 26% of the total kill and reached a high of 32% in 1981. The estimates of reported unretrieved kill are biased by hunter response. Further discussion of crippling rates will be pursued in succeeding sections of this report.

During years of normal water conditions, 25% of the annual duck harvest occurred on opening day (Table 42). An average of 61% of the harvest was taken the first week with a high of 67% reported in 1978. In years with split seasons, as much as 76% of the annual harvest had taken place by the end of the second opening day (13-17 Oct).



Of 1,560 ducklings marked within 25 miles of Grand River Marsh, only 9 were harvested on Grand River Marsh.

Hunting Season Recovery of Ducks Associated With Grand River Marsh

Direct recovery rates are used here as an index to shooting pressure on the age and sex cohorts of mallards, blue-winged teal, and wood ducks (Tables 43-45).

Mallard. Direct recovery rates indicate that young mallards banded at GRM are shot at a higher rate than adults; however, differences ($P < 0.05$) generally were detected only for the 1977-81 totals (Table 43). Total direct recovery rates for immature males and local males were both higher than the rate for adult males ($P < 0.01$). No differences between immature male and local male total direct recovery rates were detected ($P > 0.05$). The only detectable difference in total direct recovery rates of females was between adult female and local female rates ($P < 0.01$).

Differences in direct recovery rates within years were only detectable in 1980 and 1981. In 1980, the direct recovery rate of local males (22%) was greater than that of the immature males (5%) at $P < 0.01$. In 1981, local female and male recovery rates were higher than rates for adults at $P < 0.05$. In 1981, the direct recovery rate of immature males was higher than either adult rate ($P < 0.05$). No differences were detected between recovery rates of local males and local females ($P > 0.05$). There was only one case of a difference between yearly direct recovery rates within an age-sex category. The immature male direct recovery rate of 5% for 1980 was different ($P < 0.01$) than the rates for all other years.

In general, direct recovery rates for GRM local mallards were higher than those for the Great Lakes states for 1966-71, which were 8-17% for local males and 8-14% for local females (Anderson 1975). Detecting statistical differences in direct recovery rates for a single banding area is, in most cases, precluded by small sample sizes of banded birds and recoveries. Further expansion of direct recovery rates to harvest rates requires the use of band reporting rates which are unknown in the case of GRM and surely would be biased by our intensive bag checks.

Blue-winged teal. Only in 1979-81 were there enough blue-winged teal adults bait-trapped on GRM to get comparisons of direct recovery rates between adults and locals (Table 44). Annual direct recovery rates were not significantly different between adult females and local females in 1979-81 or for the total overall recovery rate ($P > 0.05$). The local male direct recovery rate was significantly higher than that of adult males during 1980 and for the total overall recovery rate for 1977-81 ($P < 0.05$). It appears that local males, local females and

TABLE 40. *Percent species composition of ducks bagged at Grand River Marsh, 1977-81.*

Species	Percent of Total Bag				
	1977	1978	1979*	1980	1981
Mallard	37	22	62	39	37
Blue-winged teal	15	19	6	15	6
Green-winged teal	22	10	6	9	11
American wigeon	5	24	7	4	17
Wood duck	5	2	1	1	1
American black duck	1	1	4	2	2
Common pintail	2	2	3	6	5
Northern shoveler	4	3	4	3	2
Gadwall	5	7	5	3	6
Scaup	tr	2	tr	tr	2
Redhead	tr	1	1	1	2
Ring-necked duck	3	5	3	16	4
Goldeneye	0	tr	tr	tr	tr
Bufflehead	tr	1	tr	tr	1
Canvasback	tr	tr	1	1	tr
Ruddy	1	tr	0	tr	tr
Scoters	tr	0	0	0	0
Hooded merganser	0	1	1	0	1
Other mergansers	tr	0	0	tr	0
Number ducks checked	995	1,193	414	2,113	1,087

*Marsh drawn down, over 80% of the duck kill occurred after 20 October as water levels increased making excellent feeding in moist soil plants that were flooded.

adult females receive nearly equal gunning pressure while adult males are being shot at a lower rate. The high proportion of adult females in the bag at GRM agrees with the higher direct recovery rate for adult females. There also were detectable yearly differences within the local female and local male age-sex categories. There were significant differences between local female direct recovery rates for 1977 and 1978, 1978 and 1979, 1979 and 1980, and 1977 and 1979 ($P < 0.05$). There were significant differences between local male direct recovery rates for 1977 and 1978, 1977 and 1979, and 1977 and 1981 ($P < 0.05$). Apparently measurable differences in shooting pressure on locals were occurring between years. Since only 11% of the local female recoveries and 6% of the local male recoveries from GREA came from GRM, little of the difference could be attributed to hunting pressure or season dates on GRM itself.

Wood Duck. Wood duck direct recovery rates are based on small sample sizes (Table 45) and should be viewed accordingly. Local males appear to be shot at a higher rate than the other 2 male cohorts. However, as expected, no significant difference was detected at $P > 0.05$.

Crippling Rates

Minimum estimates of crippling loss (number lost/number retrieved plus number lost) occurring under varied steel and lead shot rules were derived from the hunter interview data (Tables 46-48). The effect of shot size on crippling rates was not examined during this study.

Annual duck crippling losses averaged 27% at GRM (Table 46). Reported crippling losses on Wisconsin public hunting areas averaged 21% during 1949-52 (Jahn and Hunt 1964). Differences in hunter behavior and the degree of difficulty in retrieving downed birds due to wetland vegetation makes direct yearly comparisons difficult. Crippling losses of ducks for 1977, 1978 and 1980 were not different ($P > 0.05$) even though steel shot in 12-gauge guns, (used by 75% of the hunters) was required in 1977 and 1978, but lead was allowed and used in all areas in 1980. In fact crippling was greater ($P < 0.05$) in 1980, when there were no steel requirements, than in 1979 when steel was required in 12-gauge guns. During 1981, duck crippling was higher than all previous years ($P < 0.05$). This was the first year all use of lead shot was prohibited.

Annual crippling losses of geese at GRM averaged 22% during 1977-81. During 1977-79, the rate of crippling

TABLE 41. *Estimated duck kill by species on Grand River Marsh, 1977-81.**

Species	1977	1978	1979	1980	1981	Average
Mallard	565	452	719	1,368	985	818
American black duck	13	9	50	71	70	43
Blue-winged teal	184	387	51	407	139	234
Green-winged teal	315	197	54	275	256	219
American wigeon	73	526	63	129	378	234
Northern shoveler	61	47	6	93	58	53
Gadwall	82	153	59	104	145	109
Wood duck	69	47	10	23	33	36
Common pintail	32	36	20	214	116	84
Ring-necked duck	49	83	32	594	106	173
Redhead	7	23	7	39	53	26
Other	38	89	21	77	152	75
Total	2,053	2,602	1,441	4,581	3,686	2,873
Retrieved	1,488	2,049	1,092	3,394	2,491	2,103
Unretrieved**	565	553	349	1,187	1,195	770
% Unretrieved	28	21	24	26	32	26

*Estimates of duck kill were calculated by expanding daily car counts by hunters per car, ducks per hunter, and the species composition from the daily bag check results.
**Reported knocked down but not retrieved.

TABLE 42. *Percent of the duck harvest and of hunter trips associated with certain periods of the hunting season at Grand River Marsh, 1977-81.*

Year	Opening Day	1st Week	2nd Opening Day	1st Week & 2nd Opening Day	1st & 2nd Opening Days	Remainder of Season After 2nd Opening Day
Duck Harvest						
1977	29	63	13	76	42	25
1978	33	67	8	75	41	25
1979*	3	14	1	15	4	85
1980**	19	53	—	—	—	47
1981	20	61	6	67	26	33
Mean	25[1]	61[1]	9[2]	72[2]	37[2]	28[2]
Hunter Trips						
1977	6	30	7	36	13	64
1978	7	28	6	34	14	66
1979*	2	17	6	20	8	80
1980**	6	29	—	—	—	—
1981	10	33	7	40	16	60
Avg.	7[1]	30[1]	7[2]	37[2]	14[2]	63[2]

*Marsh drawn down, little duck use and harvest until after 20 October.
**No split in duck season.
[1]1979 not included in mean calculations due to the drawdown.
[2]Only 1977, 1978 and 1981 included in mean calculation.

TABLE 43. *Direct recovery rates (%) of mallards associated with Grand River Marsh, 1977-1981.**

Year	Female			Male		
	Adult	Immature	Local	Adult	Immature	Local
1977	10 (284)**	13 (292)	16 (93)	8 (106)	15 (316)	16 (117)
1978	9 (136)	10 (387)	13 (48)	7 (115)	14 (305)	21 (19)
1979	7 (60)	11 (493)	13 (162)	10 (99)	17 (442)	16 (154)
1980	7 (70)	9 (92)	14 (57)	— (15)	5 (143)	22 (51)
1981	8 (308)	11 (600)	19 (36)	7 (267)	15 (578)	21 (42)
Total	9 (858)	11 (1,864)	14 (396)	9 (602)	15 (1,784)	18 (383)

*Locals banded as flightless young on Grand River Marsh and within 25 miles during July-August. Adults and immatures caught at Grand River Marsh 1 August-15 September in preseason cannon traps.
**Number banded.

TABLE 44. *Direct recovery rates (%) of blue-winged teal associated with Grand River Marsh, 1977-81.**

	Female		Male	
Year	Adult	Local	Adult	Local
1977	— (15)**	5 (219)	— (5)	8 (229)
1978	— (1)	6 (124)	— (2)	2 (98)
1979	1 (81)	1 (327)	2 (66)	4 (339)
1980	4 (133)	3 (179)	1 (197)	4 (226)
1981	4 (131)	5 (208)	2 (125)	3 (246)
Total	3 (361)	4 (1,057)	1 (395)	4 (1,138)

*Locals and immatures captured while nightlighting during July and August. Adults bait-trapped or caught on nests during May-June.
**Number banded.

TABLE 45. *Direct recovery rates (%) of wood ducks associated with Grand River Marsh, 1977-81.**

	Female			Male		
Year	Adult	Immature	Local	Adult	Immature	Local
1977-81	9(64)	9(46)	7(92)	6(268)	4(70)	10(108)

*Locals banded as flightless young on Grand River Marsh and within 25 miles during July-August. Adults and immatures caught at Grand River Marsh 1 August-15 September in preseason cannon traps.

TABLE 46. *Crippling rates of ducks and geese reported by hunters on Grand River Marsh, 1977-81.*

	Crippling Rates (%)		
Year	Ducks	Geese	Shot and Gauge Requirements*
1977	28[a-c] (995)**	18[a] (2,022)	12-gauge steel shot on marsh areas
1978	25[a-c] (1,193)	22[b] (1,549)	12-gauge steel shot on marsh areas
1979	24[b] (414)	26[c] (624)	12-gauge steel shot on marsh and uplands
1980	26[c] (2,113)	20[a,b] (803)	No steel shot requirements
1981	32[d] (1,087)	26[c] (685)	Steel shot required in all gauges and areas
Mean	27 (5,802)	22 (5,683)	

*Lead shot allowed in all gauges and areas not specified.
**Total birds bagged.
a-d Figures in the same column with same letters are not different (P > 0.05); X^2 test was used on original number of crippled per number bagged.

TABLE 47. *Crippling rates by gun gauge and type of shot as reported by hunters at Grand River Marsh, 1977-81.*

		Crippling Rates (%)			
Gauge	Shot Type	Ducks		Geese	
10	Lead	25[a]	(200)*	24[b,d]	(510)
	Steel	**	(24)	**	(46)
12	Lead	27[a]	(1,433)	22[b,d]	(537)
	Steel	28[a]	(3,294)	22[b,d]	(3,723)
16	Lead	24[a]	(145)	15[c]	(165)
20	Lead	26[a]	(510)	19[c,d]	(527)
	Steel	**	(14)	**	(307)
Total	Lead	26[1]	(2,288)	21[1]	(1,739)
	Steel	28	(3,332)	21	(4,076)

*Total birds bagged.
** < 50 birds bagged, no comparisons made.
a-d Figures in the same column with same letters are not different (P > 0.05); X^2 test on original numbers of reported crippled bagged.
1 Totals not different (P > 0.05); X^2 test on original numbers reported crippled and bagged.

increased each year ($P < 0.05$). In 1980, with no steel shot requirements and the heavy use of lead, the crippling rate was not different ($P > 0.05$) than either 1977 or 1978 which were under steel shot requirements (12 ga. guns). Goose crippling in 1981 was higher ($P < 0.05$) than in 1980 but not different ($P > 0.05$) from the 1979 rate.

Since annual crippling rates included data from hunters using different gauges of shotguns and lead or steel shot, no direct comparisons between lead and steel can or should be made using these annual rates. Comparisons by gauge of gun and type of shot are made in Table 47 for all years combined. The use of lead and steel in only 12-gauge guns provides the most appropriate comparison of lead and steel shot. Reported duck crippling by gauge revealed rates ranging from 25-28% with no differences ($P > 0.05$) among crippling rates for any gauge or shot type. Ten-gauge lead loads appear to cripple no less ducks than lead loads in 12-, 16- or 20-gauge guns. Crippling rates (1977-81) for 12-gauge loads in lead and steel of 27% and 28% respectively were not different ($P > 0.05$). Similarly, tests of 12-gauge lead and steel shot on ducks in Missouri indicated no differences in crippling (Humburg and Sheriff 1980). Further field tests of 12-gauge steel loads on 15 federal refuge and state wildlife management areas during 1973-75, indicated no differences in crippling between lead and steel 12-gauge loads (Kimball 1975). Crippling rates from GRM incorporating all gauges and calculated for lead vs. steel were 26% and 28%, respectively. These rates of duck crippling also were not different ($P > 0.05$).

Crippling rates for Canada geese varied by gauge from 15% to 24%. The only crippling rate that was different ($P < 0.05$) was the rate reported by users of 16-gauge lead loads (15%). Comparison of all hunters using lead vs. steel loads for geese indicated rates of 21% for each category.

Comparisons of 12-gauge shooters during 1977-81 revealed some interesting changes in crippling rates (Table 48). The reported crippling of ducks by 12-gauge shooters declined from 1977 to 1979 ($P < 0.05$). In 1980, shooters using lead in 12-gauge guns crippled ducks at a higher rate than those choosing steel shot ($P < 0.05$). In 1981, when steel shot was first required to be used by hunters shooting all gauges of guns, the rate of crippling by 12-gauge shooters increased to 32%, higher ($P < 0.05$) than all previous years. Approximately 20% of the hunters using guns other than 12-gauges during 1977-79, presumably to escape using steel shot, finally switched to 12-gauge in 1981. This put some hunters in the field with little experience with shooting steel shot and may explain the rise in the crippling rate to 32% by the same gauge category that had previously reported crippling rates of 23-29%.

In direct opposition to the situation for ducks, crippling of Canada geese by users of 12-gauge guns showed an increase ($P < 0.05$) over the 1977-79 period. In 1980, when hunters had a choice between lead and steel ammunition, those who used steel shot for geese, crippled geese at a lower ($P < 0.05$) rate than those returning to the use of lead. This also occurred for ducks. The reported crippling rates for geese were lower than those for ducks in nearly all cases. Other tests of 12-gauge loads for goose hunting found no differences (statistically) between crippling rates of lead and steel (Anderson and Roetker 1978).

In summary, regardless of shot type or gun gauges used, 24-30% of the duck kill and 18-26% of the goose kill were unretrieved. Ten-gauge lead loads did not reduce crippling in comparison to the 12-gauge lead or steel loads for either ducks or geese. A direct comparison of lead and steel, based on reported crippling rates by 12-gauge shooters in 1980, demonstrated no detectable difference ($P > 0.05$) in crippling rates between shot types.

TABLE 48. *Comparisons of lead and steel shot crippling rates on Grand River Marsh, 1977-81 (12 gauge only).*

		Crippling Rates (%)			
Year	Shot Type	Ducks		Geese	
1977	Steel	29[a]	(734)*	16[a]	(1,422)
1978	Steel	25[a-d]	(857)	23[b,d]	(1,115)
1979	Steel	23[b,c]	(325)	26[b,c]	(435)
1980	Steel	23[d]	(316)	14[a,d]	(134)
	Lead	27[a,c]	(1,433)	22[b]	(537)
1981	Steel	32[e]	(1,062)	27[c]	(617)
Mean	Steel	26	(3,294)	21	(3,723)

*Total birds bagged.

[a-e]Figures in the same column with the same letter are not different ($P > 0.05$); X^2 test was used on original number of crippled per number bagged.

SUMMARY AND FUTURE CONSIDERATIONS

BREEDING POPULATIONS ON PUBLIC LAKES AND WILDLIFE MANAGEMENT AREAS

Seven lakes and five state wildlife areas represented 3% of the landscape within the 2,500-mile^2 GREA and accommodated up to 14% of the mallards, 30% of the blue-winged teal and 21% of the other species breeding within the area. The GRM represented 0.4% of the area investigated and attracted up to 3% and 6% of the total study area population of mallards and blue-winged teal, respectively. Consequently, to have a significant impact on breeding populations of the entire GREA, a large proportion of the public lands would have to be affected by management practices in order to attract additional breeders. A doubling in breeding pairs on GRM would increase the populations on the GREA by a maximum of 3% for mallards and 6% for blue-winged teal. Put another way, it would require a 100% increase in breeding mallards on all studied public lands (12 areas) within the GREA to raise the breeding population on the total 2,500-mile^2 area by 10%.

Ideally, if present populations are to be maintained, management of private lands for duck production would be required. At best, our efforts on public lands in Wisconsin will provide for only a small portion of our waterfowl resource, unless present acreages are greatly increased. The other alternative to management of increased acreages of public or private lands is to use the limited funds available on the areas with the densest concentrations of breeders, which at present are the public wildlife management areas.

CARP REMOVAL AND DRAWDOWN

The complete drawdown of the main flowage on GRM for one growing season and the removal and exclusion of nearly all its carp greatly increased subsequent duck use. The regrowth of moist soil plants, emergent and submergent vegetation, and an increase in diversity of invertebrates increased the potential waterfowl feeding and cover areas on the main impoundment. Breeding pairs of both mallards and blue-winged teal doubled during the 2 years after treatment on the marsh, while populations of the same species on the total GREA were declining. During the two years before treatment of the main impoundment, brood rearing was concentrated almost exclusively on two smaller carp-free impoundments. After treatment nest placement expanded into more of the area surrounding the main impoundment, which included the most recently planted nesting cover. Observations indicated brood use also increased on the main impoundment following treatment.

NESTING COVER QUALITY AND RELATED NEST USE AND SUCCESS

A block of cover on the southwest corner of GRM was converted from grain and goose browse plantings into nesting cover (brome, timothy, alfalfa, clover mixtures) in 1975-78. These cover plots were little used by nesting ducks until 2-3 years after establishment. Lack of use during the first growing year was obviously the result of sparse cover. Response was still slow during succeeding years as cover conditions were improving, and it was not until 5-6 years after planting that the cover was generally utilized by bluewings and mallards. Blue-winged teal utilized nesting cover just as far from water as that used by mallards at GRM.

Comparing nest success among cover types was difficult where predation rates were high and overall nest success was low (8-29% at GRM). There were many instances where small numbers of active nests per cover type hampered finding statistical differences in nest success rates. As an extreme example, calculated nest success estimates of 37% (40 nests studied) and 13% (62 nests studied) for 2 major cover types in 1981 were not different ($P > 0.05$). When cover categories were pooled and sample sizes reached 80 or more nests, statistical differences of 13-20% were detectable between nest success rates. Large sample sizes, therefore, were required when testing for differences in nest success (Mayfield estimates) due to the inherent variability of survival rates of different nests. This in turn meant comparing only large acreages or very general cover types such as all planted cover or managed nesting cover.

The mean of cover readings at hatched nests was greater (3 of 5 years) than at nests destroyed by predators. Overall (1977-81) they were not different although the trend was toward better height-density readings at hatched nests. This trend was not due to nest initiation dates because hatched nests were not initiated later than nests destroyed by predators. Success rates were different among 6 ascending categories of vegetation density at the nest for only 2 of the 5 years studied. Increased success rates were not detected with increased cover density as measured when nests were found.

Nests were categorized by the height-density means of fields where they were located. Again, no pattern of increased nest success with increased vegetation densities was evident.

In conclusion, no deterrent effect against predation by cover "quality" could be documented within the range of cover height-density available on GRM in June. These height-densities are felt to be similar to much of the existing brome-alfalfa cover on other state wildlife areas in Wisconsin. However, the Wisconsin Department of Natural Resources is currently establishing stands of switchgrass on waterfowl management lands, which tend to have denser vegetation than those at Grand River Marsh (Petersen 1982, Bartelt and Vine 1982).

BROOD MORTALITY

Little brood mortality occurred between nest and water for observed radio-marked broods. Broods were able to travel up to 0.9 mile in 2-3 hours with little loss of ducklings. Other hens were known to nest farther from water but were not monitored with radios. This indicates that nesting cover can be established up to a mile from water without jeopardizing brood survival.

Estimates of duckling losses after reaching brood waters averaged 31% for mallard broods and 15% for blue-winged teal broods. These are the highest mortality rates yet reported in Wisconsin and are minimum estimates since the loss of total broods is not included. Correcting these figures for hens which lost entire broods, was difficult since radio-equipped hens were observed to leave broods for lengthy periods. These same hens, if observed loafing or feeding alone would have been assumed to have lost their entire broods, using traditional brood census methods.

Brood survival to flight stage may be the weakest component in estimating production for breeding duck populations. Results from this study indicate the only reliable method for deriving these estimates was from observations of marked broods. Our findings and those of Talent et al. (1983) point out a definite need for further investigations of brood mortality rates.

CONTRIBUTION OF LOCAL PRODUCTION

The estimated number of ducklings resulting from hatched nests on GRM ranged from 500 to 1,200 annually. Losses due to brood mortality of approximately 20% reduce this number to 400-960 fledglings. Of these, approximately 350-800 blue-winged teal and mallards were added to the fall flights. Of these, only 2-4 bluewings and 1-2 mallards were harvested on GRM and an additional 6-14 bluewings and 4-11 mallards were reported shot elsewhere in Wisconsin. Thus, large impoundments such as GRM appear better at providing fall hunting opportunity than at producing large numbers of ducklings. However, GRM does not appear to be the primary staging area for locally produced ducks and therefore does not act as a "sink" or shootout area for locally produced ducks. Fall concentrations of ducks are drawn from a wide geographic area and appear highly mobile even after arriving in the area.

HUNTING PRESSURE AND DUCK HARVEST

During the first week of the season, 30% of the hunting pressure at GRM occurs. Another 7% of the yearly pressure is concentrated on the second opening day in years with split seasons. The average number of hunters per day on opening day, opening week and the second opening day were 490, 255, and 440, respectively. Maximum use was 1 hunter/2 acres of wetland open to hunting. Severe crowding like this led to competitive high shooting ("skybusting") and confrontations over space and game. The typical answer from hunters asked about their crippling losses was "I knocked down a couple but they went over by some other guy, so I didn't look for them: he probably picked them up." For the remainder of season, only 1-2% of the season's hunting pressure occurred per day and fewer problems associated with crowding developed. The split season has introduced a second day with the same crowding and problems as the initial opening day.

The duck harvest was heaviest during the opening week. Opening-day hunters harvested 25% of the yearly bag at GRM and 60% of the ducks shot were harvested in the first week. The second opening day averaged only one-third the harvest of the first opening day.

It would seem that any increases in restrictive regulations should be aimed at the opening week. High-point values designed to protect mallard hens and other less plentiful species are not protecting these birds as much as originally thought. During opening week the average number of ducks per hunter per day equals one. Hunters were hunting in large groups — often 3 or more per boat or blind. They were not being selective and soon distributed the high-point birds among their party or other nearby hunters. Even then, few hunting parties reached the bag limit and those that did were replaced by the "excess" of hunters who already were out on the marsh.

A split season may have provided partial protection at best for locally produced mallards since 50% of the recoveries of local mallards marked on the study area and recovered there occurred after 11 October. It had been felt in the past that a split in the season would allow migrants to dilute the population of locals and reduce hunting pressure on them in Wisconsin. Seventy-seven percent of the locals recovered, however, were shot before they left Wisconsin. Trends in recovery rates in all years indicated higher pressure on locals than fall-banded birds, although statistical differences were not detected.

CRIPPLING LOSSES

Crippling losses of ducks on GRM ranged from 24-32% under all combinations of steel and lead shot regulations. In 1980 steel shot requirements were dropped by action of the state legislature. A direct comparison was then possible for 12-gauge users of lead vs. steel shot. Hunters that used 12-gauge guns (87% of the total hunters) reported a lower ($P < 0.05$) crippling rate for steel shot (23%) than for lead (27%).

However, the major problem was crippling itself, not the difference between shot types. A 23% unretrieved loss is just as unacceptable as 27%. Hunter crowding is a major cause of these losses at GRM as it promotes skybusting even among experienced hunters. The extremely high shooting pressure and hunter numbers kept birds at extreme ranges and caused hunters to try to fire the first shot before someone else flared the incoming birds. Ducks and especially geese were unretrieved because hunters feared following cripples through several other hunting groups' "territories". Another problem was the experience level of the hunters themselves. Hunters hunting public lands such as Grand River cannot become experienced waterfowl shots when they average only 0.5 duck/hunter/trip or 1 goose/year. Hunter proficiency must be improved to reduce today's unacceptable levels of crippling.

APPENDIX A: Scientific Names of Plants and Animals Cited

Birds

American bittern	*Botaurus lentiginosus*
American black duck	*Anas rubripes*
American coot	*Fulica americana*
American crow	*Corvus brachyrhynchos*
American wigeon	*Anas americana*
Black scoter	*Melanitta nigra*
Blue-winged teal	*Anas discors*
Bufflehead	*Bucephala albeola*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Common goldeneye	*Bucephala clangula*
Common pintail	*Anas acuta*
Gadwall	*Anas strepera*
Green-winged teal	*Anas crecca*
Hooded merganser	*Lophodytes cucullatus*
Lesser scaup	*Aythya affinis*
Mallard	*Anas platyrhynchos*
Northern shoveler	*Anas clypeata*
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Ruddy duck	*Oxyura jamaicensis*
Surf scoter	*Melanitta perspicillata*
White-winged scoter	*Melanitta fusca*
Wood duck	*Aix sponsa*

Fish

Carp	*Cyprinus carpio*

Reptiles

Fox snake	*Elaphe vulpina*

Mammals

American badger	*Taxidea taxus*
Franklin's ground squirrel	*Spermophilus franklini*
Virginia opossum	*Didelphis marsupialis*
Raccoon	*Procyon lotor*
Red fox	*Vulpes fulva*
Striped skunk	*Mephitis mephitis*
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*

Invertebrates

Snails	Gastropoda
Water fleas	Cladocera
Cyclops	Copepoda
Scuds	Amphipoda
Spiders	Arachnida
Stoneflies	Plecoptera
Mayflies	Ephemeroptera
Dragonflies	Odonata
True bugs	Hemiptera
Beetles	Coleoptera
Flies	Diptera

Plants

Alfalfa	*Medicago sativa*
Algae	Algae
Aster	Asteraceae
Bluegrass	*Poa* spp.
Clover	*Trifolium* spp.
Common arrowhead	*Sagittaria latifolia*
Common waterweed	*Elodea canadensis*
Coontail	*Ceratophyllum demersum*
Curly-leafed pondweed	*Potamogeton crispus*
Field goldenrod	*Solidago nemoralis*
Forked duckweed	*Lemna trisulca*
Great bladderwort	*Utricularia vulgaris*
Leafy pondweed	*Potamogeton foliosus*
Quackgrass	*Agropyron repens*
Reed canary grass	*Phalaris arundinacea*
River bullrush	*Scirpus fluviatilus*
Sago pondweed	*Potamogeton pectinatus*
Sedge	Cyperaceae
Slender pondweed	*Potamogeton pusilus*
Small duckweed	*Lemna minor*
Smooth brome grass	*Bromus inermis*
Timothy	*Phleum pratense*
Water-meals	*Wolfia spp.*
Water milfoils	*Myriophyllum spp.*
Water smartweed	*Polygonum amphibium*

APPENDIX B: Invertebrate Sampling

TABLE 49. *Number of invertebrates trapped on selected sampling sites in relation to drawdown and carp removal, 1978-81.*

		Drawdown/Carp Removal Area—Main Impoundment*									Carp-Free Control Areas								
		Site 1			Site 2			Site 3			NE Impoundment			NW Impoundment			Dug Pond		
Invertebrate Item	Common Name	1978	1980	1981	1978	1980	1981	1978	1980	1981	1978	1980	1981	1978	1980	1981	1978	1980	1
Gastropoda	Snails	9	6	2	0	8	0	3	19	3	280	10	7	35	3	0	4	1	
Crustacea																			
Cladocera	Water fleas	6,590	1,504	22	4,870	4,987	635	2,271	2,096	385	35	214	238	32	38	670	35	1,546	
Copepoda	Cyclops	2,668	76	8	503	425	12,689	694	764	439	194	62	127	50	10	43	3,547	566	
Amphipoda	Scuds	0	13	5	0	0	14	2	1	62	9	2	33	3	0	180	1	0	
Arachnida	Spiders	505	163	23	653	270	404	6,516	98	76	28	119	97	19	351	37	86	108	
Plecoptera	Stoneflies	0	1	0	0	4	0	0	4	0	0	14	0	0	0	0	0	12	
Ephemeroptera	Mayflies	2	17	8	0	230	43	3	161	11	2	84	7	3	0	40	1	2	
Odanata	Dragonflies																		
Lestidae		0	0	2	0	0	0	0	1	0	2	0	0	2	0	0	0	0	
Coenagrionidae		0	0	2	0	0	0	0	0	3	0	0	3	0	0	0	0	0	
Aeschnidae		0	0	0	0	1	0	5	3	0	0	0	0	0	0	0	0	1	
Hemiptera	True bugs																		
Mesoveliidae		0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	
Notonectidae		36	3	6	0	2	5	0	15	24	1	5	6	0	3	109	0	15	
Pleidae		0	4	8	3	4	0	0	0	13	373	264	460	24	20	3,070	0	0	
Nepidae		0	1	2	0	0	0	3	5	0	2	1	0	0	0	0	0	0	
Belostomidae		4	8	3	0	6	1	0	0	0	9	6	8	1	2	5	0	8	
Corixidae		8,841	4,892	457	728	7,524	1,677	4,959	4,403	260	918	2,223	3,135	130	3,219	240	95	529	
Coleoptera	Beetles																		
Haliplidae		0	605	149	2	45	14	1	47	21	1	116	98	0	82	350	0	389	
Dytiscidae		6	0	0	0	23	10	6	5	37	109	25	69	113	3	13	189	164	
Hydrophilidae		3	0	6	0	0	1	0	2	6	19	5	7	2	1	28	36	18	
Diptera	Flies																		
Culicidae		0	0	0	1	7	5	0	4	1	1	17	0	1	3	1	0	26	
Chironomidae		45	9	0	92	26	7	2	18	14	14	23	9	0	52	0	1,238	32	
Simulidae		0	0	0	0	1	0	0	0	0	0	0	3	0	1	0	0	0	
Stratiomyidae		0	0	0	4	0	2	0	5	0	1	0	0	0	0	0	3	6	
No. of insect families		7	9	11	6	14	11	7	16	10	14	16	9	9	12	9	6	12	

*Carp removed in 1979 with drawdown.

APPENDIX C: Blue-winged Teal Nesting Success

TABLE 50. *Percent blue-winged teal nesting success in relation to Robel vegetation height-density measurements at the nest sites on Grand River Marsh, 1977-81.**

	Visual Obstruction Measurements (cm)						
Year	1-10	11-20	21-30	31-40	41-50	51-60	Total
1977	10	9	18	31	1		13
1978	4	32	23	26	77	13	29
1979	31	28	7		36		24
1980	3	9	6	6	14	20	8
1981	9	20	14	8	2		15
1977-81 TOTAL	11	20	13	14	26	16	17

*Robel et al. (1970).

TABLE 51. *Percent blue-winged teal nesting success in relation to the vegetation in nesting fields as measured by Robel visual obstruction measurements on fields at Grand River Marsh, 1977-81.**

	Visual Obstruction Measurements (cm)						
Year	1-10	11-20	21-30	31-40	41-50	51-60	Total
1977	35	5	13	5		61	14
1978	55	22	32				29
1979	12	23	20	51	18		23
1980	5	11	5	14	8		8
1981	16	30	13	5	0		14
1977-81	14	20	17	16	9	38	16

*Robel et al. (1970).

TABLE 52. *Percent blue-winged teal nest success by major cover types at Grand River Marsh, 1977-81.*

Year	Dry Marsh	Old Fields	4- to 8-Year-Old Planted Nesting Cover*	Greater Than 9-Year-Old Planted Nesting Cover
1977	69(15)**	11(28)	(0)	4(26)
1978	27(8)	28(69)	79(9)	36(18)
1979	32(20)	14(25)	14(25)	17(22)
1980	3(30)	9(44)	13(17)	10(32)
1981	5(30)	12(32)	46(26)	13(57)
1977-81	14(98)	17(191)	37(58)	16(126)

*Planted to brome, alfalfa, timothy and clover — present species primarily brome-alfalfa.
**Number of active nests studied per cover type.

APPENDIX D. Mean nest initiation dates of hatched and predator destroyed nests at Grand River Marsh, 1977-81.*

Year	Mean Initiation Date $\pm$ 95% C.I.			
	Hatched	N	Destroyed by Predator	N
1977	138.3 $\pm$ 3.0	33	134.3 $\pm$ 3.6	51
1978	136.1 $\pm$ 1.9	80	137.2 $\pm$ 2.4	76
1979	131.6 $\pm$ 2.2	48	133.3 $\pm$ 2.2	61
1980	143.6 $\pm$ 3.5	45	146.8 $\pm$ 2.4	136
1981	133.3 $\pm$ 2.4	67	138.7 $\pm$ 2.9	105

*No significant differences ($P \leq 0.05$) in any year between means of nest initiation dates.

APPENDIX E: Hunting Regulations

Year	Season Dates	Season Length	Steel Shot Requirements
1977	1-9 Oct 15 Oct-19 Nov	45	12-gauge guns. All waters and within 150 yd of waters.
1978	1-8 Oct 14 Oct-24 Nov	50	12-gauge guns. All waters and within 150 yd of waters.
1979	1-7 Oct 13 Oct-24 Nov	50	12-gauge guns. All areas of Grand River Marsh.
1980	6 Oct-24 Nov (no split)	50	None required.
1981	4-11 Oct 17-27 Oct	50	All gauges. All areas of Grand River Marsh.

*1978 Value was raised to 35.

Bag Limit (Point system)			
1st Period Points	Species	Year	2nd Period Points
100	Canvasback	77-81	100
	Black duck	77-81	
	Redhead	77-79	
	Hen mallard	77-81	
	Wood duck	77-81	
70	Hooded merganser	77-81	70
	Drake mallard	77-81	
	Redhead	80-81	
	Ringneck	77-81	
	Ruddy	77-81	
25*	Goldeneye	77-81	25*
	Bufflehead	77-81	
	Wigeon	77	
	Others not listed	77-81	
	Wigeon	77-81	
	Pintail	77-81	
	Blue-winged teal	77-81	
15	Green-winged teal	77-81	15
	Gadwall	77-81	
	Shoveler	77-81	
	Scaup	77-81	
	Other mergansers	77-81	

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