Duck production and harvest in St. Croix and Polk counties, Wisconsin. No. 194 2002

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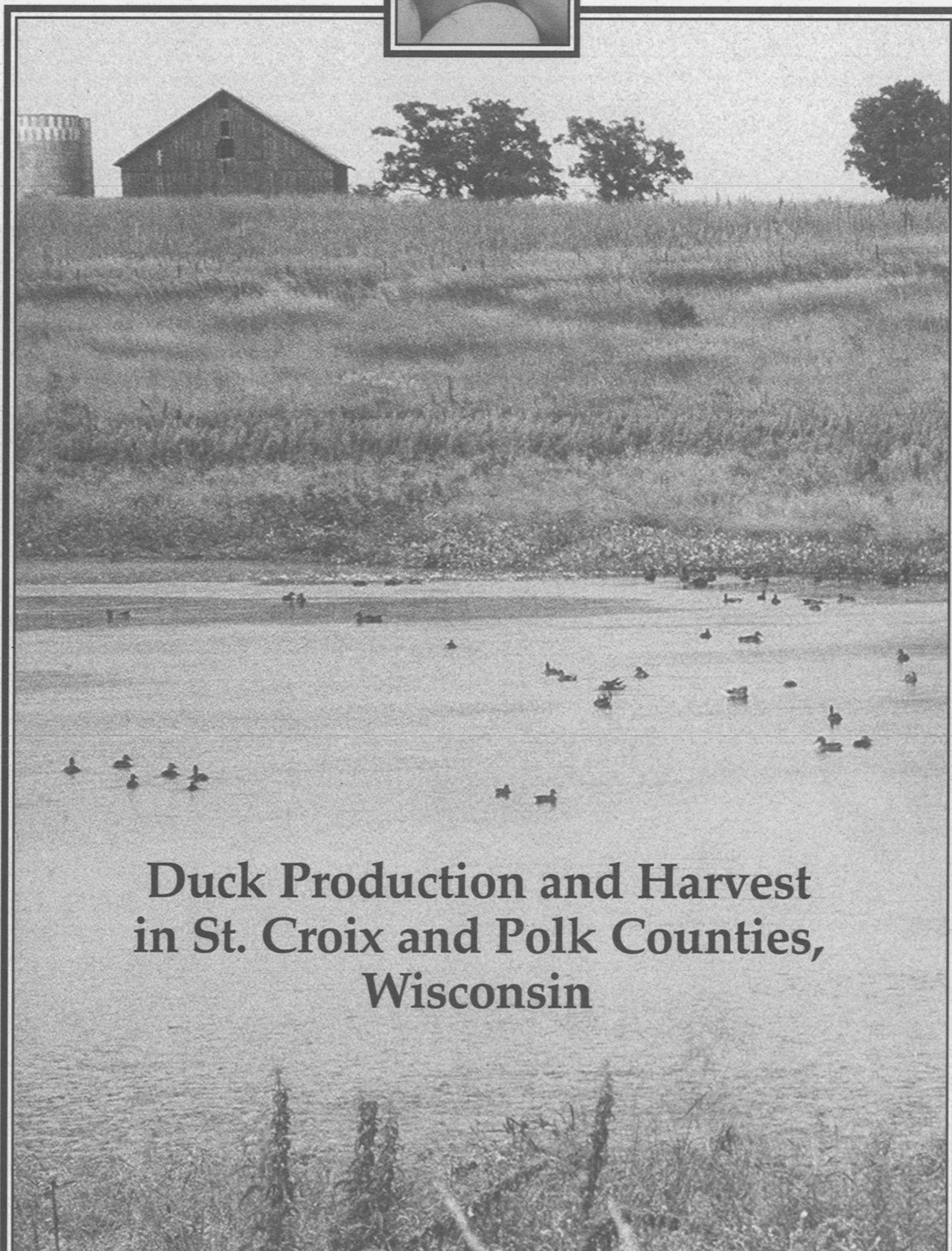

Duck Production and Harvest in St. Croix and Polk Counties, Wisconsin

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Cover photos: Bruce Bacon

ABSTRACT

A study, conducted during 1982-91 in northwest Wisconsin, evaluated management techniques designed to increase Mallard (*Anas platyrhynchos*) and Blue-winged Teal (*Anas discors*) production and determined the contribution of duck production to the local hunting harvest. The 415-mi^2 (321,280 acre) study area in St. Croix and southern Polk counties contained around 7,000 acres (2.1%) of state and federal Waterfowl Production Areas (WPAs). Each year duck breeding pairs and broods were censused by air and by ground and approximately 1,000 acres of upland nesting cover were searched for nests. I sampled nest predators and alternate prey populations annually and captured, marked, and released over 5,000 immature and adult waterfowl during 1982-90. I interviewed hunters in the field during the first 2 days of the hunting season to determine their success. The major objective of the study (to evaluate habitat management techniques to increase duck production in WPAs) was only partially met, primarily due to inadequate sample sizes. Wetland densities, duck occupancy, and breeding pair densities declined during the 1987-88 drought. Mean 1982-91 duck breeding pair densities for the study area were 7.0 pairs/mi^2 (1.6 Mallard, 2.6 Blue-winged Teal, 2.8 other species). Mean duck breeding pair densities on the WPAs were 68.4 pairs/mi^2 (17.9 Mallard, 29.0 Blue-winged Teal, 21.5 other). Mean 1982-90 nest success was 21.3% for 621 WPA duck nests of which 63% were Blue-winged Teal, 36% Mallard, and 1% other species. This rate exceeds the 20% nest success needed for a stable population under Wisconsin conditions. There was no difference between mean Mallard and Blue-winged Teal nest success for the 9-year period (p=0.8). Mean duckling production was 3 ducklings/WPA wetland acre based upon mark/resight estimates. Thirteen percent of marked Mallards and 5% of marked Blue-winged Teal were shot within the study area. Mallards and Blue-winged Teal comprised 35% and 12% of the harvest respectively during the first two days of the season. Mean hunter success was 0.8 ducks/hunter trip, with 10 hours being needed to bag one duck during dry years.

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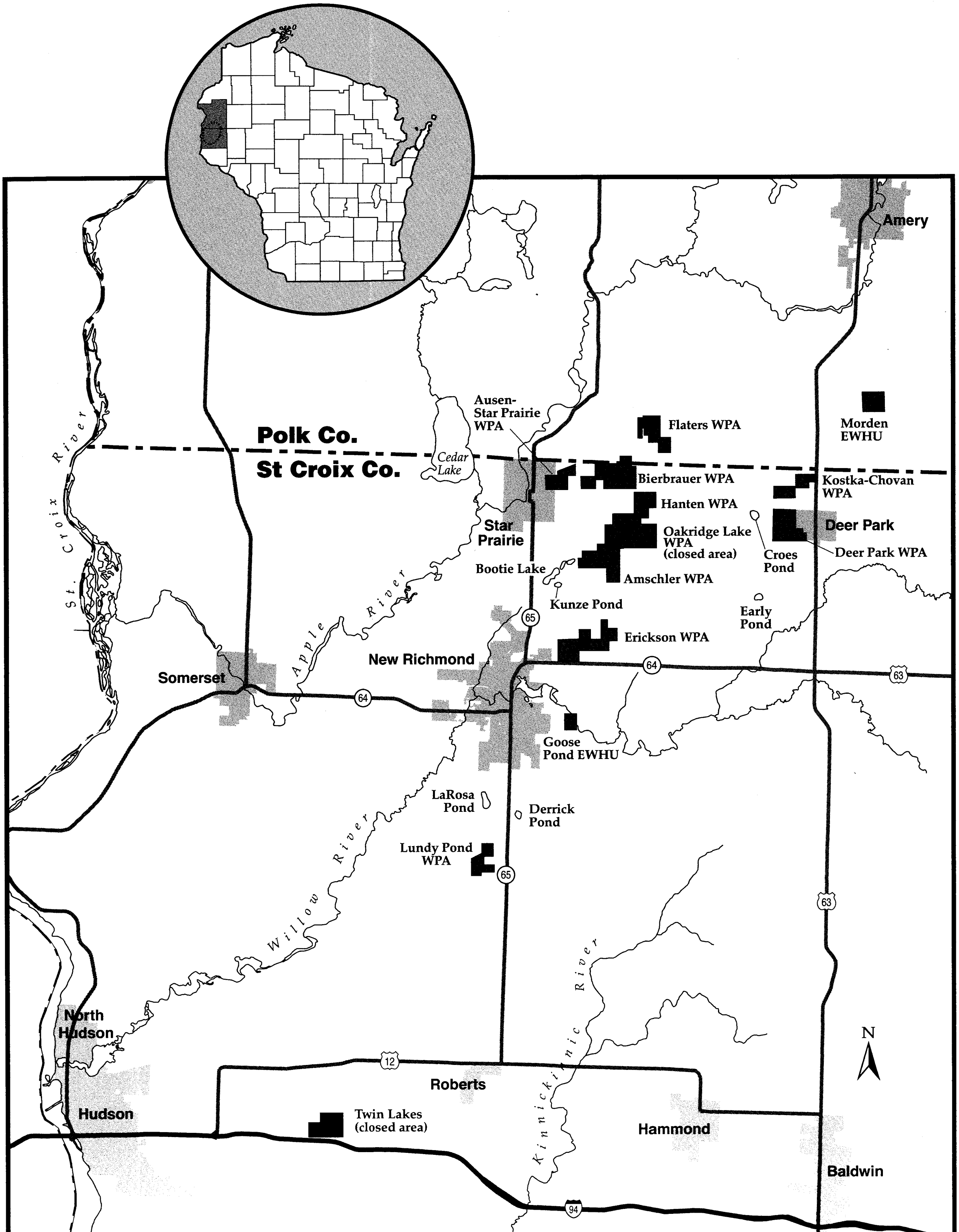

Figure 1. Outline map of Wisconsin showing location of study area in St. Croix and southern Polk counties *and* outline map of study area showing the St. Croix, Apple (including the Cedar Lake outlet), Willow, and Kinnickinnic rivers; Oakridge Lake and Twin Lakes closed areas; Amschler, Ausen-Star Prairie, Bierbrauer, Deer Park, Erickson, Flaters, Hanten, Kostka-Chovan and Lundy Pond WPAs; Morden EWHU; Bootie Lake; and Croes, Derrick, Kunze, LaRosa, and Early ponds. Please note that WPA boundaries may not be exactly to scale.

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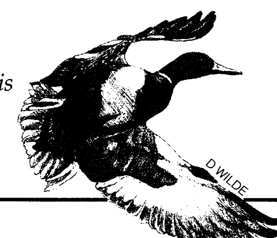
Example of a sign designating a Waterfowl Protection Area (WPA). This particular sign is located at the Bierbrauer WPA.



INTRODUCTION

This study was part of a research effort conducted from 1982-1991 to evaluate management techniques for increasing waterfowl and Ring-necked Pheasant (*Phasianus colchicus*) production in St. Croix and Polk counties in northwest Wisconsin (Evrard and Lillie 1987, Evrard 1995, Evrard 1996c). A major objective was to determine factors affecting nesting success of upland nesting ducks, mostly Mallards (*Anas platyrhynchos*) and Blue-winged Teal (*Anas discors*) in public wildlife management lands. This study was prompted by low duck nesting success reported from the prairie pothole region of North America (Cowardin et al. 1983, Klett et al. 1988) and from Wisconsin (Gatti 1987) in the late 1970s and early 1980s due to excessive mammalian predation. In addition to documenting duck production, this study attempted to determine duck production contribution to the harvest in the study area.

STUDY AREA

The study was conducted within a 415 mi^2 (321,280 acres) highland region between the St. Croix and Chippewa rivers in St. Croix and southern Polk counties, Wisconsin (Fig. 1). The study area is located in the Western Prairie Ecological Landscape of the National Hierarchical Framework of Ecological Units (Keys and Carpenter 1995). A terminal moraine of the Superior Lobe of the Wisconsin glaciation formed the landscape (Langton 1978), where up to 100 ft of glacial till overlies sandstone and dolomitic limestone bedrock. Soils are mainly sandy loams of the Santiago-Jewett-Magnor Association and the topography is level to gently sloping. Groundwater is classified as hard or very hard (Borman 1976). The study area is 85% uplands, 14% wetlands, and 1% water.

A continental climate with short, warm, humid summers, and long, cold, snowy winters characterizes the area (Burley 1964). The mean temperature is 44.1°F and the mean annual precipitation is 29.5 in, with 65% of the total precipitation occurring from May to September. The growing season averages 135 days with the average last spring frost occurring on May 14 and the average first frost on September 26 (Burley 1964).

At the time of European settlement 58% of the area was wooded, 27% was tallgrass prairie, and 15% was wetlands and water (Langton 1978). Since settlement the prairie and much of the woodland have been converted to agriculture. Most (75%) of the study area is intensively farmed for corn, alfalfa hay, oats, and soybeans with emphasis on dairy production. Currently only 11% of the area is wooded. Wetlands have fared better and make up 13% of the study area. Petersen et al. (1982) estimated that 2.7% of the wetlands were destroyed from 1958 to 1977. Most of the wetland losses consisted of small, easily drained Type II, III, and IV wetlands (Shaw and Fredine 1956, Petersen et al. 1982).

Recognizing the value of numerous and relatively unaltered wetlands for waterfowl production, the United States Fish and Wildlife Service (USFWS) in 1974, provided duck stamp funds for wetland acquisition in Wisconsin (Petersen et al. 1982). Wisconsin Department of Natural Resources (DNR) personnel using federal and state dollars acquired wetlands and adjacent uplands that became part of the federal Waterfowl Production Area (WPA) system (DeBates 1967). Approximately 7,000 acres or 2.2% of the study area is in state and federal wildlife management areas. DNR wildlife managers cared for the Wisconsin WPAs until 1994, when the USFWS assumed management responsibilities.

This study focused on nine WPAs, totaling 2,260 acres and consisting of 60% grassy upland nesting cover, 24% wetlands, 12% woodlots, and 4% wildlife food plots. The 9 WPAs were clustered near the city of New Richmond for logistical reasons but were representative of other WPAs within the study area (Fig. 1).

The quantity and quality of the vegetation in the WPAs was determined by measuring the visual obstruction (VOR) along with other measurements. Here VORs are recorded using Robel poles.

Methods

Vegetation

A variety of vegetation management techniques in WPA nesting cover were tested to determine their value for nesting ducks. These techniques included prescribed burning in the spring (April and May) and summer (July and August) and cultivation of corn, oats and hay, typical of the crop rotation used by local dairy farmers. Mowing and rotational grazing were also tested to a limited extent.

During 1982-90, within the nine WPAs, vegetation was examined annually in 100 fields totalling approximately 1,000 acres of upland grassy nesting. The quantity and quality of the vegetation was determined by measuring the visual obstruction rating (VOR) (Robel et al. 1970), height, and litter depth. Measurements were taken in the spring following snowmelt and in the late summer after plant growth had ceased. Ten circular plots (33 ft in diameter) were regularly spaced by pacing on an imaginary line running diagonally across each field. In each plot, eight VORs(4 in and 4 out) were taken on Robel poles; one placed at the center and one at each cardinal direction on the edge of the plot (Robel et al. 1970).

In the early fall vegetation survey, ten rectangular plots (1 x 2 ft) (Daubenmire 1959) were placed at the center of each 10-ft circular plot in each field to estimate cover and frequency for calculating Importance Values (IV) for plant species (Curtis 1959). Vegetation comparisons were made using the Student's *t*-test and correlation analysis in the Epistat statistical package (Gustafson 1984).

Wetlands, Duck Breeding Pairs and Broods

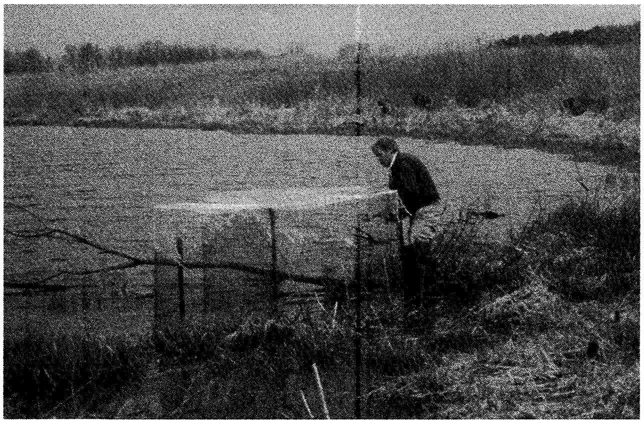
Waterfowl breeding pairs were censused each year, once in early May from the air using the same aircraft, pilot, one of the two observers, and methods outlined in the annual Wisconsin waterfowl breeding survey (March et al. 1973, Hunt et al. 1982, Gatti 1988). The study area lies within the 9,430 mi^2 Northern High Region of the statewide survey. This region's name reflects its relatively good habitat and duck numbers compared to the Northern Low Region. The study area was surveyed using 10 random, east-west, 20-mi long, 0.25-mi wide transects, flown at an altitude of 200 ft and an air speed of 80-85 mph in a Cessna 180 or 185 aircraft (Gatti 1988). The 10 transects were chosen using a random numbers table from 52 potential transects superimposed on east-west quarter section map lines (Steel and Torrie 1960). Transects were at least 1 mi apart to minimize the problem of counting the same ducks on different transects. Approximately 10% of the study area was censused using this method.

An observer on one side of the plane counted wetlands by type (Shaw and Fredine 1956, March et al. 1973, Wheeler and March 1979) and noted their occupancy by waterfowl. Both observers counted all waterfowl seen within the transects on their respective side of the aircraft. Pairs, lone males, and male groups of up to five were used to estimate the number of indicated pairs (Dzubin 1969). This method may overestimate breeding females, but the error may be inconsequential for this type of study (Rotella et al. 1995).

One transect, selected because it was adjacent to roads, was searched on the ground in an effort to develop correction factors for those ducks not seen or missed from the air (Martinson and Kaczynski 1967). Since small sample sizes were a problem, correction factors or the visibility rate (Gatti 1988) was obtained for the Northern High Region of the statewide survey. Wetland occupancy rates in the study area were corrected using the ground count of the single transect.

Student's *t*-test and correlation coefficients were used to test for differences and examine the relationships between: breeding pair and wetland densities, between wetland and breeding duck densities in the study area, and in the Northern High Region of the state wide aerial waterfowl survey (Hunt et al. 1982). Significance for this and all other statistical tests were at the $P < 0.05$ level.

Wetlands were censused in the nine WPAs from the ground for duck pairs and broods (Bennett 1967) twice in May and June. Wetland margins were walked in the early morning hours to flush all waterfowl present, with



PHOTOS: BRUCE BACON

In order to mark ducks during the spring with leg bands, ducks were captured using swim-in bait traps (left) or decoy traps (right) and then released.

care taken not to double count birds. The maximum count for each species was used to determine the number of indicated pairs and broods. Ducks broods were aged based upon the plumage-appearance age subclasses developed by Gollop and Marshall (1954).

During April and May 1982-90, ducks were captured using swim-in bait traps (Hunt and Dahlka 1953) and decoy traps (Anderson et al. 1980, Sharp and Lokemoen 1985). All duck species were marked with standard USFWS aluminum leg bands and released. Male and female Mallards and Blue-winged Teal were additionally marked with plastic nasal saddles (Doty and Greenwood 1974, Greenwood 1977) color coded (Gullion 1951) to individual ducks.

Duck Nesting

In 1982, research crews searched approximately 1,000 acres of upland grassy cover in nine WPAs for duck nests, making one search in May and June using a cable chain drag device stretched between two vehicles (Higgins et al. 1969, Miller and Johnson 1978). From 1983-90, three searches were conducted annually. Nest searches were not conducted in the WPAs in 1991.

A nest bowl containing at least one egg was defined as a nest. Laying and incubating female ducks were generally flushed from the nest when the cable chain device was dragged over them. Vegetation held the cable chain drag high enough over the nests so that the eggs were not damaged. Once a nest was located, it was marked with a 5-ft high stake 10 ft north of the nest. The nest code (species and number) was written on surveyor's plastic tape attached to the tip of the stake. The eggs were counted and candled (Weller 1956) to estimate the day of hatch. Vegetation measurements, including VORs (Robel et al. 1970) and IVs (Curtis 1959), were among the 34 variables recorded at a nest site.

I visited nests every 7-10 days to determine their fate. A nest in which one egg hatched was considered successful, as determined by the presence of detached shell membranes or ducklings in the nest bowl (Dzubin and Gollop 1972, Klett et al. 1986). A nest containing at least one intact egg that was not being incubated and no additional eggs were laid, was considered abandoned and not used in the calculation of nest success. A nest was considered destroyed if all eggs were destroyed or missing. I determined predator species responsible for destroyed nests by field sign at the nest site based upon criteria developed by Rearden (1951) and Einersen (1956).

A cable chain drag device (pictured here) stretched between two vehicles was used to search grassy cover for duck nests.

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Mallard eggs hatching.

Ducks were marked throughout the study using nasal saddles and leg bands. Ducklings were marked with web tags. Here a female Blue-winged Teal has been marked with a nasal saddle.

Nest success was calculated using the method developed by Mayfield (1961, 1975) with the 40% modification of Johnson (1979). Nest success comparisons were made using LIFETEST Proc. of the SAS Statistical Package (SAS Institute 1990). Factors affecting nesting success were determined through the use of exponential regression analysis using 34 variables.

Nest densities were estimated by dividing the number of successful nests found by the Mayfield nest success estimate. These density estimates should be considered minimum estimates since it is assumed that not all successful nests were found.

All nests, regardless of their fates, were used to determine habitat preferences of nesting ducks (Greenwood et. al. 1995). All nests found were pooled for all years by species.

On the day prior to projected hatch, Mallard and Blue-winged Teal nests were visited to capture the females with hand nets and mist nets (Bacon and Evrard 1990). Captured females were marked with aluminum leg bands and individually color-coded nasal saddles. During the early morning of the projected hatch day, nests were revisited to capture newly hatched ducklings before they left the nest. Captured ducklings were marked with numbered monel tags placed in the foot webbing between their toes (Alliston 1975). Duckling sexes were not determined but a 52 male:48 female sex ratio was assumed for Mallards (Sowls 1955), and a 58 male:42 female sex ratio was assumed for Blue-winged Teal (Bennett 1938).

In July 1982-90, flightless young and adult ducks were captured by drive trapping (Cooch 1953) and night lighting (Cummings and Hewitt 1964) and marked with leg bands. Flightless ducklings, estimated to be at least 4 weeks old (Evrard 1996a), were leg banded and nasal saddled. Younger ducklings, having feet too small to hold a standard leg band, were web tagged only. Adult ducks were marked with individually color coded nasal saddles while flightless leg banded ducklings were marked with nasal saddles color coded to the marshes in which they were captured.

Duck Broods

All complete duck broods were aged using the classification system of Gollop and Marshall (1954) based upon growth and plumage characteristics. Estimated brood mortality was based upon attrition in brood size over time from hatch through Class I, II, and III. Differences were tested using the Student's *t*-test.

Counts of marked (nasal saddled) and unmarked Class II and older Mallard and Blue-winged Teal ducklings provided mark/resight estimates (Otis et al. 1978) of duckling production on WPA wetlands. Since most duckling mortality takes place during the first few weeks following hatch (Dzubin and Gollop 1972, Ball et al. 1975, Ringleman and Longcore 1982, Talent et al. 1983, Duebbert and Frank 1984, Fleskes 1986, Orthmeyer and Ball 1990, Fleskes and Klaas 1991, Higgins et al. 1992, Mauser et al. 1994), estimates of numbers of Class II and older ducklings can approximate production of fledged ducklings (Hestbek et al. 1989, Mauser and Jarvis 1994).

In the morning following marking, ratios of marked and unmarked Class II and older ducklings were obtained using Bennett's (1967) point sampling method. These efforts met all four assumptions of mark/resight population estimates. First, no more than 8 hrs elapsed from marking to resighting, so there was no natality and very little mortality. Emigration or immigration from the wetland on which they were marked was minimal since the ducklings were flightless and little time had elapsed from marking to resighting. Second, very few ducklings lost their nasal saddles. Based upon recapture of banded birds that had lost their markers, reported nasal saddle loss for birds age >1 yr ranged from 0.2% (Evrard 1986a, Evrard 1996b) to 2.3% in Saskatchewan (Arnold and Clark 1996) to 19% in North Dakota (Lokemoen et al. 1990). Third, errors in correctly identifying, counting, and recording the ducklings during marking and resighting were minimal (Evrard 1996a). Finally, based on observed duckling behavior, it was assumed that marked and unmarked birds had equal chances of being observed during the point counts.

In August and September, flying young and adult ducks were captured using swim-in bait traps and marked with leg bands. Nasal saddle codes, leg band, and web tag numbers were recorded when marked ducks were resighted and recaptured throughout the year.

Banded birds were separated by sex into three age classes: adult, immature, and local. An *adult* is classified as a bird hatched before the year of banding; an *immature* is classified as a hatching year bird capable of flight; and a *local* is classified as a hatching year bird not yet capable of flight (Munro and Kimball 1982). Immature and local birds were combined into a *young* class. Chi-square analysis was used to determine if differences exist between the recovery rates of the various age and sex cohorts.

Duck Concentration Sites

Although no formal surveys were conducted in the spring, summer, or fall to determine waterfowl concentration sites, groups of waterfowl encountered within the study area were noted, with priority given to recording waterfowl concentrations containing marked birds.

In conjunction with formal USFWS surveys, winter (December and January) waterfowl counts at known and suspected concentration sites were taken from aircraft and from the ground by DNR personnel. Open water areas of the Kinnikinnic, Apple, Willow, and St. Croix Rivers were censused, including several spring-fed ponds.

Predator and Alternate Prey Surveys

Three indirect indices (counts of pocket gopher mounds, counts of fossorial mammal burrows, and small mammal trapping) and three direct indices (road-kill, scent station, and spotlight surveys) were used to determine how predator populations and selected prey fluctuated in relation to waterfowl nest success. Differences and relationships were tested using the Student's *t*-test and correlation coefficients.

Numbers of pocket gopher (*Geomys bursarius*) mounds and fossorial mammal burrows within the 33-ft diameter vegetation sampling plots were used as indices to asses prey availability and potential nest predators.

Small mammal trapping provided another prey index (Zippen 1958). Small mammals were snap trapped in 12 different nesting fields in 5 WPAs each year from 1982-90. The nesting fields were managed by burning, mowing, and cultivation, representing nest cover of various ages (i.e. time after management disturbance). Six grids of 50 snap traps each were set for two 10-day periods in June and July each year. Five rows of 10 traps (40 mouse- and 10 rat-sized) were placed in each 0.7 acre rectangular grid. Trap locations were marked with orange surveyor's tape. The traps were baited with peanut butter and checked daily. Fields trapped were chosen to represent seral vegetation stages produced by the management techniques listed above. A catch per effort statistic, adjusted for snapped traps (Nelson and Clark 1973), was used as a simple index for small mammal populations.

Road killed predators were recorded on all study area roads April through October from 1982-90. Distances that vehicles were driven within the study area during the same period were recorded. No estimates of traffic volume were available. The index used was expressed as road killed predators per 1,000 mi driven. McClure (1951) and Case (1978) conclude that road kills provide information for monitoring wildlife populations. Verts (1967) and Rolley and Lehman (1992) use road kill data to compare regional striped skunk (*Mephitis mephitis*) and common raccoon (*Procyon lotor*) populations.

A scent station survey (Linhart and Knowlton 1975) consists of 10 lines 2 mi long along secondary roads, 5 adjacent to WPAs and 5 in private lands (PL) (Roughton and Sweeny 1982). The line transects were located >1 mi apart to prevent biases from mobile predators. Each transect had 10 scent stations spaced 0.2 mi apart and were located in a grassy ditch adjacent to the road. About 30% of the WPA transects were adjacent to public wildlife management lands. The PL transects were >1 mi from the nearest WPA.

Each scent station consisted of a 3-ft diameter circle of bare, finely sifted sand. The stations were treated each autumn with a soil sterilant herbicide to control vegetation encroachment. A single fatty acid scent (FAS) tablet (Roughton 1982) was placed in the center of the freshly sifted sand. The stations were revisited the following morning, recording animal sign, and removing the FAS tablet. Each FAS tablet was used only once. Transects were run monthly from May through August in 1984-90.

Two road spotlight transects (Rybarczyk et al. 1981) were selected with one traversing an area with little public wildlife management properties (PL) and the other traversing an area with considerably more public lands (WPA).


BRUCE BACON

Making a scent station.

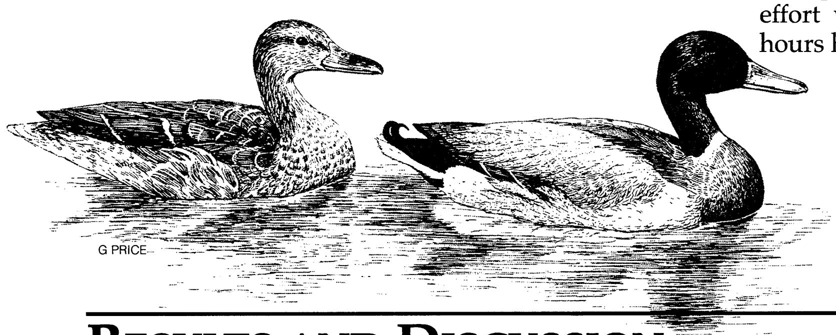
The PL transect was 25 mi long from which 7,360 acres (woods were excluded due to leaf out) were searched. Wildlife management lands adjacent to the road were 7% of the total transect. The WPA transect was 26 mi long from which 7,044 acres (woods excluded) were searched. Wildlife management land adjacent to the road was 22% of the total transect. Nearly 5% of the study area was included within these two transects.

Roads were driven at 10-15 mph one hour after sunset on nights of high humidity. Roads were driven three times annually in late April (after leafout) and May, 2 weeks apart from 1984-90. Transect route directions were alternated. Two observers, including the driver, each used 200,000-candle power spotlights to search habitat to a distance of 0.25 mi on each side of the road. Binoculars and occasionally a 20X scope were used to identify animals. Dogs were not recorded. Surveys were not conducted during high winds, low humidity, rain, fog, or below freezing temperatures.

Duck Harvest

DNR crews interviewed hunters in St. Croix County during the first 2 days of the 1982-91 duck hunting seasons. Crews drove through the county beginning at noon on the opening day of the season and in the early morning of the second day, counting all vehicles of suspected duck hunters on public and private lands. The numbers of hunters and vehicles involved in interviews were also recorded. Crews asked hunters encountered if they had bagged any ducks and how many hours they had hunted. Any ducks bagged were checked to determine species, sex, age, and for the presence of web tags, bands, and nasal saddles.

Hunter numbers were determined by multiplying the number of vehicles counted by the mean number of hunters per vehicle involved in the interviews. Relative hunter success was expressed as the number of ducks bagged per hunter trip (Jahn and Hunt 1964). Minimum estimated duck harvest for the first 2 days of the season, an index to the total season harvest, was determined by multiplying hunter success by hunter numbers. Hunter effort was determined by calculating the number of hours hunted to bag a bird.



Results and Discussion

Wetland Density

During the first 5 years of the study, the number of wetlands in the study area was relatively stable (Table 1). Wetland density, however, was less than that found in the Northern High Region (13.0/mi^2, Andryk et al. 1991)during the same period (t=3.156, df=8, P=0.01). There was a significant relationship between total wetland densities compared to the Northern High Region during the ten years of the study (r=0.745, t=3.155, P=0.01). During a drought period from late 1986 through 1988, temporary wetlands (Types I, VII, and VIII, Shaw and Fredine 1956) disappeared and densities of more permanent wetlands declined (Table 1).

Wetland Occupancy

Waterfowl occupancy rates followed a trend similar to wetland occurrence. Mean occupancy for all wetlands in the 10 years of the study was 28.5%, ranging from 19% to 43% (Table 2). Occupancy dropped dramatically throughout the drought period from 1986 to 1988. With the return to normal precipitation in 1989, wetland occupancy rose along with wetland densities (Tables 1 and 2). Occupancy rates from previous Wisconsin studies ranged from 11% in the central plain (Jahn and Hunt 1964) to 56% in southeastern Wisconsin (Wheeler and March 1979). The more permanent wetlands (Types III, IV, and V) in my study area had consistently higher occupancy rates than the more temporary wetland (Types I, II, VI, and VII) (Table 2). Occupancy rates for streams and ditches were low (Table 2). This agrees with earlier work done in Wisconsin (March et al. 1973, Wheeler and March 1979, Petersen et al. 1982, Andryk et al. 1991) and Minnesota (Lee et al. 1964).

Spring Duck Concentration Sites

Ducks favored flooded fields and other temporary wetlands when they arrived in the spring. This was probably a response to food availability. Concentration sites included publicly owned areas (Oakridge Lake, Ausen Pond, Hanten Pond, Lundy Pond, Amschler WPAs, and Morden Extensive Wildlife Habitat Unit (EWHU)) and privately held wetlands (Bootie Lake, Twin Lakes, and Derrick Pond) (Fig. 1). These larger, more permanent wetlands also served as roost sites. The largest number of ducks observed at any one site in the spring was 1,800 birds on Oakridge Lake in 1990 (Table 3).

Table 1. *Wetlands per mi² of study area determined by aerial surveys in May, 1982-91. Shaded years denote drought years.*

	Year										
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Mean
Wetland Type[a]											
I	1.3	1.0	1.6	0.4	2.8	0.0	0.0	0.4	0.4	2.2	1.0
II and VI	1.8	3.7	4.6	2.7	5.2	1.2	1.5	2.6	3.0	3.4	3.0
III	2.2	1.1	1.5	1.5	1.9	1.6	1.7	1.8	1.7	2.2	1.7
IV	1.8	1.2	1.8	2.1	1.4	1.7	1.2	2.4	2.5	2.6	1.9
V	3.8	2.7	2.2	2.1	1.8	1.3	1.9	2.3	1.5	2.5	2.2
VII and VIII	0.4	0.2	1.1	0.5	0.3	0.0	0.0	0.3	0.2	0.8	0.4
Subtotal	11.3	9.3	12.8	9.3	13.4	5.8	6.3	9.8	9.2	13.7	10.2
Streams	2.1	1.4	2.4	1.7	1.3	1.3	1.8	1.7	1.8	2.0	1.8
Ditches	0.3	0.5	0.5	0.4	0.2	0.1	0.2	0.1	0.3	0.3	0.3
Total	13.7	11.2	15.7	11.4	14.9	7.2	8.5	11.6	11.3	16.0	12.3

[a]Wetland types taken from Shaw and Fredine 1956.

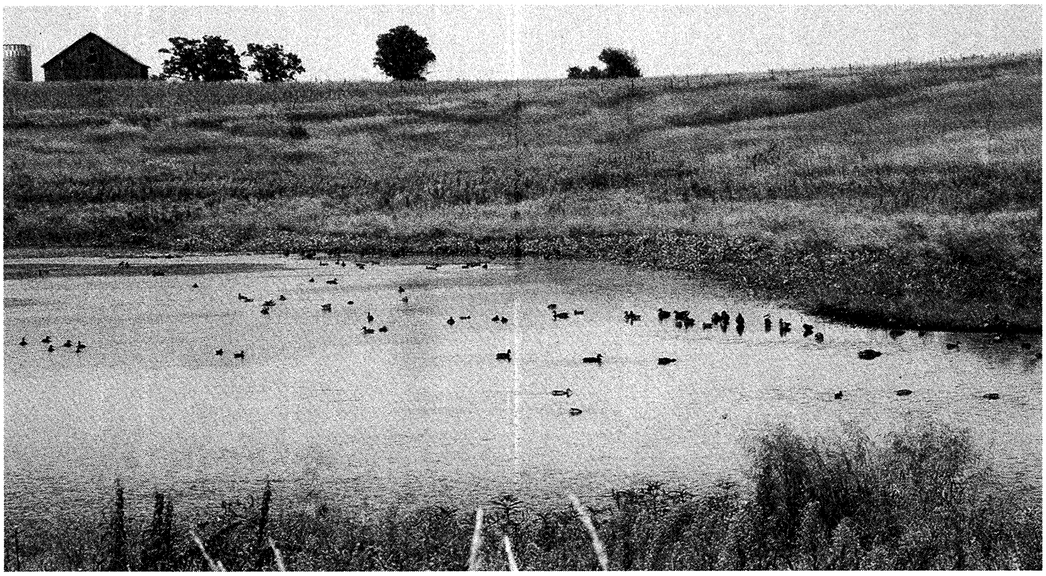
Table 2. *Percent of study area wetlands occupied by ducks as determined by ground transect, May, 1982-91. Shaded years denote drought years.*

	Year										
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Mean
Wetland Type[a]											
I	12	0	0	0	0	0	0	33	0	0	4.5
II and VI	12	7	18	23	0	0	50	12	0	11	12.2
III	27	33	67	46	16	14	0	36	50	54	34.3
IV	54	40	60	50	33	40	50	60	44	70	50.1
V	50	67	0	0	0	50	67	100	0	33	36.7
VII and VIII	0	0	0	0	0	0	0	0	0	0	0.0
Subtotal	27	29	29	28	17	19	19	41	33	43	28.5
Streams	25	0	0	0	50	50	33	33	0	25	21.6
Ditches	0	0	0	0	0	0	0	0	0	0	0.0
Total	26	26	31	26	19	22	22	41	33	41	28.7

[a]Wetland Types taken from Shaw and Fredine 1956.

Table 3. *Peak spring, fall, and winter duck observations, St. Croix and Polk counties, 1982-91.*

Year	Season	Date	Location	No. Ducks Observed	No. Species Observed
1982-83	Spring	6 Apr	Twin Lakes	131	10
	Fall	2 Oct	Oakridge Lake (closed area)	645	—
1983-84	Spring	19 Apr	North Fish Lake	250	2
	Fall	25 Oct	Oakridge Lake (closed area)	2,000	1
1984-85	Spring	14 Apr	Flooded cornfield	269	6
	Fall	14 Nov	Oakridge Lake (closed area)	998	6
	Winter	12 Feb	St. Croix River, Hudson	380	3
1985-86	Spring	27 Mar	Twin Lakes	400	6
	Fall	2 Oct	Amschler WPA	297	3
	Winter	9 Jan	St. Croix River, Hudson	242	2
1986-87	Spring	21 Apr	Cedar Lake	249	5
	Fall	3 Nov	East Twin Lake	950	5
	Winter	8 Jan	St. Croix River, Hudson	431	4
1987-88	Spring	26 Mar	Ausen WPA	361	5
	Fall	17 Oct	Oakridge Lake (closed area)	1,102	7
	Winter	8 Jan	St. Croix River, Hudson	502	4
1988-89	Spring	5 Apr	Oakridge Lake (closed area)	300	1
	Fall	7 Oct	Oakridge Lake (closed area)	580	3
	Winter	4 Jan	St. Croix River, Hudson	347	1
1989-90	Spring	19 Apr	Morden WPA	500	8
	Fall	14 Nov	Oakridge Lake (closed area)	5,050	3
	Winter	12 Feb	St. Croix River, Hudson	360	3
1990-91	Spring	10 Apr	Oakridge Lake (closed area)	1,800	—
	Fall	31 Oct	Oakridge Lake (closed area)	3,420	3
	Winter	10 Dec	St. Croix River, Hudson	1,136	5
1991-92	Spring	19 Mar	Apple River, Johannesburg	113	4
	Fall	5 Oct	Oakridge Lake (closed area)	1,300	2



BRUCE BACON

Ducks on Kunze Pond, St Croix Co., WI.

Fall Duck Concentration Sites

By the first week of August, small flocks of ducks could be seen flying around the study area. Ducks concentrated in late August and early September on Oakridge Lake, Bierbrauer Lake, Bootie Lake, Twin Lake, Flaters Pond, Early Pond, LaRosa Pond, and Kunze Pond (Fig.1).

Once the hunting season began, the ducks concentrated in the Oakridge Lake (Jahn and Hunt 1964) and Twin Lakes Closed Areas, and on private wetlands closed to hunting (Table 3). Peak numbers during the study exceeded 5,000 ducks in the Oakridge Lake Closed Area and 1,000 ducks in the Twin Lakes Closed Area during the 1989 hunting season (Table 3). Faanes (1981) reported Mallard numbers exceeding 10,000 were found in both refuges in the late 1970s. Petersen et al. (1982) counted 10,000 waterfowl, mostly Mallards and Ring-necked Ducks, during the same period in the same area, excluding the Twin Lakes refuge. They reported up to 2,000 American Wigeon using the Oakridge Lake refuge during the fall.

Winter Duck Concentration Sites

Little suitable duck habitat remains once ice and snow arrives (Jahn and Hunt 1964). In most years, half of the wintering ducks in the study area are found on the St. Croix River in the city of Hudson (Table 3). Other significant winter concentration sites are the city of Amery and the outlet of Cedar Lake (Fig. 1). In all three areas Mallards dominate the duck population and are fed by humans. The only marked ducks from the study were several Mallards observed in the Cedar Lake outlet. Rarer ducks were occasionally seen. In March 1983, a male Oldsquaw (*Clangula hyemalis*) was observed with Mallards in an ice free spring pond near the Apple River (Evrard 1984). A male Northern Pintail (*Anas acuta*) was seen in February 1985 on the Apple River in Amery.

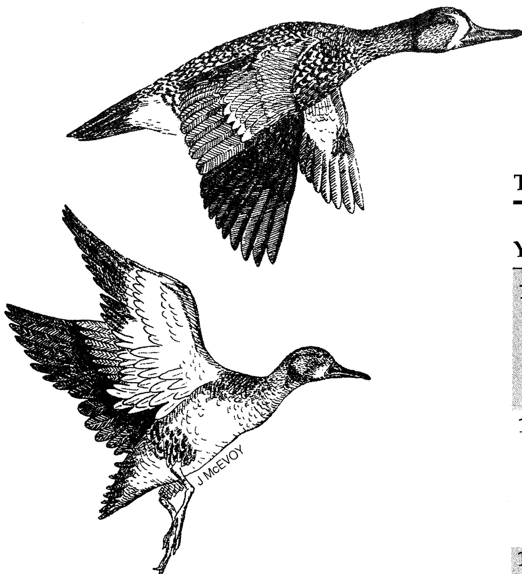
On 5 January 1990 an intensive aerial survey was made of all potential wintering sites within and adjacent to the study area. The area covered included the Apple River from Amery to the St. Croix River (including the Cedar Lake outlet), the Willow River from New Richmond to the St. Croix River, the Kinnickinnic River from Baldwin to the St. Croix River, and the St. Croix River from Stillwater, Minnesota to the junction with the Mississippi River. Approximately 1,300 Mallards, 60 Black Ducks (*Anas rubripes*), 70 Common Goldeneyes (*Bucephala clangula*), and 250 Common Mergansers (*Mergus merganser*) were counted.

Duck Breeding Pairs

Fifteen duck species were encountered during the WPA breeding pair surveys (Tables 4 and 5). Evidence of nesting was documented for eight species: Mallard, Blue-winged Teal, Wood Duck (*Aix sponsa*), Ring-necked Duck (*Aythya collaris*), Hooded Merganser (*Lophodytes cucullatus*), Ruddy Duck (*Oxyura jamaicensis*), Green-winged Teal (*Anas crecca*), and Northern Shoveler (*Anas clypeata*) (Evrard and Lillie 1996). The other seven species (Gadwall [*Anas strepera*], American Wigeon [*Anas americana*], Lesser Scaup [*Aythya affinis*], Redhead Duck [*Aythya americana*], Bufflehead [*Bucephala albeola*], Common Merganser, and Red-breasted Merganser [*Mergus serrator*]), were lingering spring migrants or summering pairs.

Mean Mallard breeding density in the study area, 97.8% of which was private land, was 1.7 pairs/mi^2. The Blue-winged Teal density was 2.7 pairs/mi^2 (Table 4). The mean density of other ducks combined was 2.8 pairs/mi^2 (Table 4), and the mean density for all ducks was 7.2 pairs/mi^2 (Table 4).

While Mallard breeding density in the study area was similar to the Northern High Region (t=0.756, df=9, P=0.47), Blue-winged Teal pair density was nearly 2 times



greater in the study area compared the the Northern High Region (t=3.88, df=9, P=0.004). There was no difference in mean pair density for other ducks (t=0.567, df=9, P=0.58) and for total ducks (t=1.442, df=9, P=0.18) when compared to the Northern High Region.

The Mallard and Blue-winged Teal pair estimates for this study (Table 4) were within the lower limits of the 95% confidence interval reported by Petersen et al. (1982). Breeding pair densities reported in this study were comparable to other areas in the state. Wheeler and March (1979) estimated a total duck breeding density of 8.8 pairs/mi^2 (1.8 Mallard, 5.7 Blue-winged Teal, and 1.3 other ducks) from helicopter surveys in southeastern Wisconsin. In another southern Wisconsin study, Wheeler et al. (1984) indicated a total breeding density of 5.2 pairs/mi^2 (1.8 Mallard, 2.6 Blue-winged Teal, and 0.8 other ducks).

As would be expected within the study area, breeding pair densities were significantly higher on WPAs than on private land (t=12.320, df=9, P<0.000001). There was no synchrony in density changes from year to year (r=-0.258, t=0.754, P=0.47) (Table 5). Mean Mallard breeding pair density was 18 pairs/mi^2 and mean Blue-winged Teal density was 29 pairs/mi^2 in the WPA (Table 5). Pair densities of other ducks ranged from 12 to 39 pairs/mi^2 in the WPA. The mean pair density estimate for all ducks was 69 pairs/mi^2.

In the same study area, Petersen et al. (1982) reported mean WPA breeding pair

Table 4. *Duck breeding pair estimates for study area, 1982-91.*

Year/Species	Breeding Pair Index	Air/Ground Ratio[a]	Breeding Pair Estimate	Breeding Pairs/mi^2
1982				
Mallard	480	0.46	1,040 (28)[b]	2.1
Blue-winged Teal	360	0.28	1,290 (35)	2.6
Other[c]	110	0.08	1,380 (37)	2.7
Total	950		3,710	7.4
1983				
Mallard	450	0.64	750 (17)	1.4
Blue-winged Teal	290	0.14	2,070 (47)	4.1
Other	110	0.07	1,570 (36)	3.1
Total	850		4,390	8.6
1984				
Mallard	350	0.64	550 (10)	1.1
Blue-winged Teal	240	0.09	2,670 (51)	5.3
Other	120	0.06	2,000 (39)	4.0
Total	710		5,220	10.4
1985				
Mallard	530	0.32	1,660 (19)	3.3
Blue-winged Teal	550	0.375	1,470 (17)	2.9
Other	190	0.035	5,430 (64)	10.8
Total	1,270		8,560	17.0
1986				
Mallard	240	0.20	1,200 (57)	2.4
Blue-winged Teal	180	0.30	600 (29)	1.2
Other	60	0.19	320 (14)	0.6
Total	480		2,100	4.2
1987				
Mallard	470	0.69	680 (24)	1.3
Blue-winged Teal	530	0.31	1,710 (58)	3.4
Other	150	0.29	520 (18)	1.0
Total	1,150		2,910	5.7
1988				
Mallard	340	0.70	490 (21)	1.0
Blue-winged Teal	280	0.31	900 (39)	1.8
Other	260	0.28	930 (40)	1.8
Total	880		2,320	4.6
1989				
Mallard	660	0.88	750 (33)	1.5
Blue-winged Teal	440	0.60	730 (32)	1.4
Other	170	0.21	810 (35)	1.5
Total	1,270		2,290	4.5
1990				
Mallard	520	0.66	790 (26)	1.6
Blue-winged Teal	530	0.335	1,580 (52)	3.1
Other	160	0.25	640 (22)	1.2
Total	1,210		3,010	5.9
1991				
Mallard	570	0.775	730 (44)	1.5
Blue-winged Teal	410	0.731	560 (33)	1.1
Other	100	0.258	390 (23)	0.8
Total	1,080		1,680	3.4

[a] Derived from statewide aerial surveys (Andryk et al. 1991).
[b] Numbers in parentheses represent percent of total.
[c] Other species include: Green-winged Teal, Shoveler, Wood Duck, Ring-necked Duck, Lesser Scaup, Bufflehead, and Hooded Merganser.

Table 5. *Duck breeding estimates (pairs/mi²) for WPAs, 1982-91.*

	Waterfowl Production Area[a]									
Year and Species	**613**	**710**	**716**	**717**	**719**	**720**	**724**	**727**	**733**	**Mean**
1982										
Mallard	9	14	20	—	8	—	20	40	9	17
Blue-winged Teal	3	21	20	—	26	—	68	51	73	37
Other[b]	3	16	12	—	16	—	10	31	41	18
Total	15	51	52	—	50	—	98	122	123	72
1983										
Mallard	17	11	13	12	14	19	10	11	18	14
Blue-winged Teal	14	7	9	21	17	6	34	23	41	19
Other	3	5	7	4	7	26	2	31	23	12
Total	34	23	29	37	38	51	46	65	82	45
1984										
Mallard	9	14	9	16	6	19	18	14	28	15
Blue-winged Teal	9	14	22	40	24	58	24	18	28	26
Other	12	14	7	0	12	32	6	7	23	13
Total	30	42	38	56	42	109	48	39	79	54
1985										
Mallard	20	18	7	16	12	32	22	18	14	18
Blue-winged Teal	3	16	24	52	25	84	40	32	41	35
Other	20	4	9	12	2	36	12	5	74	19
Total	43	38	40	80	39	152	74	55	12	72
1986										
Mallard	6	11	—	8	12	45	14	7	18	15
Blue-winged Teal	0	4	—	24	25	45	28	16	28	21
Other	12	20	—	4	17	19	4	2	37	14
Total	18	35	—	36	54	109	46	25	83	50
1987										
Mallard	17	14	—	8	25	40	24	18	28	22
Blue-winged Teal	9	9	—	24	17	20	30	28	28	21
Other	26	11	—	36	23	4	18	28	60	25
Total	52	34	—	68	65	64	72	74	116	68
1988										
Mallard	14	26	—	20	11	12	24	25	18	19
Blue-winged Teal	6	22	—	35	8	36	36	20	41	26
Other	14	18	—	40	16	24	22	4	23	20
Total	34	66	—	95	35	72	82	49	82	65
1989										
Mallard	9	24	—	12	14	36	20	5	14	17
Blue-winged Teal	17	42	—	72	12	42	30	16	41	33
Other	9	26	—	20	23	68	6	16	32	25
Total	35	92	—	104	49	136	56	37	87	74
1990										
Mallard	14	20	—	28	13	32	24	9	23	20
Blue-winged Teal	26	10	—	56	22	52	36	18	83	38
Others	0	28	—	32	48	100	30	9	41	36
Total	40	58	—	116	83	184	90	36	147	94
1991										
Mallard	12	36	—	24	8	32	30	11	27	22
Blue-winged Teal	24	16	—	24	18	32	30	11	27	22
Other	20	24	—	44	22	44	24	20	64	33
Total	56	76	—	124	61	124	90	53	128	89
Means (all years)										
Mallard	13	19	12	16	12	30	21	16	20	18
Blue-winged Teal	11	16	19	42	21	43	36	24	44	29
Other	12	17	9	21	19	39	13	15	42	22
Totals	36	52	40	79	52	112	70	55	106	69

[a] Waterfowl Production Areas are identified by numbers as follows: 613-Flaters, 710-Oakridge, 716-Deer Park, 717-Lundy Pond, 719- Erickson, 720-Ausen-Star Prairie, 724-Bierbrauer, 727-Amschler, and 733-Hanten.

[b] Other duck species include: Gadwall, Wigeon, Shoveler, Green-winged Teal, Wood Duck, Redhead Duck, Ring-necked Duck, Lesser Scaup, Bufflehead, Ruddy Duck, Common Merganser, Red-breasted Merganser, and Hooded Merganser.

densities of 12.4/mi² for the Mallard, 15.0 for the Blue-winged Teal, and 37.3 for all ducks in the study area in 1978-79. On waterfowl management areas in southern Wisconsin, Wheeler et al. (1984) found higher breeding pair densities than in surrounding private lands. Their estimates were 35.2 breeding pairs/mi² for all ducks (6.0 for Mallards, 18.4 for Blue-winged Teal, and 10.9 for other ducks).

March et al. (1973) found that average breeding duck densities were up to 14 times greater on waterfowl management areas than the mean density for the three regions of Wisconsin they surveyed. In my study, breeding pair densities were 10 times higher in WPAs than in nearby private, agricultural lands. Drewien and Springer (1969) concluded that Blue-winged Teal wetland use is probably influenced by the availability of undisturbed nest cover adjacent to wetlands.

What other factors can control breeding pair densities? One hypothesis is that homing of successfully nesting hens and their daughters (Sowls 1955, Coulter and Miller 1968, Majewski and Beszterda 1990, Lokemoen et al. 1990, Clark and Shutler 1999) would increase breeding pair densities in subsequent years. In this study, however, there was no significant relationship between the mean Mayfield nest success for Mallards (r=+0.080, t=0.214, P=0.84), Blue-winged Teal (r=+0.039, t=0.102, P=0.92), or all ducks (r=-0.037, t=0.098, P=0.92) in any given year (n) compared to the breeding pair densities for the same species the following year (n+1). Years of higher nest success did not result in an increase in breeding pair densities the following year. Perhaps, the scale or size of the study area masked increases in breeding pair densities due to homing of successfully nesting females.

There was no significant relationship between waterfowl breeding pair densities for all ducks and total wetland densities in the study

Duck nesting cover. Top photo is Flaters WPA. Bottom photo is Amschler WPA.

area (r=-0.040, t=0.112, P=0.91). The same lack of relationship was evident when comparing only wetlands with the highest occupancy by all ducks, Types III, IV, and V (r=-0.161, t=0.462, P=0.66). These results agree with those reported by March et al. (1973) for Wisconsin, but are contrary to what Krapu et al. (1983) found in eastern North Dakota for Mallards and what Leitch and Kaminski (1985) found in Saskatchewan for Blue-winged Teal, where breeding pair densities increased with an increase in density of May ponds or wetlands.

When examining individual wetlands types, a significant relationship was found between Type III wetland densities and Blue-winged Teal breeding pair densities (r=-0.688, t= 2.683, P=0.03). As the density of Type III wetlands in the study area increased, teal breeding pair densities decreased. Reasons for this response are unclear.

Vegetation

Nest cover was placed into three types based upon IVs≥0.50. Nest cover dominated by switch grass (*Panicum virgatum*) had a mean early VOR of 28.2 centimeters (cm) (n=91) and a late VOR of 55.6 cm (n=97) during 1982-90. Nest cover dominated by cool season grasses, predominately bluegrass (*Poa pratensis*), quackgrass (*Agropyron repens*), smooth brome (*Bromus inermis*), timothy (*Phleum pratense*), and foxtails (*Setaria* spp.), had a mean early VOR of 13.7 cm (n=531) and a mean late VOR of 37.8 cm (n=544). Forb dominated nest cover, mostly ragweed (*Ambrosia artemisiifolia*), milkweed (*Asclepias vetticillata*), goldenrod (*Solidago* spp.), clover (*Trifolium* spp.), alfalfa (*Medicago* spp.), and sweet clover (*Meliotus* spp.), had a mean early VOR of 14.9 cm (n=118) and a mean late VOR of 51.1 cm (n=131). A complete plant species list for nest cover can be found in Evrard and Lillie (1996).

Petersen et al. (1982), in the same area as this study, reported a mean 100% VOR of 21.1 cm for residual switch grass, followed by an annual quackgrass weed mixture (6.1 cm), timothy-bluegrass-quackgrass mixture (4.1 cm), and an annual bluegrass weed mixture (3.0 cm). They found switch grass to be more resistant to snow pack than cool season grasses.

The mean early VOR of 15.7 cm for all WPA nest cover was significantly less than the mean late VOR of 42.7 cm (t=6.834, df=8, P=0.01) (Table 6). Mean early VORs varied

Table 6. *Vegetation measurements (cm) of WPA nesting cover, 1982-90.*

Year	Mean VOR		Mean Height		Mean Litter Depth	
	Early	Late	Early	Late	Early	Late
1982	9.13	35.36	—	—	—	—
1983	7.86	41.19	40.55	90.45	3.17	2.87
1984	8.08	55.01	30.88	93.56	4.32	2.63
1985	23.97	46.11	74.62	78.22	3.10	2.62
1986	13.47	46.38	47.45	85.80	3.54	3.16
1987	25.41	42.15	74.62	84.30	3.75	2.63
1988	17.87	23.23	62.67	56.65	3.95	3.09
1989	11.18	46.19	44.82	87.23	2.68	2.84
1990	23.97	49.34	74.16	85.19	2.53	2.46
Mean	15.66	42.77	49.97	73.49	3.00	2.48
Standard Deviation	7.28	9.14	24.86	29.56	1.27	0.96

between years with a low of 7.86 cm in 1983 to a high of 25.41 cm in 1987 (Table 6). The low mean late VOR recorded in 1988, was due to the lack of rainfall caused by the drought (Table 6). Mean early vegetation height (49.97 cm) was significantly less than mean late height (73.49 cm, t=2.828, df=8, P=0.02) (Table 6). As with the VORs, there was less variation in the mean late height than in the mean early height (Table 6).

There was a significant relationship between early vegetation VORs and early vegetation height (r=+0.862, t=4.491, P=0.03), but not between late VORs and late vegetation height (r=+0.567, t=1.920, P=0.10). As the mean early vegetation VORs increase, the mean early vegetation height increased.

Based upon the differences between mean early and late vegetation VORs and height, it is apparent that heavy snow in some winters flattened and decreased the quality of the vegetation available as residual nesting cover the following spring.

The mean early litter depth (3.0 cm) was greater than the mean late litter depth (2.48 cm, t=2.648, df=8, P=0.03) (Table 6). This relationship was consisted among years (r=+0.893, t=5.251, P=0.001). It appears that the snow pack, which flattened the residual vegetation (i.e. lowered mean early VORs and height), increased the mean early litter depth. Decomposition of the dead residual vegetation during the growing season reduced the mean litter depth measured at the cessation of plant growth in the early autumn (Table 6).

Duck Nesting

A total of 796 duck nests were found in WPAs during 1982-90 (Table 7). Blue-winged Teal comprised 63%, Mallards 36%, and other species (Green-winged Teal, Northern Shoveler and Ring-necked Duck) 1% of the total nests found. Interestingly, three Ring-necked Duck nests were found in upland nesting cover (Evrard et al. 1987). Ringnecks normally nest in aquatic vegetation over or adjacent to water (Mendall 1958).

In a 1977-81 nesting study in the Grand River Marsh Wildlife Area in southern Wisconsin, Wheeler et al. (1984) found that Blue-winged Teal comprised 84%, Mallards 10%, Gadwall 4%, and other ducks (Northern Shoveler, American Wigeon, Northern Pintail, and Green-winged Teal) 2% of 918 nests found. They reported an estimated mean density of 2.2 nests per acre using a nest searching technique identical to this study. The mean nest density estimated in this study was considerably lower (0.14 nests/acre) despite nearly identical breeding pair estimates (i.e. 73.0 pairs/mi^2 in Wheeler et al. 1984 and 68.4 pairs/mi^2 in this study). An explanation may be the nesting cover in the Grand River Marsh Wildlife Area was concentrated around one large wetland (Wheeler et al. 1984) while nesting cover in this study surrounded many small wetlands widely dispersed throughout the study area.

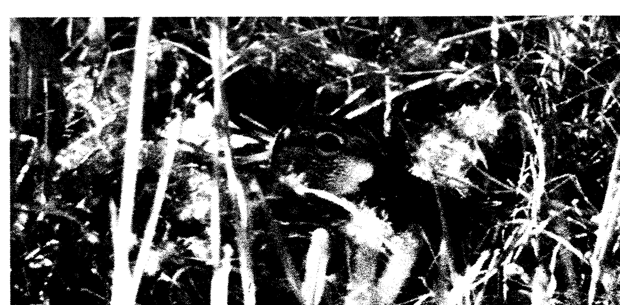
Nest Characteristics

The mean VOR at 291 Mallard nests (36.1 cm) was significantly greater than the mean VOR at 534 Blue-winged Teal nests (24.9 cm, t=10.887, df=9, P=0.000002). With these preferences and the very strong relationship that exists between the single vegetation height measurement and the mean of eight VOR vegetation measurements at each nest (r=+0.919, t=8.746, P=0.000001), it is apparent that Mallards in this study and other studies (Schranck 1966, Fleskes, 1986, Glup 1987) prefer to nest in taller, denser vegetation than Blue-winged Teal. Duebbert and Lokemoen (1980) found that 98% of 499 Mallard nests were found in cover that exceeded 30.5 cm in height. Livezey (1981b) found the mean height at Mallard nests to be 18$\pm$1 cm and 15$\pm$1 cm for Blue-winged Teal in retired croplands in the Horicon National Wildlife Refuge. Lokemoen et al. (1990) found higher Mallard nest densities in tall and dense cover (with greater VORs) while Blue-winged Teal selected shorter cover nearer to water. In an Iowa study, the mean VOR at Mallard nests was 34.0 cm, significantly greater than the mean VOR of 24.9 cm at Blue-winged Teal nests (Fleskes and Klaas 1991). Shaffer et al. (1985) in a study of 15 areas in North Dakota, Saskatchewan, and Manitoba suggested that Blue-winged Teal do not nest in fields where the VOR is $\leq$20.32 cm in the early spring.

In this study, dominant plant species at Mallard nests was Switchgrass (36%) and Bromegrass (30%) with other grasses (11%) and forbs (16%) making up the balance of the vegetation. This was residual vegetation from the previous growing season. Glup (1987), in an Iowa study, found that Mallards were more frequently found in Switchgrass.


JAMES O. EVRARD

Blue-winged Teal nest found while cable dragging.


RON GATTI

Blue-winged Teal nesting in dense cover.

Dominant plant species at Blue-winged Teal nests in this study was bluegrass (31%), Bromegrass (26%), and quackgrass (20%) with the balance being other grasses (8%) and forbs (8%). Some of these grasses were residual, but green growing grass was also important. Bluegrass and bromegrass was heavily used by Blue-winged Teal as nesting cover in other studies (Burgess et al. 1965, Krapu et al. 1970, Heiser 1971, Miller 1976, Kaiser et al. 1979, Weller 1979, Livezey 1981b, Glup 1987).

Blue-winged Teal tended to nest closer to water (mean distance=357.5 ft) than the Mallard (mean distance=591.4 ft). This finding agrees closely with previous studies (Sowls 1955, Bergquist 1973, Duebbert and Lokemoen 1976, Duebbert and Frank 1984).

Nest Success

Mean Mayfield duck nest success during this study was 21.3% for 621 duck nests (Table 8, Fig. 2). Wheeler et al. (1984) found a mean Mayfield nest success of 17% in his southern Wisconsin study during 1977-81.

In this study, there was no difference between pooled 1982-90 mean Mayfield nest success for the Mallard (21.6%) and Blue-winged Teal (22.2%) in the WPAs (t=0.265, df=7, P=0.80) (Table 8). The 1982 Mallard nest success estimate (6%) is questionable due to the small sample size of eight nests (Greenwood et al. 1995). Initially, nest success for Mallards and Blue-winged Teal were similar,

Table 7. *Duck nests found in WPAs and estimated number present, 1982-90.*

	Year									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
Species										
Mallard	15	23	27	33	33	48	45	27	33	284
Blue-winged Teal	49	67	77	52	45	58	46	51	56	501
Green-winged Teal	0	2	1	1	0	0	0	0	0	4
Northern Shoveler	1	1	1	1	0	0	0	0	0	4
Ring-necked Duck	0	0	1	1	0	0	0	1	0	3
Total nests	65	93	107	88	78	106	91	79	89	796
Estimated nests[a]	94	115	131	168	180	200	156	138	153	1,335
Percent found	69	81	82	52	43	53	58	57	58	59.6
Acres searched	998	897	1,082	1,082	1,089	1,092	1,092	1,080	1,087	9,499
Nests[a]/100 acres	9.2	12.8	12.0	15.2	16.4	18.0	14.0	12.8	14.0	14.0

[a] Density = Number of hatched nests divided by Mayfield nest success (Miller and Johnson 1978).

Table 8. *Percent duck nest success for WPAs, 1982-90 (Mayfield Method).*

	Mallard	Blue-winged Teal	Other Species[a]	Total
Year				
1982	6 (8)[b]	20 (24)	— (0)	16 (32)
1983	33 (18)	33 (48)	— (2)	32 (68)
1984	31 (14)	33 (61)	— (2)	34 (77)
1985	19 (19)	25 (40)	— (3)	23 (62)
1986	18 (30)	13 (39)	— (0)	15 (69)
1987	23 (40)	22 (57)	— (0)	22 (97)
1988	17 (28)	23 (43)	— (0)	15 (71)
1989	11 (24)	20 (42)	— (1)	16 (67)
1990	36 (30)	11 (48)	— (0)	19 (78)
Mean	21.6 (211)	22.2 (402)	— (8)	21.3 (621)

[a] Other duck species include: Shoveler, Green-winged Teal and Ring-necked Duck.
[b] Numbers in parenthesis represent the number of nests where fates were known and that were used in Mayfield nest success calculations. No estimates of nest success were made for samples of <5 nests.

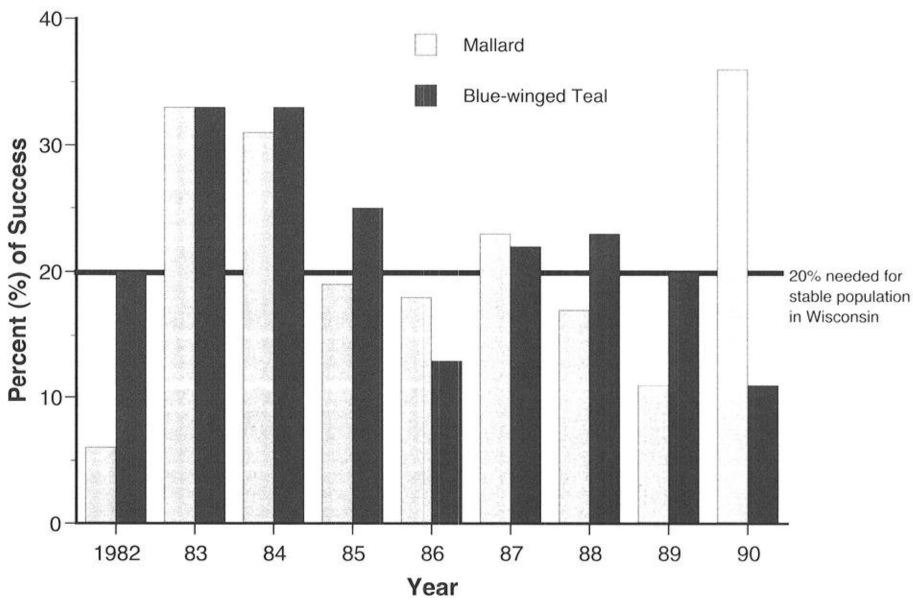


Figure 2. *Mayfield nest success for Mallard and Blue-winged Teal in Waterfowl Production Areas.*

Table 9. *Percent duck[a] nest success on individual WPAs, 1982-90 [Mayfield method].*

	Waterfowl Production Area[b]									
Year	**613**	**710**	**716**	**717**	**719**	**720**	**724**	**727**	**733**	**Total**
1982	—	15	—	—	25	—	10	9	24	16
	(0)[c]	(6)	(0)	—	(9)	—	(4)	(10)	(2)	(32)
	—	[17][d]	—	—	[26]	—	[14]	[29]	[3]	[89]
	(9)[e]	*(9)*	*(0)*	—	*(11)*	—	*(8)*	*(21)*	*(3)*	*(61)*
1983	24	15	44	6	58	—	60	26	1	32
	(10)	(6)	(5)	(4)	(16)	—	(13)	(12)	(3)	(69)
	[17]	[12]	[7]	[50]	[21]	—	[16]	[15]	[0]	[138]
	(13)	*(8)*	*(5)*	*(7)*	*(17)*	—	*(14)*	*(13)*	*(6)*	*(83)*
1984	64	12	45	2	59	100	57	46	32	34
	(4)	(4)	(3)	(18)	(21)	(2)	(11)	(9)	(4)	(77)
	[6]	[5]	[4]	[25]	[29]	[2]	[11]	[22]	[3]	(107)
	(4)	*(7)*	*(3)*	*(20)*	*(22)*	*(2)*	*(14)*	*(9)*	*(4)*	*(85)*
1985	29	100	100	100	17	0	10	40	29	23
	(6)	(1)	(1)	(3)	(19)	(1)	(16)	(11)	(4)	(61)
	[12]	[1]	[1]	[3]	[54]	[0]	[64]	[14]	[9]	[158]
	(6)	*(4)*	*(1)*	*(3)*	*(31)*	*(1)*	*(17)*	*(16)*	*(4)*	*(83)*
1986	16	100	—	100	5	100	15	11	23	15
	(6)	(1)	—	(1)	(23)	(2)	(19)	(8)	(8)	(69)
	[25]	[1]	—	[1]	[133]	[2]	[39]	[15]	[17]	[233]
	(6)	*(2)*	—	*(1)*	*(26)*	*(2)*	*(21)*	*(11)*	*(8)*	*(77)*
1987	3	15	—	24	14	14	54	15	9	22
	(3)	(4)	—	(2)	(28)	(8)	(28)	(17)	(8)	(96)
	[17]	[8]	—	[14]	[50]	[33]	[37]	[32]	[33]	[224]
	(3)	*(5)*	—	*(2)*	*(26)*	*(8)*	*(31)*	*(17)*	*(9)*	*(101)*
1988	0	1	—	0	18	4	31	7	26	15
	(2)	(6)	—	(2)	(12)	(3)	(25)	(9)	(13)	(73)
	—	—	—	—	[22]	—	[45]	[22]	[22]	[111]
	(3)	*(6)*	—	*(3)*	*(17)*	*(5)*	*(28)*	*(11)*	*(15)*	*(88)*
1989	28	2	—	12	40	20	32	11	10	16
	(5)	(8)	—	(7)	(14)	(1)	(18)	(5)	(8)	(68)
	[8]	—	—	[6]	[20]	—	[32]	[18]	[20]	[104]
	(6)	*(8)*	—	*(7)*	*(14)*	*(1)*	*(19)*	*(9)*	*(11)*	*(75)*
1990	20	0	—	2	11	100	43	3	27	19
	(8)	(3)	—	(11)	(16)	(3)	(24)	(10)	(2)	(77)
	[15]	—	—	[17]	[40]	—	[35]	[17]	[3]	[127]
	(8)	*(7)*	—	*(13)*	*(19)*	*(5)*	*(24)*	*(10)*	*(2)*	*(88)*

[a] Duck species include: Mallard, Blue-winged Teal, Shoveler, Green-winged Teal, and Ring-necked Duck.

[b] Waterfowl Production Areas are identified by numbers as follows: 613-Flaters WPA, 710-Oakridge WPA, 716-Kostka-Chovan WPA, 717-Lundy Pond WPA, 719-Erickson WPA, 720-Star Prairie-Ausen WPA, 724-Bierbrauer WPA, 727-Amschler WPA and 733-Hanten WPA.

[c] Numbers in parenthesis represent the number of nests used to calculate Mayfield nest success.

[d] Numbers in brackets represent the number of estimated nests using the Mayfield method.

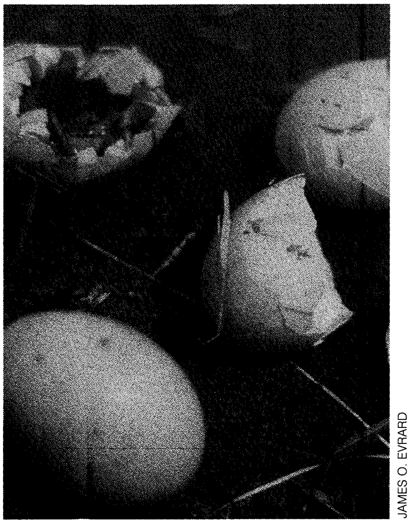
[e] Italic numbers in parenthesis represent the number of nests actually found.

rising and falling synchronously (Fig. 2). However in 1989, Blue-winged Teal nest success was nearly double that of Mallards. In 1990, that situation was reversed with Mallards having a nest success nearly three times greater than Blue-winged Teal (Fig. 2).

USFWS researchers in the Dakotas determined that a Mayfield nest success of 15% was needed to maintain a stable Mallard population (Cowardin et al. 1983) and a Mayfield nest success of 20% for a stable Blue-winged Teal population (Klett et al. 1988). In Wisconsin, Gatti (1987) calculated that a Mayfield nest success of 20% was needed for a stable Mallard population due to higher mortality factors in Wisconsin than in the Dakotas. Mean nest success for the Mallard and the Blue-winged Teal in this study was at or above the 20% population maintenance level in 7 of the 9 years (Fig. 2). The mean nest success was higher than 1982-85 nest success reported for Canadian prairie potholes by Greenwood et al. (1995).

Duck nest success is highly dynamic, varying both temporally and spatially. When nest density increases, nest success often decreases (Glover 1956, Weller 1979, Martz 1967, Kaiser et al. 1979, Livezey 1981a, Cowan 1982, Hill 1984b, Hill 1984c, Fleskes 1986, Fleskes and Klass 1991). Gatti (1987), studying nesting ducks in three Wisconsin study areas during 1983-85, found lower nest success on larger management areas. The past studies he reviewed showed an inverse relationship between nest success and duck population densities, which are generally higher on larger properties (Gatti 1987). It may be that the relatively small and widely dispersed WPAs make it more difficult for predators to encounter nests compared to larger wildlife management areas and refuges (Dzubin and Gollop 1972, Sargeant 1972).

There was no relationship between yearly nest success and nest density for pooled WPAs



Predator destroyed Mallard nest.

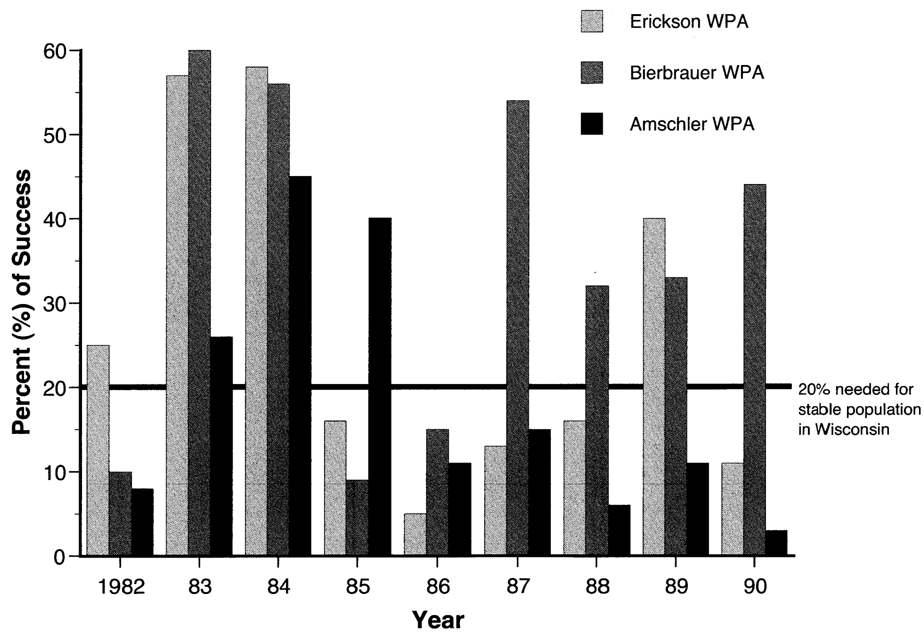


Figure 3. *Mayfield nest success for all ducks in selected Waterfowl Production Areas.*

(r=0.190, t=0.511, P=0.62). But there was a significant relationship when comparing nest success and density in individual WPAs with 6 or more duck nests in a year (r= -0.498, t=3.252, P=0.03) (Table 9).

This supports Gatti's (1987) conclusions that: 1) nest success on single study areas is highly variable between years, 2) nest success is not synchronous between study areas in any single year, and 3) no study area has high nest success in 3 consecutive years. Greenwood et al. (1995) also reported similar findings for 17 study areas spaced across the prairie pothole region of Canada.

Applying the metapopulation theory (Taylor 1991) to Wisconsin, Gatti (1987) speculated that waterfowl production is stable or increasing despite below replacement nest success in some areas (or populations) in some years. For this to occur, nest success in other areas of the state has to be above replacement level.

It is possible to apply that concept to this study. The study area could be considered a metapopulation and three WPAs having at least eight nests sampled annually (719-Erickson, 724-Bierbrauer, and 727-Amschler) could be considered member populations (Table 9). At first glance it might appear that there is synchrony in nest success among the three WPAs. However, there appeared to be some variation in annual nest success between these WPAs (Fig. 3). This variation could be caused by something as simple as a fox (*Vulpes vulpes*) family hunting in a particular WPA one year and not using the same WPA the following year. Fleskes and Klass (1991) found that duck nest success increased dramatically in the absence of foxes. The dynamic nature of duck nest success found in this study could be a response to predator induced, density dependent nest success.

Given the relatively low mean density of duck nests in this study (0.14/acre), it is unlikely that nest predators were searching for duck eggs as a major food source. Sugden and Beyersbergen (1986) thought that a minimum nest density of 2-3 nests per acre was needed to trigger density dependent nest predation by crows (*Corvus brachyrhynchos*). At that density, crows evidently developed a search image for nests rather than finding them incidentally.

In a sandplain grassland study in Maine, Vickery et al. (1992) found that the striped skunk was the major nest predator of grassland bird nests. They concluded, however, that the skunks found the nests incidental to their foraging for their main prey, invertebrates. The same conclusion was reached by Crabtree and Wolfe (1988), in a study of skunk predation on waterfowl nests in Utah.

Habitat may be managed to discourage nest predators. Burning reduces invertebrates during the first year following the burn (Anderson et al. 1989, Siemann et al. 1997). As a result, there may be a lower number of predators foraging for invertebrates, thus reducing the chances of incidental nest predation. Johnson and Temple (1990) reported lower nest predation for five songbird species in recently ($\leq$3 yr) burned tallgrass prairie.

In this study, the red fox, striped skunk, raccoon, and American badger (*Taxidea taxus*) were thought to be the predators responsible for most of the nest destruction. However, Greenwood (1989), Trevor et al. (1991), Lariviere and Messier (1997), Hernandez et al. (1997), and Sargeant et al. (1998) recently cast doubt upon the determination of mammalian nest predators based upon interpretation of sign at the nest.

Klett et al. (1988) attributed most duck nest predation in the U.S. prairie pothole region to the red fox, striped skunk, American mink (*Mustela vison*), raccoon, badger, and Franklin's ground squirrel (*Spermophilus franklinii*). Glover (1956) found most Blue-winged Teal nest destruction in Iowa was caused by skunks, mink, and raccoons. Gates (1965) thought skunks and raccoons were the most important duck nest predators in his east central Wisconsin study area. Bergquist (1973) reported that the skunk, raccoon, and ground squirrels were responsible for most of the nest predation encountered in northwest Wisconsin. More recently, Sovada et al. (1999) found a high frequency of ducks and duck eggs in the diet of badgers in west central Minnesota and southeastern North Dakota.

An examination of pooled 1982-90 nests for Mallards and Blue-winged Teal showed no difference in success rates between early and late nests. Mallard nest success for 116 early nests and 108 late nests was 19% and 26% respectively (χ^2=1.03, df=1, *P*=0.31). Blue-winged Teal nest success for 240 early nests and 174 late nests was 24% and 26% respectively (χ^2=0.03, df=1, *P*=0.87). Nests were categorized as early or late if their initiation date (date of first egg) occurred before or after the mean nest initiation date.

Factors Affecting Nest Success

The 34 variables measured at the nest were included in a exponential regression model to determine what environmental factors, if any, affected nest success for Mallard and Blue-winged Teal in WPAs.

Since there was no difference between mean Mallard and mean Blue-winged Teal nest success pooled for years (*P*=0.80, Table 8) the two species were combined. Nest success for pooled Mallard and Blue-winged Teal varied significantly between years (χ^2=22.42, df=7, *P*=0.01) and between WPAs (χ^2=27.54, df=5, *P*=0.0001).

Hatched Mallard nests had only slightly greater VORs (14.6 in) than destroyed Mallard nests (14.3 in; χ^2=4.200, df=1, *P*=0.04). Hatched Blue-winged Teal nests also had slightly greater VORs (10.1 in) than destroyed nests (9.3 in, χ^2=7.17, df=1, *P*=0.007). Some studies have reported higher nest success related to greater vegetation concealment at the nest (Glover 1956, Duebbert 1969, Kirsch 1969, Bengston 1970, Heiser 1971, Dwernychuk and Boag 1972, Kirsch et al. 1978, Livezey 1981a, Hines and Mitchell 1983, Hill 1984a, Cowardin et al. 1985, Glup 1987, Higgens et al. 1992, Guyn and Clark 1997, Clark and Shutler 1999), whereas other studies found no relationship between vegetative nest cover and nest success (Byers 1974, Wheeler et al. 1984, Clark et al. 1991) had.

Hatched Mallard nests had slightly less grass coverage at the nest (76%) than destroyed nests (80%; χ^2=4.72, df=1, *P*=0.03) and conversely, higher coverage of forbs at hatched nest (24%) than at destroyed nests (16%; χ^2=3.89, df=1, *P*=0.05).

Successful Blue-winged Teal nests also had slightly less grass coverage around the nest (83%) than unsuccessful nests (88%; χ^2=7.01, df=1, *P*=0.008). Heiser (1971) reported significantly more forb cover at hatched Blue-winged Teal nests than at destroyed nests. In this study, hatched Blue-winged Teal nests had more bromegrass cover (29% vs. 20%; χ^2=5.80, df=1, *P*=0.02) and less bluegrass cover (25% vs. 34%; χ^2=8.85, df=1, *P*=0.003) than destroyed nests.

There were no differences in Mallard (χ^2=0.52, df=2, *P*=0.772) and Blue-winged Teal (χ^2=2.303, df=2, *P*=0.32) nest success in nest cover dominated by switch grass, cool season grasses, or forbs. Mallard nest success was 22% in switch grass dominated nest cover (≥0.50 IV) (n=17 nests), 23% in cool season grasses (n=118 nests), and 19% in forbs (n=38 nests). Blue-winged Teal nest success in switch grass was 29% (n=21), 23% in cool season grasses (n=259), and 20% in forb dominated nest cover (n=45).

Litter depth at the nest was less for successful Blue-winged Teal nests (2.8 cm) than for destroyed nests (3.6 cm; χ^2=4.48, df=1, *P*=0.03). A possible explanation for this result may be that deeper litter could result in more voles and, therefore, lower nest success. Successful and destroyed Blue-winged Teal nests appeared to be located nearly the same distance from the edge of the nesting cover (mean distance=134 ft vs. 138 ft, respectively) but were further from water (388 ft vs. 310 ft, respectively; χ^2=8.35, df=1, *P*=0.004). Kantrud (1993) reported that duck nest success increased with and increase in the distance from water.

Nest Success and Predator Indices

When pooled mean WPA Mayfield nest success is compared by years with predator and prey indices, several relationships became apparent. Although no relationships were found for the Mallard, nest success for Blue-winged Teal was correlated with the roadkill index for all predators (*r*=-0.70, *t*=2.624, *P*=0.03), for red fox (*r*=-0.804, *t*=2.707, *P*=0.05), and for raccoon (*r*=-0.910, *t*=4.375, *P*=0.01). As the predator populations increased, nest success for the Blue-winged Teal, but not the Mallard, decreased. This could explain the disparity between nest success of Mallards and Blue-winged Teal in 1989 and 1990 (Fig. 2). Byers (1974) found that predator abundance in one Iowa management area was inversely related to Blue-winged Teal nesting success. There were no apparent relationships between nest success and the other two predator indices, the spotlight survey and the scent station survey in this study.

The results of this part of the study suggest that the relatively inexpensive roadkill survey can provide indices to predator populations which can be related to Blue-winged Teal nest success. As the number of roadkilled fox and raccoon increased throughout the study area, nesting success for Blue-winged Teal in the WPAs decreased.

Relationships Among Predator Indices

The roadkill index for all predators was significantly related to the scent station index (r=0.853, t=3.265, P=0.03) but not the spotlight index (r=-0.263, t=0.54, P=0.61). The scent station index was not significantly related to the spotlight index (r=-0.207, t=0.42, P=0.69). When examined on a species level, the only significant relationship existed between raccoon population indices on spotlight transects and scent station transects (r=+0.898, t=4.088, P=0.02).

Roadkill Survey Indices

During 1983-1985, 95.7% of all road-killed predators were recorded. The striped skunk was the most numerous and consistent road-killed species followed by the raccoon and the red fox during 1984-90 (Table 10). A few badger and mink were occasionally recorded. As a result of a recent range extension from the south, the Virginia opossum (*Didelphis virginiana*) appeared late in the study and was first recorded as a roadkill in 1990.

There appeared to be two peaks in predator roadkills, one in 1986 and the other in 1990, and lows in 1983 and 1989. The 1986 peak indicated high skunk population with modest raccoon and fox populations (Table 10). The 1990 peak indicated high raccoon and fox numbers, not skunk (Table 10). The causes for fluctuations of numbers of the nest predators are unknown.

Roadside Scent Station Survey

The red fox was the most common predator recorded on WPA scent station transects followed by the dog, cat, and striped skunk during 1984-90 (Table 11). On the PL transects, the dog was most common followed by the cat, fox, and skunk. Predator numbers (fox, raccoon, skunk, badger, mink, and weasel) at WPA transects were significantly correlated with predator numbers at PL transects (r=0.77222, df=5, P=0.04). The number of predators fluctuated similarly on both WPA and PL scent station transects but were significantly higher on WPA transects (t=4.565, df=6, P=0.004). There was a significant difference in cover types between the WPA and PL transects (χ^2=24.560, df=7, P=0.001). WPA transects were characterized by fewer agricultural fields (58% vs. 78%), more undisturbed grassland (22% vs. 5%) and wetlands (8% vs. 1%), and fewer buildings (3% vs. 6%). The habitat differences existing between WPA and PL transects may be the reason for the larger number of potential duck nest predators recorded on the WPA transects.

Table 10. *Road-killed predators per 1,000 miles driven in study area, April - October, 1982-90.*

	Year								
	1982	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
Predator									
Red Fox	—	0.05	0.02	0.05	0.12	0.02	0.08	0.02	0.12
Common Raccoon	0.05	0.08	0.12	0.20	0.38	0.15	0.18	0.15	0.45
Striped Skunk	0.22	0.05	0.30	0.35	0.96	0.50	0.22	0.12	0.40
Virginia Opossum	—	—	—	—	—	—	—	—	0.05
American Badger	0.02	0.02	—	—	0.02	—	0.02	—	—
Mink	0.02	0.02	0.02	0.05	0.05	0.05	0.02	0.01	0.05
Total	0.31	0.22	0.46	0.65	1.53	0.72	0.52	0.30	1.07
Miles Driven (thousands)	19.6	27.2	29.4	24.8	22.1	28.3	27.1	35.6	31.4

Table 11. *Predator visits to roadside scent stations adjacent to WPAs and private lands (PL), 1984-90.*

	Year														Totals	
	1984		**1985**		**1986**		**1987**		**1988**		**1989**		**1990**			
	WPA	**PL**	**WPA**	**PL**	**WPA**	**PL**	**WPA**	**PL**	**WPA**	**PL**	**WPA**	**PL**	**WPA**	**PL**	**WPA**	**PL**
Predator																
Red Fox	4	0	9	8	8	3	10	8	5	2	7	1	9	6	52	28
Common Raccoon	0	3	0	2	2	2	1	2	3	0	4	2	3	2	13	13
Striped Skunk	4	3	7	7	3	2	6	6	0	1	6	4	1	1	27	24
American Badger	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0
Mink	1	0	1	0	1	0	2	2	0	0	0	0	0	0	5	2
Weasel	0	1	2	0	1	0	3	0	1	0	0	0	0	0	7	1
Domestic Cat	1	0	4	2	8	2	2	2	2	4	3	7	9	13	29	20
Dog	5	10	4	8	9	8	2	2	5	11	2	13	9	5	36	57
Unknown	1	2	0	0	5	2	0	0	0	1	1	0	0	0	7	5
Total	17	19	28	27	37	19	26	22	16	19	23	27	31	27	178	160

Red fox population trends on WPA transects were correlated with trends on PL transects (r=0.81595, df=5, P=0.02). Red fox numbers were also significantly higher on WPA transects than PL transects (t=5.694, df=6, P=0.001) (Table 11). Striped skunk populations on WPAs were strongly correlated with PL transects (r=0.98295, df=5, P=0.00007) but skunk numbers were only slightly higher on WPA transects vs. PL transects (t=2.35907, df=6, P=0.056). There was no significant relationship between raccoon, house cat, and dog population trends or numbers on WPA and PL scent station (r=0.674731, df=5, P=0.10).

Scent station indices were found to agree with known populations of raccoons in western Tennessee (Leberg and Kennedy 1987) and Florida (Conner et al. 1983), but not in eastern Tennessee (Nottingham et al. 1989) and Alabama (Hill and Summer 1980). Gabor et al. (1994) found that roadside scent stations were not as valuable scent stations placed randomly. However, scent stations were valid population indices for striped skunks in Minnesota (Fuller and Kuehn 1985) and dogs (*Canus domesticus*) and house cats (*Felis catus*) in Alabama (Hill and Sumner 1980).

Spotlight Survey

The house cat (*Felis catus*) was the most numerous predator recorded on both WPA and PL spotlight transects (Table 12). There were no statistical differences between the cover components of the WPA and PL transects (χ^2=8.444, df=6, P=0.21). However, numbers of house cats were significantly higher on WPA transects (t=3.509, df=5, P=0.02) where slightly more idle land could provide better hunting habitat for the exotic predator. Spotlight surveys have been tested as a population index for various species including raccoon (Rybarczyk 1978, Rybarczyk et al. 1981) and striped skunk (Jacobson 1969, Cool and Fredrickson 1976).

Nest Success and Prey Indices

Blue-winged Teal nest success was correlated with pocket gopher mound densities in late April (r=0.832, t=3.675, P=0.01), but Mallard nest success was not (r=+0.295, t=0.756, P=0.48). Mounds are known to have different soil chemistry and vegetation than the surrounding undisturbed habitat (Huntly and Reichman 1994). As a result, there is greater species richness in nesting cover containing pocket gopher mounds. The disturbed soil of the mounds support an early succession of vigorous annual and biennial plants (forbs) which may provide cover needed for successful Blue-winged Teal nests (Heiser 1971).

Densities of pocket gopher mounds were correlated with densities of large fossorial mammal burrows in late April (r=0.720, t=2.540, P=0.04) and in early August (r=0.915, t=5.571, P=0.001). Since most of these burrows were dug by badgers searching for pocket gophers (Lampe 1982), based on the results of this study increased badger activity did not significantly increase Blue-winged Teal nest predation despite badgers being known to prey upon duck nests (Sovada et al. 1999).

Small Mammal Trapping

To satisfy sample size needs, nesting fields that were trapped during 1982-90 were pooled on the basis of management treatment histories. Eleven mammalian species were captured (Table 13). Voles (*Microtus* spp.) made up 51% of the small mammals trapped. Prairie voles (*Microtus ochrogaster*) were known to be present. The meadow vole (*Microtus pennsylvanicus*) is the preferred prey for duck nest predators such as the striped skunk and red fox (Eadie 1943, Fritzell 1975, Keenan 1980, Voorhees and Cassel 1980, Greenwood 1981, Yoneda 1983). The thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*) comprised 17% of all small mammals trapped followed by the deer mouse (*Peromyscus maniculatus*) and white-footed mouse (*Peromyscus leucopus*) (13%), and the masked shrew (*Sorex cinereus*) (12%). The northern short-tailed shrew (*Blarina brevicauda*) and the meadow jumping mouse (*Zapus hudsonius*) comprised 6% of the remaining catch.

It appeared that there were two peaks in *Microtus* spp. numbers during this study, one in 1984 and the other in 1988. These peaks resembled the 3-year cycle reported for voles (Krebs and Myers 1974, Birney et al. 1976, Hansson and Henttonen 1988).

Disturbances such as burning, mowing, grazing, and cultivating are necessary to prevent woody plants from invading humid grasslands. In this study, small mammal species composition changed following management disturbances such as prescribed burning designed to prevent woody encroachment (Table 13). Because fire destroys the vegetative cover and litter layer, numbers of *Microtus* spp. decreased markedly in burned nesting fields and gradually increased (F=2.170, df=7, P=0.05) in the succeeding years following the burn as litter depth deepened (F=3.841, df=7, P=0.001) although the relationship was not particularly strong (r=0.164, t=2.221, P=0.03).

Table 12. *Predators observed per mi² during spotlight surveys on private lands (PL) and WPAs, 1984-90.*

		Year						
		1984[a]	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
Predators								
Red Fox	PL	0.17	0.07	0.03	0.08	0.08	0.13	0.16
	WPA	—	0.13	0.03	—	0.05	0.19	0.08
Common Raccoon	PL	0.07	0.23	0.10	0.16	0.19	0.19	0.29
	WPA	—	0.20	0.20	0.19	0.27	0.37	0.29
Striped Skunk	PL	0.03	0.07	0.13	0.05	0.11	0.03	0.13
	WPA	—	0.17	0.03	0.03	0.03	0.03	0.03
American Badger	PL	0.03	—	0.01	—	0.01	0.03	—
	WPA	—	0.01	0.01	—	—	—	—
Mink	PL	—	—	—	—	—	—	—
	WPA	—	—	—	—	—	—	0.03
Domestic Cat	PL	0.61	0.64	0.53	0.77	0.88	0.85	1.00
	WPA	—	1.09	0.91	0.61	1.28	1.20	1.55
Total	PL	0.91	1.01	0.82	1.06	1.28	1.28	1.55
	WPA	—	1.62	1.20	0.83	1.63	1.79	1.97

[a] Surveys were conducted monthly from April through August.

Voles prosper in heavy vegetation with a deep litter layer (Moreth and Schramm 1972, Kantak 1981, Snyder and Best 1988). Eliminating the litter through management may reduce vole numbers. Vickery et al. (1992), in a sandplain grassland in Maine, reported a dearth of predators that was managed by a biennial prescribed burning that decreased the litter layer and kept small mammal populations at low levels.

In contrast, *Peromyscus* spp. and thirteen-lined ground squirrels prospered immediately following a burn but declined in the years following the burn (Table 13). The shrews and the jumping mouse followed a pattern similar to voles (Table 13).

The results for this portion of the study are similar to others. Meadow voles and short-tailed shrews (*Blarina brevicauda*) are fire negative species (Tester and Marshall 1961, Springer and Schramm 1972, Moreth and Schramm 1972, Schramm and Willcutts 1970, Vacanti and Geluso 1985, Geluso et al. 1986), whereas deer mice (*Peromyscus maniculatus*), white-footed mice (*P. leucopus*), and thirteen-lined ground squirrels are fire positive species (Tester and Marshall 1961, Springer and Schramm 1972, Schramm and Willcutts 1970, Kaufman et al. 1983, Kaufman et al. 1988, Kaufman et al. 1990, Clark and Kaufman 1990).

The effects of the cultivated crop rotation upon small mammal populations were similar to those of burning (Table 13). *Peromycus* spp. was the dominant species trapped in cornfields, but oat fields provided better habitat for a wider variety of small mammals (Table 13). In first year hay fields *Peromyscus* spp. declined and the thirteen-lined ground squirrel peaked (Table 13). *Microtus* spp. increased and *Permomyscus* spp. decreased

Table 13. *Mean adjusted Catch per Effort[a] by treatment for small mammals trapped in selected WPAs, 1982-90; n values are reported in parenthesis.*

	Species[b]							
Treatment	M.	C.	P.	S.	B.	Z.	Other Species[c]	Total
Burn (8)	0.6	0.9	1.5	0.2	<0.1	<0.1	<0.1	3.4
Burn +1 (10)	3.3	1.6	0.5	0.9	0.1	0.3	<0.1	6.7
Burn +2 (8)	4.8	1.5	0.2	1.2	0.3	0.5	0.9	8.4
Burn +3 (8)	3.4	1.4	0.1	1.3	0.2	0.3	0.1	6.7
Burn +4 (5)	3.0	0.9	0.0	1.5	0.6	0.1	<0.1	6.1
Burn +5 (4)	4.9	1.3	0.0	1.4	0.5	0.2	<0.1	8.4
Burn +6 (3)	4.5	1.5	0.0	0.6	0.0	0.0	0.0	6.6
Burn +7 (2)	1.8	1.3	0.4	0.1	0.0	0.0	0.1	3.8
Mow (2)	3.0	1.2	0.1	0.2	0.2	0.1	0.1	4.9
Mow +1 (2)	3.4	0.5	0.0	0.2	0.2	0.0	0.4	4.6
Mow +2 (2)	5.4	0.9	0.0	1.6	0.6	0.1	0.0	8.6
Mow +3 (2)	6.7	1.4	0.0	2.6	2.6	0.6	0.2	14.2
Mow +4 (1)	3.5	0.6	0.0	1.7	0.2	0.0	0.2	6.2
Mow +5 (1)	1.5	0.0	0.0	0.0	0.0	0.0	0.0	1.5
Corn (6)	0.1	0.7	4.4	0.0	0.2	<0.1	0.2	5.6
Oats (6)	0.5	0.6	3.4	0.1	0.1	0.4	<0.1	5.2
Hay 1 (5)	1.5	2.0	2.9	<0.1	0.0	0.0	0.0	6.5
Hay 2 (5)	5.1	0.8	0.9	0.2	0.0	0.0	0.0	7.0
Hay 3 (4)	4.2	1.4	0.8	0.4	0.1	<0.1	0.2	7.1
Hay +1 (4)	5.4	1.1	0.4	0.3	0.0	<0.1	<0.1	7.2
Hay +2 (3)	9.5	1.1	0.0	1.1	0.3	0.0	0.0	12.0
Hay +3 (4)	8.0	1.1	0.2	0.4	<0.1	0.0	0.1	9.8
Hay +4 (1)	0.0	1.5	0.9	0.0	0.0	0.2	0.0	2.6
Hay +5 (3)	1.6	0.8	0.0	0.6	0.8	0.0	0.1	3.9
Hay +6 (4)	2.8	0.4	0.0	0.7	0.2	<0.1	0.1	4.2
Hay +7 (2)	1.5	0.8	0.4	2.3	0.4	0.2	0.0	5.6
Hay +8 (1)	16.2	0.4	0.0	5.7	0.0	2.2	0.0	24.5

[a] Nelson and Clark 1973.

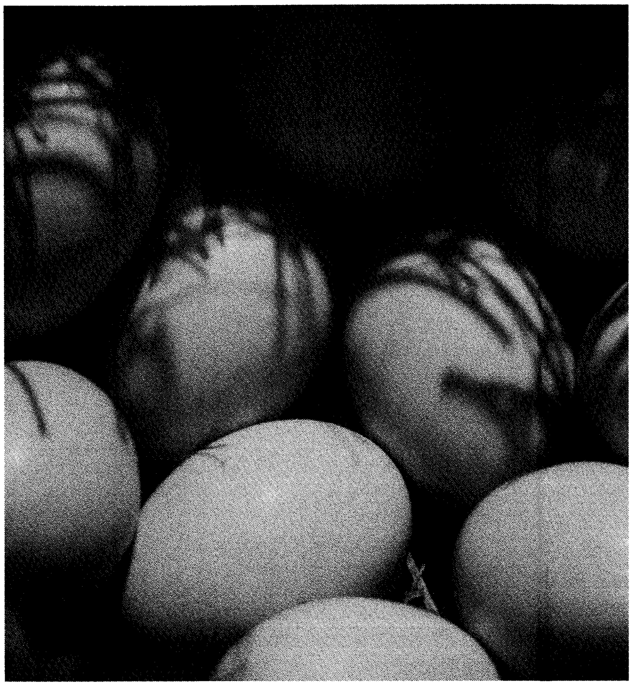
[b] M = Meadow vole (*Microtus pennsylvanicus*) and Prairie vole (*Microtus ochrogaster*), C. = Thirteen-lined ground squirrel (*Spericamus tridecemlineatus*), P = Deer mouse (*Peromyscus maniculatus*) and White-footed mouse (*Peromyscus leucopus*), S = Masked shrew (*Sorex cinereus*), B = Northern short-tailed shrew (*Blarina brevicauda*), and Z = Meadow jumping mouse (*Zapus hudsonias*).

[c] Other species include: 1 house mouse (*Mus musculus*), 1 chipmunk (*Tamias striatus*), 2 short-tailed weasels (*Mustela erminea*),and other unidentified small mammals, birds, and amphibians.

Prescribed summer burn on a WPA.

in 3 succeeding years of hay in the cultivation rotation (Table 13). Again, this may be the result of increasing litter depth. *Microtus* spp. numbers peaked in hay fields that were fallowed (>H+3, Table 13). Small mammal population fluctuations in mowed fields were similar to those in burned and cultivated fields (Table 13).

How do small mammal numbers affect duck nesting success? There was no difference between small mammal indices from nesting fields where there were similar numbers of hatched (mean Adjusted Catch per Effort (ACE)=5.2) and destroyed (mean ACE=5.2) Mallard and Blue-winged Teal nests (t=0.009, df=50, P=0.99). Based on this result, small mammal numbers did not increase or decrease duck nesting success. In other studies, however, there have been differing findings regarding the impact of small mammal populations on the nest success of upland nesting ducks. Some studies have concluded that vole populations buffer nest success with small predators, satisfying their hunger with abundant voles and destroying fewer duck nests (Byers 1974, Weller 1979). Other studies have found the converse, that abundant vole populations attract predators to nesting cover, thus destroying more bird nests in the process (Roseberry and Klimstra 1970).


BRUCE BACON

Mallard nest found on Ausen WPA showing a clutch size of 10 eggs.

Nesting Chronology

Using Mallard nests found in 1982-90, the mean peak 7-day period for nest initiation was May 8-14. This was based upon backdating using the mean clutch size and incubation period (Greenwood et. al. 1995). The nest initiation curve derived from backdating aged Mallard broods during the same years was May 1-7. During the same years, the mean peak nest initiation week for Blue-winged Teal nests was May 15-21. The mean peak nest initiation week derived from Blue-winged Teal broods was May 8-14.

The one week difference between Mallard and Blue-winged Teal breeding chronology curves derived from nests, versus initiation curves calculated from broods, may be due to the small error associated with aging duck broods using Gollop and Marshall's (1954) criteria (Evrard 1996a).

An examination of the nest initiation curves show that Mallards begin nesting earlier and over a longer time period than Blue-winged Teal. The Mallard's longer nesting curve may be an indication of renesting. Nest initiations, however, end for both species at approximately the same time. This may indicate an evolutionary response to lack of adequate time for late hatching ducklings to fledge prior to fall wetland freezing.

Nest initiation dates varied in earlier Wisconsin studies. In Crex Meadows, Mallard nest initiation began in late March and ended in early May with three peaks, an indication of substantial renesting (Jahn and Hunt 1964). At Horicon Marsh, Mallard nesting began in late April and ended in early June with a peak during the third week of May (Jahn and Hunt 1964). In the Grand River Marsh, Wheeler et al. (1984) reported two peaks in the Mallard nest initiation curve; one in late April and a slightly higher peak in late May, indicating significant renesting. In another southeastern Wisconsin study, Wheeler and March (1979) found peak Mallard nest initiations varying from mid-April to mid-May. Blue-winged Teal exhibited a shorter and later breeding season than the Mallard with only one peak, whether the curve was based upon nest or brood observations.

Clutch Size

In this study the mean clutch size for 204 hatched Mallard nests was 9.9±0.3 eggs and 11.0±0.2 eggs for 333 hatched Blue-winged Teal nests (Table 14). The mean Mallard clutch size was nearly one egg larger than what has been reported elsewhere in the Midwest. In Wisconsin, the mean reported Mallard clutch size ranged from 8.0 eggs in the northwest (Bergquist 1973) to 9.1±0.6 in the southeast (Wheeler et al. 1984). In a North Dakota study, Higgens et al. (1992) found a mean Mallard clutch size of 9.1 eggs. The mean clutch size for Blue-winged Teal nests in this study was higher than that reported elsewhere. In northwest Wisconsin, the mean Blue-winged Teal clutch was 10.7 eggs (Bergquist 1973) and 10.9±1.2 eggs in southeast Wisconsin (Wheeler et al. 1984). Higgens et al. (1992) found a mean clutch size of 10.3 eggs for Blue-winged Teal in North Dakota. Bellrose (1980) summarized nesting studies from throughout North America. He reported mean clutch sizes of 9.0 eggs for Mallard nests and 9.8 eggs for Blue-winged Teal nests.

Table 14. *Waterfowl brood attrition, 1982-90.*

Year and Species	Clutch	At Hatch	Mean Brood Size Class I[a]	Class II	Class III
1982					
Mallard	9.8 (8)[b]	8.7 (5)	6.8 (12)	5.5 (13)	7.8 (10)
Blue-winged Teal	10.4 (26)	10.5 (13)	8.2 (33)	7.5 (17)	7.4 (8)
1983					
Mallard	9.8 (19)	9.2 (10)	6.9 (48)	6.8 (30)	6.2 (47)
Blue-winged Teal	11.1 (47)	10.6 (32)	7.7 (39)	6.1 (26)	5.6 (32)
1984					
Mallard	10.4 (19)	9.6 (16)	8.1 (34)	6.0 (7)	6.8 (6)
Blue-winged Teal	10.9 (57)	10.4 (38)	8.2 (46)	8.8 (25)	7.1 (30)
1985					
Mallard	9.9 (24)	9.6 (14)	6.8 (25)	6.0 (6)	6.8 (15)
Blue-winged Teal	10.9 (38)	10.8 (22)	6.5 (49)	6.8 (17)	6.3 (19)
1986					
Mallard	10.3 (26)	8.0 (12)	8.1 (17)	6.6 (14)	6.4 (8)
Blue-winged Teal	11.0 (28)	10.9 (14)	8.0 (39)	7.2 (33)	6.8 (8)
1987					
Mallard	10.1 (36)	9.7 (22)	7.2 (55)	6.1 (31)	6.0 (22)
Blue-winged Teal	10.9 (45)	10.0 (23)	8.3 (45)	6.3 (35)	6.3 (16)
1988					
Mallard	9.8 (26)	8.5 (8)	7.4 (58)	7.5 (17)	5.9 (37)
Blue-winged Teal	11.3 (32)	9.8 (17)	5.3 (35)	7.4 (12)	4.6 (13)
1989					
Mallard	9.2 (18)	7.9 (7)	6.9 (43)	5.5 (27)	5.9 (16)
Blue-winged Teal	11.2 (33)	10.0 (15)	9.1 (41)	6.8 (24)	6.2 (17)
1990					
Mallard	9.9 (28)	9.4 (18)	7.1 (45)	6.0 (42)	6.4 (17)
Blue-winged Teal	11.4 (27)	10.7 (13)	7.7 (42)	6.8 (37)	5.6 (19)
Mean 1982-90					
Mallard	9.9±0.3[c] (204)	9.0±0.5 (112)	7.3±0.4 (337)	6.2±0.5 (187)	6.5±0.5 (178)
Blue-winged Teal	11.0±0.2 (333)	10.4±0.3 (187)	7.7±0.9 (369)	7.1±0.6 (226)	6.2±0.7 (162)

[a] Class I = 1-18 days, Class II = 19-42 days, Class III = 43-55 days. Classes taken from Gollop and Marshal (1954).
[b] Number in parenthesis represents the number of nests or broods.
[c] 95% confidence limits at $p < 0.05$.

Duck Broods

Estimated brood mortality was based upon observed attrition of mean brood size between duckling age classes (Gollop and Marshall 1954). This method provides an estimate of minimum mortality since it does not account for broods that are lost in their entirety during the brood period (Dzubin and Gallop 1972, Ball et al. 1975, Bellrose 1980, Wheeler et al. 1984, Duncan 1986, Rotella and Ratti 1992, Mauser et al. 1994). Another problem is the potential error that can be made in classifying broods in the field (Evrard 1996a).

For Mallards, there was a significant difference in mean brood size from hatch to Class I (t=5.556, df=8, P=0.0005) and from Class I to Class II (t=4.510, df=8, P=0.002), resulting in a 19% and 15% duckling loss respectively (Table 14). There was no difference in mean brood size from Class II to Class III ducklings (Table 14, t=0.679, df=8, P=0.52). Total observed Mallard duckling mortality, not including loss of entire broods, was 28% from hatch to Class III.

For Blue-winged Teal, there was a significant difference in mean brood size from hatch to Class I (t=7.152, df=8, P=0.0001) and from Class II to Class III (t=2.898, df=8, P=0.02), resulting in a 26% and a 13% loss respectively (Table 14). There was no difference from Class I to Class II (Table 14, t=1.268, df=8, P=0.24). Total observed Blue-winged Teal duckling losses in this study were 40% from hatch to fledgling.

Jahn and Hunt (1964) reported a 16% loss between Class I and III Mallard broods for 1950-56 in Wisconsin. Dzubin and Gollop (1972) reported an 11% loss between Class I and III Mallard broods in a Canadian prairie. When adding losses of entire broods, they estimated an average loss of 36% between hatching and Class III broods. Mean Mallard brood mortality from hatch to fledgling (including losses of entire broods) was 56% in north central Minnesota (Ball et al. 1975), 65% in south central North Dakota (Talent et al. 1983), and 78% in southwest Manitoba (Rotella and Ratti 1992). Jahn and Hunt (1964) estimated the average loss for Blue-winged Teal from Class I to Class III was 10%.

Most duckling mortality takes place during the first few weeks after hatch. Based upon brood attrition (not including losses of entire broods), 39% of total Mallard duckling mortality and 52% of total Blue-winged Teal duckling mortality occurred during the first week after hatch in this study.

The mean number of Blue-winged Teal ducklings hatched at the nest was significantly greater than the mean number of Mallard ducklings hatched at the nest (Table 14, t=5.821, df=8, P=0.0004). Higher Blue-winged Teal duckling mortality resulted in no significant difference between the mean Class III brood sizes for Blue-winged Teal and Mallards (Table 14, t=1.264, df=8, P=0.24).

Comparable mean Class III Mallard brood sizes reported for Wisconsin include: 6.5±0.2 (Jahn and Hunt 1964), 6.6 (Bergquist 1973), 6.5±0.4 (March and Hunt 1978), 6.3±0.8 (Wheeler and March 1979), and 5.6±0.7 (Wheeler et al. 1984). Comparable mean Class III Blue-winged Teal brood sizes include: 7.1±0.4 (Jahn and Hunt 1964), 6.3±0.4 (J.R. March, DNR, unpublished data), 6.2±0.8 (Wheeler and March 1979), 5.7 (Bergquist 1973), and 5.7±1.1 (Wheeler et al. 1984). There were no significant differences between mean Mallard and mean Blue-winged Teal Class III brood sizes in these respective studies.

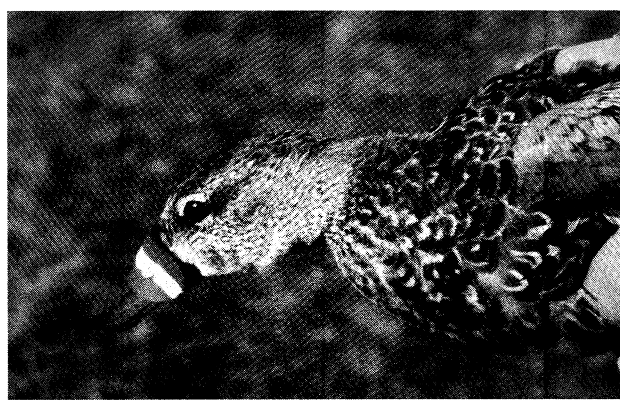
The causes of duckling mortality are many. Although anecdotal in nature, several animals not normally thought to be significant duckling predators were involved in duckling predation in this study. A webtag originally attached to a Blue-winged Teal duckling was found in the cast pellet of a Great Horned Owl (*Bubo virginianus*). House cats were seen on several occasions stalking adult nesting female ducks, and even caught a newly hatched Canada Goose (*Branta canadensis*) gosling (Evrard 1989).

Mean duckling production in selected WPA wetlands averaged 1.4 ducklings/acre for Mallards and 1.6 ducklings/acre for Blue-winged Teal (Table 15). These densities, based upon mark/recapture (resight) estimates (Otis et al. 1978), compare to a mean of 0.5 Mallard and Blue-winged Teal ducklings/acre during 1951-56 for the region in Wisconsin containing this study area (Jahn and Hunt 1964). However, production was higher (1.0 Mallard and Blue-winged Teal ducklings/acre) in the southern part of the state during that period. Wheeler and March (1979) estimated an average annual production of 0.5 Mallard and Blue-winged Teal Class III ducklings/acre in Types III, IV, and V wetlands in their southeastern Wisconsin study during 1973-75. Wheeler et al. (1984) reported a mean production of 0.2 ducklings/acre permanent water in the Grand River Marsh Wildlife Area in southeastern Wisconsin during 1977-81. The ducklings were predominately Blue-winged Teal. Jessen (1970) reported production of flying young Mallards ranging from 0.2/acre of wetland in Minnesota to 6.0/acre of wetland in Alberta, Canada.

Table 15. *Duckling production per acre of WPA wetland based on mark/resight estimates, 1982-90.*

Year and Location		Mallard	Blue-winged Teal
1982	Erickson Marsh	—	2.3 ± 0.6[1]
	Goose Pond	2.3 ± 1.7	—
1983	Erickson Marsh	—	1.2 ± 0.4
	Ausen Pond	2.4 ± 0.7	1.8 ± 1.2
1984	Ausen Pond	—	3.2 ± 1.8
1985	Ausen Pond	—	0.7 ± 0.8
	Bierbrauer Lake	—	0.2 ± 0.1
	Coot Pond	—	3.0 ± 2.4
1986	Bierbrauer Lake	—	0.4 ± 0.3
	Hanten Pond	—	0.3 ± 0.1
1987	Coot Pond	—	3.0 ± 0.3
	Star Prairie Pond	—	1.8 ± 0.0
	CENEX Pond	—	2.7 ± 0.0
1988	Ausen Pond	—	0.5 ± 0.0
	Bierbrauer Lake	0.5 ± 0.0	0.1 ± 0.0
	Flater Lake	0.6 ± 0.6	0.3 ± 0.1
1989	Goose Pond	—	2.1 ± 0.8
	Bierbrauer Lake	2.2 ± 0.4	0.5 ± 0.2
	Erickson Marsh	0.3 ± 0.1	0.2 ± 0.1
1990	Goose Pond	—	4.9 ± 3.1
	Oakridge Lake (closed area)	—	2.3 ± 1.6

[1] ±2 Standard Errors (SE)



PHOTOS: JAMES O. EVRARD

In addition to leg bands, 627 Mallards were marked with nasal saddles.

Duck Marking

Fourteen species of 5,288 waterbirds were captured and marked for this study (Table 16). Nearly half (2,403) of the birds were captured at the nest, with the rest taken in bait traps (378), decoy traps (797), while drive trapping (975), and by night lighting (1,113). Most of the ducks were captured in the spring with the Mallard being the most numerous species followed by the Blue-winged Teal and Wood Duck (Evrard and Bacon 1998).

A total of 2,233 ducks were marked with leg bands during this study (Table 17). Of the 149 Mallards that were leg banded 26 (17.4%) were recovered (20 reported shot by hunters and 6 recaptured) while 13 of the 156 leg banded Blue-winged Teal (8.3%) were recovered (8 recaptured and 5 reported shot, Evrard 1999).

In addition to leg bands, 627 Mallards and 937 Blue-winged Teal were also marked with nasal saddles. Over a third (37.5%) of the saddled Mallards were recovered (115 observed, 81 shot and 39 recaptured), while only a fifth (19.6%) of the saddled Blue-winged Teal were recovered (84 recaptured, 57 observed, and 43 shot). Only 3 (0.2%) nasal saddles were lost by birds with leg bands recaptured in subsequent years. One nasal saddled Blue-winged Teal was recaptured that had lost its leg band.

During this study, 2,332 ducklings were marked with web tags (Table 18) and 7% were recovered. Three percent of the Mallard ducklings were recaptured during the same year that they were marked and 2% were recaptured in subsequent years. For web tagged Blue-winged Teal ducklings, 8% were recaptured in the year of marking and 1% in subsequent years. This is similar to recapture rates reported elsewhere. In a Saskatchewan study, Dzus and Clark (1998) reported recapturing 3% of 1,558 web tagged Mallard ducklings in subsequent years. In Latvia, 3% of 702 web

Table 16. *Success of waterfowl capture techniques, 1982-90.*

Species	At Nest[a]	Bait Trap[b]	Decoy Trap[c]	Drive Trap	Night Light	Total
Mallard	748	73	389	43	244	1,497
Black Duck	0	1	0	0	0	1
Gadwall	0	0	1	0	0	1
Shoveler	17	0	0	0	0	17
Blue-winged Teal	1,588	120	28	229	670	2,635
Green-winged Teal	34	1	0	1	4	40
Wood Duck	15	150	0	24	106	295
Ring-necked Duck	0	23	0	9	36	68
Lesser Scaup	0	1	0	0	0	1
Bufflehead	0	1	0	0	0	1
Hooded Merganser	1	0	0	0	7	8
Canada Goose	0	0	0	669	12	681
Coot	0	3	1	0	31	35
Pied-billed Grebe	0	5	0	0	3	8
Total	2,403	378	419	975	1,113	5,288

[a] Traps used were hand, hand net, and mist net.
[b] Trap used was a Swim-in trap.
[c] Traps used were Cloverleaf and swim-in traps with female decoys.

Table 17. *Adult and juvenile waterfowl captured, marked[a], and released, 1982-90.*

	Year									
Species	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
Mallard	112	97	93	72	110	65	65	83	92	789
Black Duck	0	0	1	0	0	0	0	0	0	1
Gadwall	0	0	0	0	1	0	0	0	0	1
Shoveler	0	1	0	0	0	0	0	0	0	1
Blue-winged Teal	222	224	96	75	34	69	99	180	123	1,122
Green-winged Teal	0	3	2	0	0	0	1	1	1	8
Wood Duck	13	26	40	10	34	13	81	15	33	265
Ring-necked Duck	0	3	8	11	9	0	0	2	3	36
Lesser Scaup	0	0	0	0	0	0	0	0	1	1
Bufflehead	0	1	0	0	0	0	0	0	0	1
Hooded Merganser	0	1	0	0	0	0	2	2	3	8
Canada Goose	0	1	0	0	38	164	189	184	104	680
Coot	15	16	1	1	0	0	0	1	1	35
Pied-billed Grebe	1	0	2	1	2	1	0	0	1	8
Total	363	373	243	170	228	312	437	468	362	2,956

[a]Adults and juveniles were leg-banded and some were also nasal-saddled.

Table 18. *Ducklings captured, web-tagged, and released, 1982-90.*

	Year									
Species	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
Mallard	21	61	101	54	54	131	65	85	136	708
Shoveler	0	10	6	0	0	0	0	0	0	16
Blue-winged Teal	85	239	310	180	110	169	95	168	157	1,513
Green-winged Teal	0	10	12	10	0	0	0	0	0	32
Wood Duck	8	9	4	0	0	0	9	0	0	30
Ring-necked Duck	0	7	8	11	0	0	6	0	0	32
Canada Goose	0	0	0	0	0	0	0	1	0	1
Total	114	336	441	255	164	300	175	254	293	2,332

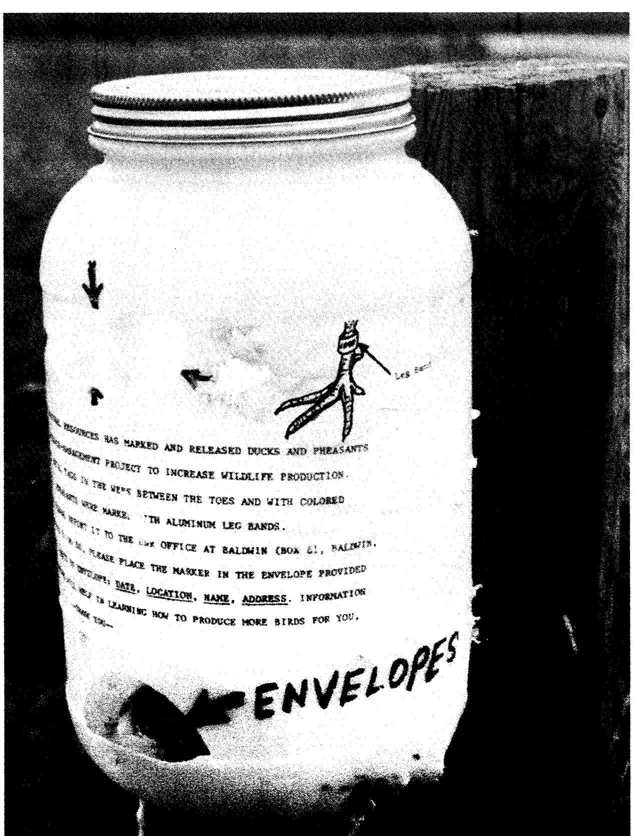
tagged Mallard ducklings were recaptured in the same year (Blums et al. 1994). The ducklings were double-marked and it was determined that there was a 5% loss of web tags during the first 3 months after hatch.

Contribution to the Harvest

Hunters shot a minimum 13.0% of local Mallards and 5.1% of local Blue-winged Teal banded within the study area from 1982-90. Direct recoveries or those birds recovered during the first hunting season after banding (Munro and Kimball 1982), accounted for 10.6% of local Mallards and 4.6% of local Blue-winged Teal. March and Hunt (1978) reported a direct recovery rate for local Mallards banded in Wisconsin during 1961-72 to be from 11% to 14%. Jahn and Hunt (1964) estimated that 16% of the immature Mallards banded in 1947-57 were first year recoveries.

In three areas of Minnesota from 1956 to 1960, Jessen (1970) reported direct recovery rates for local Mallards ranging from 17.0 to 19.6%. He concluded that 70% of mortality of local Mallards occurred within Minnesota. Mallard direct recovery rates in this study were similar between adult males (7.6%), young males (9.9%), and young females (11.4%) (Evrard 1990). The recovery rate for adult females (3.4%) was significantly lower than the rates for adult males, young males, and young females

Band return jar located on Erickson WPA.



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(χ^2=4.717, df=1, P=0.03). March and Hunt (1978) also reported a higher direct recovery rate for adult male than for adult female Mallards. In this study, the combined direct recovery rate for young Mallards (10.6%) was greater than for adults (6.5%), although it was not a significant difference (χ^2=3.630, df=1, P=0.057). This may be a good indication that young Mallards had a higher mortality rate than adult Mallards (Jahn and Hunt 1964, March and Hunt 1978, Johnson et al. 1992).

The direct recovery rate for adult male Blue-winged Teal (0.9%) was not significantly different than the adult female recovery rate (4.0%; χ^2=1.574, df=1, P=0.21), young male recovery rate (4.2%; χ^2=1.982, df=1, P=0.16), or young female recovery rate (5.1%; χ^2=2.798, df=1, P=0.09). Combined direct recovery rates for Blue-winged Teal did not differ between adults (3.0%) and young (4.6%; χ^2=1.182, df=1, P=0.28), or between males (3.5%) and females (4.7%) (χ^2=0.659, df=1, P=0.42). These results are comparable to a direct recovery rate of 2% for adult Blue-winged Teal and 4% for immature blue-wings in Wisconsin during 1947-57 (Jahn and Hunt 1964).

Hunters in this study did not select nasal saddled ducks over leg banded ducks (Evrard 1996b, Evrard 1999). There was no difference between first year recovery rates for leg banded and nasal saddled ducks (5.6%) (including: adult and young, male and female Mallards and Blue-winged Teal) than for leg banded only ducks (6.6%) during the years 1982-90 (χ^2=0.253, df=1, P=0.62). There was no difference in indirect recovery rates for saddled and banded birds (2.4%) vs. banded only birds (2.3%; χ^2=0.017, df=1, P=0.90). Similarly, there was no difference between the combined direct and indirect recovery rates of 8.0% for banded and saddled ducks and 8.9% for banded only ducks (χ^2=0.151 df=1, P=0.70).

Hunters shot 97 Mallards marked within the study area. Approximately 21.7% were recovered in the study area and adjacent townships of Polk and Pierce counties. The remaining marked Mallards were bagged elsewhere in Wisconsin and Minnesota (17.6%), Arkansas (12.5%), Illinois (10.3%), Iowa and Louisiana (5.1% each), North Dakota and Mississippi (4.1% each), Michigan and Missouri (3.1% each), South Dakota, Indiana, and Tennessee (2.1% each), and Saskatchewan, Ontario, Manitoba, Nebraska, Kentucky, Georgia, and Texas (1.0% each). Based on these results, most Mallards move south from the study area along the Mississippi River to Arkansas and adjacent Missouri, Louisiana, Mississippi, and Texas for the winter. This agrees with the observations of Jahn and Hunt (1964), Bellrose (1968), and March and Hunt (1978).

Kirby (1976) reported that 30% to 50% of the local Mallards left his Minnesota study area before October 1. Most of the adult breeding Mallards left the same study area earlier in the summer (Gilmer et al. 1977).

Forty-eight Blue-winged Teal marked in the study area were reported shot by hunters with 20.6% shot in the study area. The remaining Blue-winged Teal were shot in: Wisconsin and Minnesota (14.4%), Florida (10.2%), Louisiana (6.1%), Iowa, Illinois, Indiana, Kansas, Texas, Cuba, and Columbia (4.1% each), and Ontario, Nebraska, Missouri, Ohio, Tennessee, Kentucky, Pennsylvania, Virginia, Mexico, and Venezuela (2.0% each). Based on these results, Blue-winged Teal migrate along two routes to their winter habitat. The major route southeast through Florida, Cuba, and northern South America and a minor route southwest through Louisiana, Texas, and Mexico (Jahn and Hunt 1964, Wheeler et al. 1984).

Seventeen Mallards marked elsewhere were recovered in the area of study. Six ducks originated in Wisconsin. Five were banded at the Crex Meadows Wildlife Area (approximately 60 mi north of the study area) and one was banded in east central Wisconsin. Three Mallards were banded in Saskatchewan, two each in Minnesota and South Dakota, and one each in Illinois, Kentucky, Kansas, and Arkansas. No Blue-winged Teal marked outside the study area were recovered.

Duck Harvest

The Mallard was the most common species bagged during the first 2 days of the season accounting for 35% of the harvest, followed by Wood Ducks with 24% of the harvest, and Blue-winged and Green-winged Teal each comprising 12% of the harvest (Table 19). Nine other duck species made up the remaining 17% of the harvest.

During season-long bag checks in the study area in 1977-78, Petersen et al. (1982) found that Mallards made up 52% of the bag, followed by Wood Ducks with 20%, and Blue-winged Teal with 9%. Seven other species made up the remaining 19% of the harvest.

During 1954-57, Jahn and Hunt (1964) reported that Mallards averaged 29% of the statewide harvest during early October. Blue-winged Teal were the most important species comprising 50% of the bag. Green-winged Teal averaged 7% of the early October harvest. Hunting Wood Ducks was prohibited during this period.

Relative hunting success in this study, expressed as duck bagged per hunter trip, averaged 0.8 ducks/hunter (range 0.2 - 1.3) during the first 2 days of the season during 1982-91 (Table 19). Hunters had poor success during the drought years of 1986 and 1988, when it took 10 hrs of hunting effort to bag a duck. Even during the most successful hunting years, it took more than 3 hrs of hunting to bag 1 duck.

During the hunting seasons of 1977-78, hunters averaged 0.5 ducks/trip, taking 3.4 hrs to bag each bird in the study area (Petersen et al. 1982). In 1949 to 1952, Jahn and Hunt (1964) reported a mean of 0.9 ducks/hunter trip for 8 sites throughout Wisconsin for the whole season. The average for the first few days of the season, however, was slightly higher (1 duck/hunter).

Table 19. *Hunter bag checks during the opening weekend of the waterfowl hunting season, 1982-91.*

	Year									
	1982	1983	1984	1985	1986	1987	1988	1989[a]	1990	1991
Species										
Mallard	33	26	16	13	9	29	10	35	32	6
Black Duck	1	0	0	0	0	1	0	0	0	0
Pintail	3	0	1	0	0	0	0	6	2	0
Gadwall	0	0	0	0	0	0	0	1	0	0
Wigeon	1	0	2	0	1	1	5	1	3	1
Blue-winged Teal	20	25	4	4	8	3	0	6	7	3
Green-winged Teal	13	4	2	8	1	2	3	11	10	6
Wood Duck	49	37	14	3	5	17	2	32	25	3
Redhead Duck	1	0	1	4	0	0	0	0	0	0
Ring-necked Duck	1	6	2	25	1	3	0	0	2	0
Lesser Scaup	1	5	0	0	5	2	0	0	0	0
Hooded Merganser	2	0	0	0	0	0	0	0	1	0
Common Merganser	0	0	0	0	1	0	0	0	0	0
Total Ducks	125	105	42	57	31	57	20	93	83	19
Canada Goose	7	4	1	2	5	10	30	2[a]	1	0
Coot	0	1	0	0	1	0	0	0	0	0
Number of Hunters	182	91	54	91	85	75	81	72	73	33
Number of Ducks/Hunter	0.7	1.2	0.8	0.6	0.4	0.8	0.2	1.3	1.1	0.6
Number of Hours Hunted	577	322	203	306	352	306	242	300	301	129
Number of Ducks/Hour	0.2	0.3	0.3	0.2	0.1	0.2	0.1	0.3	0.3	0.2
Days of Week	F,S,S	S,S	M,T	S,S	S,S	T,F	S,S	S,S	S,S	S,S
October Date	1,2,3	1,2	1,2	5,6	4,5	1,2	8,9	7,8	6,7	5,6

[a] Beginning in 1989, the goose season opened in September. Twenty-nine geese were shot by 88 hunters on September 23 and 24, the opening weekend. Thirty-two geese were shot by 78 hunters on September 22 and 23, the opening weekend in 1990. Thirteen geese were shot by 60 hunters on September 21 and 22, the opening weekend in 1991.

Summary

The major goal of this study, to evaluate habitat management objectives in order to increase duck production on WPAs, was only partially met. Duck production and the contribution of the local production to the waterfowl harvest was determined (Evrard 1987b, Evrard 1988, Evrard 2000a), but knowledge gained about specific habitat manipulations (Evrard 1986b, 1996d, Evrard 2000b, Gatti et al. 1992, Lillie 1993) was limited, primarily due to inadequate sample sizes. Knowledge of basic waterfowl ecology (Evrard 1984, 1987a, 1989, 1990, Evrard et al. 1987, Lillie 1987, 1993, Lillie and Evrard 1994, Mauser 1985, McDowell 1989) and knowledge of new waterfowl research and management techniques (Bacon and Evrard 1990, Evrard and Bacon 1995, Evrard 1986a, 1996a, 1996b, 1996d, 1999), however, were gained as a result of this study.

Fifteen duck species were recorded in the breeding pair surveys with breeding or nesting documented for 8 species. The Blue-winged Teal was the most numerous species followed by the Mallard. Indicated breeding pair densities were 10 times greater in the WPAs than in the total study area.

Planted switch grass offered the best resistance to snow pack and provided the most attractive residual nest cover in the spring when Mallards began nesting. Nest cover at Mallard nests was dominated by residual switch grass while residual and growing bluegrass was the dominant plant species at Blue-winged Teal nests.

Mean 1982-90 Mayfield nest success for combined Mallard and Blue-winged Teal was 21.3%, above the 20% level needed for stable populations. Nest success varied temporally and spatially with an inverse relationship existing between nest success and nest density. Nest cover VORs were higher at successful Mallard and Blue-winged Teal nests than at unsuccessful nests but nest success did not vary significantly among nest cover vegetation types. Relationships existed between Blue-winged Teal nest success and predator and alternate prey indicies, but Mallard nest success was unaffected.

Mean clutch sizes for both the Mallard and Blue-winged Teal were larger than reported in the literature but could be balanced by higher brood mortality, indicated by attrition in observed brood size from hatch to fledgling. Mean Mallard and Blue-winged Teal duckling production, determined from marked/resight estimates, was 3 fledglings per acre, higher than reported elsewhere in Wisconsin.

Of 5,000 ducks captured and marked at nests, 17% of the Mallards and 8% of the Blue-winged Teal were eventually recovered. Thirteen percent of the Mallards and 5% of the Blue-winged Teal were reported shot by hunters. The rest of the recoveries were recaptures and observations. Of the ducks harvested, 22% of the Mallards and 21% of the Blue-winged Teal were shot in the study area and the adjoining Polk and Pierce counties.

During the first 2 days of hunting seasons, mean hunter success was 0.8 ducks harvested/hunter/day during 1982-90, which is average for Wisconsin. Mallards were the most numerous species in the harvest(35%), followed by the Wood Duck (24%), Blue-winged Teal (12%), and Green-winged Teal (12%).

Management Implications

The WPAs in St. Croix and Polk counties are essentially waterfowl production areas for Blue-winged Teal and Mallards, but provide habitat for a wide variety of other wildlife. WPA breeding pair densities compared favorably with other known densities in Wisconsin management areas. Mallard and Blue-winged Teal nest success in managed nest cover during the study was above the threshold needed to maintain stable duck populations. Duckling production was above that reported elsewhere in Wisconsin. Hunters harvested locally about 20% of those ducks produced in the WPAs. Acquisition of additional WPAs and continued habitat management, primarily warm season grass nest cover establishment and manipulation, should be encouraged.

Appendix A. Study Publications

Bacon, B.R. and J.O. Evrard. 1990. Horizontal mist net for capturing upland nesting ducks. *North American Bird Bander* 15:18-19.

Evrard, J.O. 1984a. Gray partridge in northwestern Wisconsin. *Transactions of the Wisconsin Academy of Sciences, Arts, and Letters* 71:57-59.

Evrard, J.O. 1984b. Oldsquaw duck in Polk County. *Passenger Pigeon* 46:79-80.

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Appendix A. (continued)

Evrard, J.O. and B.R. Bacon. 1995a. Bird nest densities in managed grasslands. *Passenger Pigeon* 57:89-95.

Evrard, J.O. and B.R. Bacon. 1995b. Blue-winged teal clutch augmentation. *Passenger Pigeon* 57:259-261.

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