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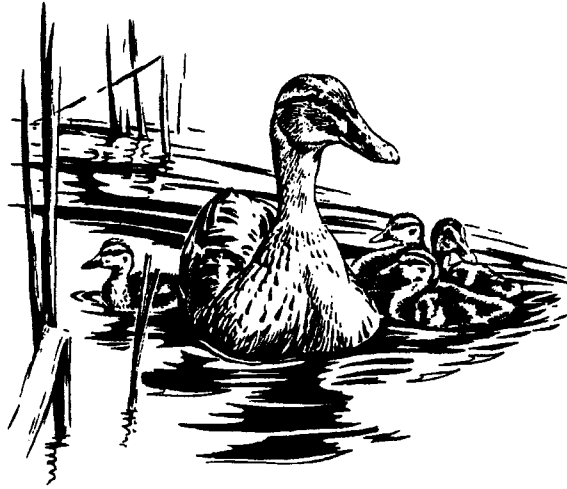
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ILLINOIS NATURAL HISTORY SURVEY

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Mallard Investigations

W-130-R-4

Annual Report

To

Illinois Department of Natural Resources

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29 August 2001**

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EXECUTIVE SUMMARY

The nesting biology of mallards (Anas platyrhynchos) was studied in central Illinois from March to July 2001. The study objectives were to develop a data set of mallard nesting information in Illinois, determine the occupancy rate of artificial nest structures by mallards in Illinois, and evaluate recruitment. For this report, we summarized the 2001 mallard nesting season data and briefly compared this year's information with the previous three years (Yetter et al. 2000).

To achieve these objectives, 17 female mallards were live trapped (Sharp and Lokemoen 1987, Ringelman 1990) during spring and fitted with radio transmitters (Pietz et al. 1995). Radio-marked females were located daily throughout the nesting seasons, and broods were located daily for 20 days posthatch (Orthmeyer and Ball 1990). Five females were recaptured this spring that carried transmitters in previous years (1999, $n = 2$; 2000, $n = 3$).

Female mallards were in better physiological condition (mass/wing chord) in spring 1998 than during the springs of 1999, 2000, and 2001. The mallard nesting season lasted 86 days in 2001. The first nest was initiated on 6 April 2001, and the range of initiation dates for first nests over the 4-yr period was 4-12 April. The number of nest attempts per female was 1.42 ± 0.19 nests/hen in 2001, which fell within the range observed during the previous three years ($1.12 \pm 0.08 - 1.74 \pm 0.17$ nests/hen). The mean nest initiation date for first attempts was 27 April in 2001 and was comparable to the range previously observed (22 April - 6 May).

The mean incubated clutch size for first nest attempts was 9.7 ± 0.4 eggs/clutch and was similar to the 1998-2000 average of 9.4 ± 0.3 eggs. The incubation period declined this year (25.2 ± 0.5 days) from the previous three year average of 26.7 ± 0.4 days; egg hatchability (80.9%) also declined from the 1998-2000 (94.7%) average. Seventy-five percent of all mallard

nests were initiated by 18 May 2001, and the projected hatch date for these nests was 23 June. The mallard nesting season in central Illinois was completed by 30 July 2001. Renesting effort (66.7%) was similar to that observed in 1998-2000.

During 2001, raccoons (Procyon lotor) and other mammals were identified as major nest predators resulting in the failure of 12 of 17 nest attempts (70.6%). A simple estimate of nest success was 29.4 percent and was the highest reported during this study. Most nests (70.6%) were located in idle grasslands. The hen success rate was estimated at 41.7 percent. The initial brood size of 7.6 ± 0.1 ducklings in 2001 was less than the 8.5 ± 0.5 ducklings leaving the nest during 1998-2000.

The Kaplan-Meier nest survival estimate in 2001 was $\hat{s} = 0.317 \pm 0.147$ and was nearly five times greater than that observed in 2000 ($\hat{s} = 0.064 \pm 0.053$). Three resident female mallards were killed while nesting this year, and survival was estimated at $\hat{s} = 0.744 \pm 0.119$. Female survival during the nesting season was 66.3 percent over the 4-yr period (1998-2001).

Mallard production exceeded female mortality during the 2001 nesting season. Recruitment was estimated at 0.704 females fledged/hen in the spring population, resulting in a potential increase of seven percent in the 2002 spring mallard population.

Fifty artificial nest structures (Hen Houses™) were deployed prior to the 2001 mallard nesting season. Mallards did not use the Hen Houses™ in 2001. Wetland habitat conditions were considered optimal for mallard production during spring 2001 when the estimated amount of surface water in basins averaged 97.2 to 99.9 percent of bankfull conditions.

SUMMARY OF ACCOMPLISHMENTS

STUDY I: THE NESTING BIOLOGY OF MALLARDS IN ILLINOIS

JOB I.1. Nesting History and Reproductive Success of Mallards in Illinois.

We examined the nesting ecology of mallards in central Illinois using radio telemetry during spring/summer 2001. The mallard nesting season was defined and basic nesting parameters were described including nest attempts/female, nest success, egg hatchability, incubated clutch size, incubation period, and brood size. Survival estimates of nests and females were determined. Due to limited samples, brood and duckling survival were not summarized for 2001; however, survival was pooled for broods and ducklings over the 4-yr period (1998-2001).

JOB I.2. Mallard Use of Cylindrical Artificial Nest Structures.

We randomly installed cylindrical artificial nest structures (Hen Houses™) in ponds and lakes at the Metropolitan Water Reclamation District of Greater Chicago (MSD) in Fulton County, IL, during Jan. - Feb. 2001. Structures were monitored for use by nesting mallards and other avifauna during spring/summer 2001.

JOB I.3. Assessment of Mallard Recruitment.

We estimated mallard recruitment during the 2001 breeding season. Recruitment was defined as the number of females added to the fall population per female in the spring population. Additionally, the proportional change in the population size was estimated from various nesting parameters and survival estimates from JOB I.1.

ANNUAL REPORT
Mallard Investigations
Federal Aid in Wildlife Restoration W-130-R-4
1 July 2000 through 30 June 2001

STUDY I: THE NESTING BIOLOGY OF MALLARDS IN ILLINOIS

INTRODUCTION

The mallard is a socially and economically important bird in North America, and it is the most abundant duck observed during the annual North American waterfowl surveys (USFWS 2001). The mallard is also the most numerous duck species in the waterfowl harvest in Illinois, the Mississippi Flyway, and the United States (Martin and Padding 2000, Peterson 2000). Hence, it is one of the most sought after species by waterfowl hunters.

Besides its importance as a migrant in Illinois where it represented 77.5 percent of the total duck use-days on the Illinois River from Spring Valley to Grafton and 58.0 percent of the total duck use-days on the Mississippi River from Rock Island to Grafton during 1993-1996 (Havera 1999:246-247), the mallard has become a common summer resident and is one of the most abundant nesting ducks in Illinois. Yetter (1992) estimated that mallards represented 61.4 percent of the breeding waterfowl population in northeastern Illinois. Historically, however, nesting mallards may not have been as abundant in Illinois. In a database compiled by the Illinois Natural History Survey (INHS), only 15 records of nesting mallards were documented in Illinois before 1930 (Havera 1999:105-106). From 1863 to 1929, nesting mallards were identified in only 9 of 102 Illinois counties. Since 1930, mallards have expanded their range in Illinois and now nest in all 102 counties. Information from the Breeding Bird Survey data compiled by the United States Fish and Wildlife Service (USFWS) indicated that mallards in

Illinois increased 5.4 percent annually and 214 percent from 1966 to 1989 (Droege and Sauer 1990, Havera 1999).

In the 1980's, the number of mallards breeding in Illinois soared. The cause of this population expansion is unknown although possible reasons include: increased nesting habitats under the 1985 Conservation Reserve Program (CRP), release of game-farm mallards by private citizens, pioneering of mallards from the traditional breeding areas of the northern prairies to nontraditional areas (i.e., Illinois, Wisconsin, Michigan, and Ohio) due to the severe droughts of the 1980's, and deployment of artificial nesting structures (Havera 1999).

While the traditional breeding grounds of prairie Canada and the northcentral United States far surpass nontraditional areas in attracting numbers of breeding mallards (USFWS 2001), mallard populations in nontraditional areas are expanding. Two decades ago, the number of mallards breeding in Wisconsin, Michigan, and Ohio was estimated at 225,000 birds. In 1999, this population was approaching one million (Petrie 1999). More stable breeding environments resulting in greater breeding success may have been the reason for this population growth. Wetlands in nontraditional nesting areas are more stable and do not undergo the severe drought cycles of the prairie wetlands (Petrie 1999).

The expansion of the mallard population has translated into a shift in the harvest derivation. Breeding reference areas (Fig. 1) defined by Anderson and Henny (1972) and Pospahala et al. (1974) were used to examine the mallard harvest. From 1961-1975, the majority of mallards harvested in Illinois were produced in prairie Canada and the northcentral United States (Munro and Kimball 1982; Fig. 2). During this time, only 8.7 percent of the mallards harvested in Illinois were produced in the Great Lakes states; however, more recent evidence suggested that the mallard harvest from this region increased to 28.2 percent in the 1990's

(Zuwerink and Gates 1999; Fig. 2). The apparent decline in Illinois' harvest of mallards produced in prairie Canada may have resulted from the increased harvest of mallards produced in the Great Lakes states.

Artificial nest structures can enhance local waterfowl production when properly managed. In Illinois, populations of giant Canada geese (Branta canadensis maxima) and wood ducks (Aix sponsa) as well as eastern bluebirds (Sialia sialis) and other songbirds have benefitted from the use of artificial nest structures. However, limited numbers of these artificial nest sites have been deployed in Illinois to enhance local mallard production. The occupancy rate, or use, of nest structures by mallards and the subsequent nest success have not been evaluated in Illinois as they have in Saskatchewan (Eskowich et al. 1998), North Dakota (Doty et al. 1975, Doty 1979, Artmann 1999), South Dakota (Stafford 2000, Stafford et al. 2000), and Wisconsin (Doty et al. 1975, Evrard 1996). In these landscapes, nest success for mallards using nest structures was elevated when compared to ground nests but use by nesting mallards was variable. Many varieties of nest structures have been designed for use by mallards; however, Eskowich et al. (1998) found that female mallards in Saskatchewan preferred a cylindrical tunnel-type structure.

In spite of the mallard's importance in the Illinois waterfowl harvest and its population expansion in the Great Lakes states including Illinois, little has been done to investigate the nesting ecology of the mallard and its use of the Hen House™ style (cylindrical) nesting structure in Illinois. Yetter (1992) estimated mallard breeding populations in northeastern Illinois and collected some corollary nesting information. Louis (1999) examined some nesting parameters of the mallard in eastcentral Illinois. Other than these two studies, there have been no recent investigations of the nesting biology of mallards in Illinois. Therefore, this study was designed to

develop a data set of basic nesting information on mallards and to evaluate the significance of mallard recruitment in central Illinois.

STUDY AREA

The study was conducted in Fulton County at the Prairie Plan site of the Metropolitan Water Reclamation District of Greater Chicago (MSD). Habitat structure in Fulton Co. was determined from the Illinois Geographic Information System, Illinois Department of Natural Resources, Springfield, Illinois, and consisted of approximately 40 percent row crop agriculture; 29 percent grassland, pasture, and hayland; 23 percent forest; 6 percent wetland and deepwater habitats; and 1 percent urban/suburban.

MSD was located between the towns of Cuba and Canton. The property consisted of 15,249 ac of reclaimed surface-mined lands (Lawrence 1987, Prairie Plan 1998). MSD was managed as a disposal site for biosolids (sludge) received from Chicago. Biosolids were transported from Chicago in dry form and spread over agricultural fields where they were incorporated into the soil. Major land categories at MSD included hay and pasture, idle grassland, row crop agriculture, upland forest, and a variety of wetland and deepwater habitats ranging from large final-cut lakes to small ponds and marshes. Upland nesting cover at MSD included smooth brome (Bromus inermis), meadow fescue (Festuca pratensis), switch (Panicum virgatum) and orchard grasses (Dactylis glomerata), timothy (Phleum pratense), alfalfa (Medicago sativa), red clover (Trifolium pratense), crown vetch (Coronilla varia), goldenrod (Solidago spp.), multiflora rose (Rosa multiflora), autumn olive (Elaeagnus umbellata), poison ivy (Toxicodendron radicans), and willows (Salix spp.).

JOB NO. I.1. Nesting History and Reproductive Success of Mallards in Illinois.

OBJECTIVES:

To determine nesting effort of female mallards.

To determine nest success of female mallards.

To collect corollary nesting information for female mallards, such as clutch size, egg hatchability, chronology, type of predation, and brood size at hatching.

To monitor brood survival for those females with successful nests.

To monitor duckling survival for those females that successfully hatch young.

METHODS

Trapping and Transmitter Attachment

Wetlands were searched daily for prenesting resident pairs of mallards. When isolated or territorial pairs were observed on a wetland for multiple days, they were considered residents and trapped using decoy traps (Sharp and Lokemoen 1987, Ringelman 1990). Traps were checked multiple times each day while other potential trap sites were continually monitored. Once a female was captured and fitted with a radio transmitter, the trap was moved to another location to avoid recapture.

When captured, mallards were banded using USFWS No. 7 leg bands and weighed with a Pesola scale (± 20 g). Morphological measurements included bill length at two points (culmen1 and culmen2), bill width, tarsus length, tarsus width, and total tarsus (± 0.1 mm) (Byers and Cary 1991), and wing chord length (± 1 mm) (IWWR 1996). Female mallards were aged (adult or yearling) according to Krapu et al. (1979).

Female mallards were fitted with a prong and suture radio transmitter (Model 2354) designed by Advanced Telemetry Systems, Inc. (ATS), Isanti, Minnesota (Mauser and Jarvis

1991, Pietz et al. 1995). Radio transmitters were equipped with 120-day batteries and 12-hr mortality switches assisted detection of predatory events. The entire transmitter weighed 10 - 12 g, or about 1 percent of a female mallard's body weight. Transmitters were attached mid-dorsally just above the shoulder joints using three sutures and a wire prong inserted subcutaneously (Mauser and Jarvis 1991, Pietz et al. 1995). The procedure was done under local anesthetic (Lidocaine) and was approved by the University of Illinois at Urbana-Champaign, Laboratory Animal Care Advisory Committee (LACAC), Office of Laboratory Animal Resources (OLAR) (Protocol # 00088).

Radio Telemetry

Radio-marked female mallards were located by triangulation (White and Garrott 1990, Samuel and Fuller 1996) using vehicle-mounted null-array antenna systems (ATS, Inc., Isanti, Minnesota). Tracking began the day following capture and transmitter attachment. Females were triangulated twice daily (≥ 6 days/week) between 0600 h and 1300 h, which is the period when laying females were most likely to be on their nests (Gloutney et al. 1993). Daily locations were marked on aerial photos. Females found in potential nesting cover were triangulated by vehicle or on foot using hand-held Yagi antennas. Nest searching ensued when the female was located away from the nest site (Paquette et al. 1997). If a female was absent from her nest for two consecutive locations, nests were inspected to learn their fate (active, abandoned, destroyed, or hatched; Klett et al. 1988, Sovada et al. 1996, Hernandez et al. 1997). Nest initiation dates were determined by subtracting the number of eggs in a nest when found from the date when the nest was located (Paquette et al. 1997). We assumed an egg laying rate of one egg/day and that incubation began when the last egg was laid. Incubation periods were calculated as (HATCH DATE-NEST INITIATION DATE-CLUTCH SIZE+1). On approximately the 18th day of

incubation, nests were visited despite the female's presence to determine the incubated clutch size assuming partial nest depredation had not occurred and to verify incubation stage (Hanson 1954, Weller 1956). Egg hatchability was determined from the presence of whole eggs and membranes at the nest site. We defined a successful nest as hatching ≥ 1 egg (Klett et al. 1988), and hen success as the probability of a female having a successful nest in one or more nest attempts (Cowardin et al. 1985). Successful females and their broods were located daily for 20 days posthatch, and attempts were made to count ducklings multiple times each week to ascertain brood and duckling survival (Orthmeyer and Ball 1990). Renesting effort was determined for those females that were unsuccessful in their first nest attempts.

Data Analysis

Female mallards were classified as residents if they attempted to nest or remained on the study area during the nesting season. Data analysis was conducted using the Statistical Analysis System (SAS Institute 2000). Significance levels were set at $P \leq 0.05$, and we report means as \pm standard error. Nesting season length was defined as the first egg laid to the last nest hatched or destroyed. The mean number of nest attempts per resident female and nest initiation date for first nest attempts were compared between age classes using t-tests (Proc TTEST, SAS Institute 2000). Two-way analysis of variance was used to compare female body condition indices (body mass [g]/wing chord [mm]; Ringelman and Szymczak 1985, Hine et al. 1996) between the age and year classes (Proc GLM, SAS Institute 2000). Nest success and hen success (Cowardin et al. 1985) were expressed as a simple percentage. Nest success was also calculated using the daily survival rate (DSR) according to the Mayfield method (Mayfield 1975) as modified by Johnson (1979). To determine the Julian date at which most of the mallard nests were completed, we estimated a nest's hatch date by adding the mean incubation period and clutch size observed

during 1998-2000 (Yetter et al. 2000) to the nest initiation date. The 75th percentile of the estimated hatch date was calculated using Proc UNIVARIATE (SAS Institute 2000).

The Kaplan-Meier product-limit estimator modified for staggered entry (Kaplan and Meier 1958, Pollock et al. 1989, White and Garrott 1990) was used to calculate female mallard survival encompassing the prenesting, nesting, and brooding periods. For determining survival, females were censored the day following the last radio contact, the day following loss of a transmitter, the day of brood loss, or the 20th day posthatch (Paquette et al. 1997). We used Program Contrast to determine differences in female survival rates between the years (Hines and Sauer 1989, Sauer and Williams 1989).

Nest survival rates were calculated using the Kaplan-Meier product-limit estimator (Proc LIFETEST, SAS Institute 2000). Nest survival estimates were compared between the female age classes using log-rank (χ^2) tests (White and Garrott 1990:241). Due to limited samples of broods, brood and duckling survival estimates for 2001 were not calculated; instead Kaplan-Meier estimates of brood and duckling survival were pooled across years 1998-2001 (Proc LIFETEST, SAS Institute 2000).

RESULTS

Trapping

Mallards were trapped on 31 days between 21 March and 27 April 2001 resulting in 322 trap-days. A total of 17 females and 74 males was captured (Table 1). More days were devoted to capturing fewer females in 2001 than in previous years (Table 1). Females were captured at a rate of 0.053 females/trap-day, which was the lowest capture rate over the 4-yr period; however, we captured more males than in preceding years. In 2001, we recaptured one male that was previously banded at MSD in 2000, and five females previously banded in 1999 ($n = 2$) and 2000

($n = 3$). This compares with four recaptured females in 2000 that were banded in 1999. In 1999, we recaptured only two females that were banded in 1998. From our sample of 17 females in 2001, three were migrants and departed the study area the day following transmitter attachment (Table 2), and the remaining 14 females were considered residents. Age structure of resident females was four yearlings and ten adults (0.40:1 yearling/adult). Age ratios during 1998-2000 were 0.47, 1.18, and 0.33 yearlings/adult, respectively. One radio-marked female that nested at MSD in 2000 was recovered by a waterfowl hunter on Oct. 2, 2000 near Humboldt, SD.

Of the 14 resident females fitted with radio transmitters during spring 2001, one was in poor body condition and did not nest (Table 2), and another was killed the day after radio transmitter attachment. The latter bird was known to be a resident female because she wore a transmitter in 2000. The remaining 12 females (9 adults and 3 yearlings) nested at MSD in 2001.

Morphological Measurements and Body Condition Indices

Various measurements were taken from resident mallards upon capture (Table 3). Only those males determined to be paired with resident females were classified as residents. As expected, males had larger physical characteristics than females. Differences existed in female body condition among year and age classes ($F_{7,109} = 3.35$, $P = 0.003$). Female body condition was similar among age classes ($F = 2.58$, 1 df, $P = 0.112$); however, year-wise comparisons identified differences ($F = 3.79$, 3 df, $P = 0.013$) in body condition. Post hoc tests indicated that females were in better shape physiologically in 1998 than in 1999-2001.

Nesting Season and Nesting Effort

The mallard nesting season lasted 86 days and was initiated on 6 April. The last known date a female was on the nest was 30 June (Table 4). The mallard nesting season in 2001 was comparable to that observed in previous years (1998-2000).

Female mallards ($n = 12$) initiated 17 nests during April-June 2001. The twelve females initiated 1.42 ± 0.19 nests/female with no differences between age classes ($t = 0.24$, 10 df, $P = 0.816$). The number of nest attempts ranged from 1.12-1.74 nests/female during 1998-2000. Mean nest initiation dates for first attempts in 2001 were similar between the age classes ($t = 0.10$, 10 df, $P = 0.921$) and averaged 27 April. The earliest mean nest initiation date was observed in 1998 (22 April), and the latest mean nest initiation date occurred in 1999 (6 May). We determined the incubated clutch size for seven first nest attempts to be 9.71 ± 0.42 eggs/clutch; no agewise comparisons were made.

Incubation and Egg Hatchability

Five successful females averaged 25.2 ± 0.5 days of incubation with a range of 24 to 26 days. The hatching rate of eggs in successful nests was low (80.9%) with only 38 of 47 eggs hatching. Both the incubation period and the hatching rate of eggs declined in 2001 when compared with the previous three years. Incubation lasted 26.7 ± 0.4 days and egg hatchability was estimated at 94.7 percent during 1998-2000.

Projected Hatch

To define the advancement of the mallard nesting season in central Illinois, the percentage of nests initiated was plotted against the Julian date. Seventy-five percent of all nests were initiated by 18 May 2001, and the last nest was initiated on 23 June (Fig. 3). The projected

hatch date for 75 percent of all nests was 23 June, while the projected hatch date for all nests was 30 July. The mean hatch date for the monitored females ($\bar{n} = 5$) was 5 June. These dates were similar to the combined 1998-2000 nest initiation date of 20 May for 75 percent of all initiated nests.

Renesting Effort and Nest Success

Six females surviving an unsuccessful first nest attempt were used to determine renesting effort by mallards in central Illinois. Four of the six females (66.7%) renested after their first nest attempt making this year comparable to that observed in 2000 (73.7%). Renesting was intermediate between values found for 1998 (87.5%) and 1999 (52.4%). The earliest and latest nest initiation dates witnessed during this study were during springs 1998 and 1999, respectively.

A simple estimate of nest success was 29.4 percent when 5 of 17 nests hatched (Table 5). Reasons for nest failure in 2001 were raccoon (2), mink (*Mustela vison*) (1), opossums (*Didelphis virginiana*) (1), and snakes (1). Another nest was destroyed when agricultural equipment crushed a nesting female while spraying a no-till, cover-crop of rye (*Secale cereale*). The 29.4 percent nest success estimate during spring/summer 2001 was the highest observed during the 4-yr study when nest success was 23.3, 15.2, and 8.9 percent in 1998-2000, respectively.

Habitats near nest sites were classified as idle grassland, pasture, hayfield, scrub-shrub, wetland, wooded, and cropland. Twelve of 17 nests (70.6%) were located in idle grassland, three nests (17.6%) in scrub-shrub, and one nest each in hayfield (5.9%) and cropland (5.9%). Successful nests were located in idle grassland ($\bar{n} = 3$), scrub-shrub ($\bar{n} = 1$), and hayfield ($\bar{n} = 1$).

To compare our results with that of previous studies, Mayfield nest success estimates were calculated according to Johnson (1979) using the daily survival rate (DSR). The DSR was

raised to the 36th power (mean clutch size + incubation period) (Yetter et al. 2000). In 2001, the Mayfield nest survival rate was 34.9 percent ($CI_{95} = 0.184, 0.655$). This estimate was higher than that recorded during the previous three years: 1998 (24.8%; $CI_{95} = 0.145, 0.418$), 1999 (19.0%; $CI_{95} = 0.109, 0.326$), 2000 (16.6%; $CI_{95} = 0.090, 0.303$).

We evaluated nest site characteristics in 2001 to determine habitat selection and relationships between habitat and nest success; however, due to our limited sample of nests during spring/summer 2001, we present the nest site characteristics from all nests with no comparisons between successful and unsuccessful nests. The vegetation height in the immediate vicinity of the nest site at nest initiation was 17.6 ± 3.4 in ($\underline{n} = 7$). The distance from a pair's loafing pond to the nest site was highly variable and averaged $1,248.7 \pm 660.9$ ft ($\underline{n} = 10$). The mean distance to other parameters were roads (337.1 ± 83.6 ft; $\underline{n} = 15$), water (196.5 ± 45.3 ft; $\underline{n} = 15$), wetland basin regardless of surface water (154.2 ± 42.0 ft; $\underline{n} = 15$), and tree or shrub within 150 ft (27.4 ± 8.1 ft; $\underline{n} = 12$).

Hen Success

Hen success estimates could be calculated for 12 females during 2001. Five of the 12 females hatched a nest for a success rate of 41.7 percent. This estimate was the highest rate recorded over the 4-yr study. Hen success rates in 1998, 1999, and 2000 were 37.0, 21.2, and 15.4 percent, respectively.

Brood Size

The brood size at hatch was determined for the five successful nests during 2001. Mean brood size at hatch was 7.6 ± 1.0 ducklings. This estimate was the lowest recorded during this study and was 10.6 percent below the 1998-2000 average (8.5 ± 0.5 ducklings $\underline{n} = 21$ broods).

Due to transmitter failures during 2001, only one brood was followed for 20 days when four of nine ducklings survived. This number was comparable to the mean 17-day brood size (3.2 ± 0.8 ducklings; $n = 14$ broods) observed during 1998-2000.

Survival

Nests: Mallard nest data was subjected to a Kaplan-Meier survival analysis. Nest survival was similar between the age classes during 2001 ($\chi^2_1 = 0.004$, $P = 0.950$), and the pooled nest survival rate was $\hat{s} = 0.317 \pm 0.117$ ($n = 17$, Table 6). This estimate was the second highest to 1998 when adult nest survival was estimated at $\hat{s} = 0.365 \pm 0.101$. The 2001 nest survival rate was nearly five times greater than that observed in 2000.

Broods and Ducklings: Due to limited samples of broods in 2001 (only one brood was radio tracked for more than two days) and the similarity of brood survival among years 1998-2000, brood survival to 20 days was computed by pooling broods across the 4-yr interval. The Kaplan-Meier estimate of brood survival for 1998-2001 was $\hat{s} = 0.796 \pm 0.094$. Two hundred sixteen ducklings hatched from 26 successful nests during the 4-yr interval. Duckling survival over this period was $\hat{s} = 0.445 \pm 0.042$. Survival curves revealed that most mortality of mallard ducklings (77 of 87 ducklings, 88.5%) occurs within the first 12 days posthatch (Fig. 4).

Females: Female survival was determined for resident females because migrants were not considered to have undergone the same risks (Table 7). Three of nine (33.3%) adult females were killed during the 2001 nesting and brood rearing seasons while all four yearlings survived. Differences in female survival among the age classes were not significant ($\chi^2_1 = 1.60$, $P = 0.205$). Female mallard survival during spring/summer 2001 was $\hat{s} = 0.744 \pm 0.119$ and was similar ($\chi^2_3 = 1.62$, $P = 0.654$) to survival estimates observed during the previous three years (Table 7).

Twenty-six of 110 females (23.6%) perished over the 4-yr period. The pooled survival estimate over the 4-yr period was $\hat{s} = 0.663 \pm 0.122$, indicating that 1/3 of our females were lost during the nesting season each year.

JOB NO. I.2. Mallard Use of Cylindrical Artificial Nest Structures.

OBJECTIVE:

To determine the occupancy rate of cylindrical artificial nest structures by mallards.

To determine nest success of mallards using cylindrical artificial structures.

To evaluate, based upon use and success found in this study, whether nesting structures are a feasible management option for mallards in Illinois.

METHODS

Basin Classification and Selection

We used spring 1986 National Wetlands Inventory (NWI) data stored on the Illinois Geographic Information System, Illinois Department of Natural Resources, Springfield, Illinois, to classify wetland and deepwater habitats at MSD on the basin level. Basins within the study area were classified as ponds (palustrine habitats) or lakes (lacustrine habitats)(Cowardin et al. 1979) depending on the water depth in the deepest part of the basin during low water levels. Basins with a water depth of > 2 m (6.6 ft) were considered lakes, and basins ≤ 2 m deep were classified as ponds. Due to prior coal-mining activities, most basins at MSD were pond and lake habitats with few existing emergent marshes.

We selected 13 random points (latitude-longitude coordinates) within the property boundaries of MSD. Four basins (2 ponds and 2 lakes) nearest each random point were selected as sites for artificial nest structures. We used the Hen HouseTM (henceforth structure) designed by the Delta Waterfowl Foundation for nesting mallards and currently produced by Dakota

Nesting Structures (Dakota Nesting Structures, P.O. Box 11, 3471 Woodland Park, Valley City, North Dakota 58072). Criteria for basin selection and nest structure placement were 1) basins without surface water in fall 2000 were excluded, 2) only one structure was erected per basin regardless of basin size, and 3) structures were placed ≥ 109 yds from each other. We attempted to elevate structures 2-3 ft above the high water line in a basin. Structures were oriented in a north-south plane, and where possible, each structure was located > 16 ft from the shoreline and < 16 ft from emergent vegetation (Artmann 2000). Therefore, 26 ponds and 26 lakes were selected for nest structure deployment. Nest structures were erected over the ice during January and February 2001.

Nest Structure and Basin Monitoring

Nest structures were monitored monthly during the breeding season for use by mallards and other avian species. The dates structures were monitored were 7-9 May, 5-11 June, and 9-10 July 2001. Structures were physically inspected for evidence of nesting via canoe or ladder. We also visually estimated the percent of a basin inundated with surface water during each visit in order to quantify the availability of water on the study area with zero percent being completely dry and 100 percent representing bankfull. These estimates were then averaged across the basin types (lakes and ponds) to provide a drought index during each survey.

RESULTS

Nest Structure Availability

At the start of the mallard nesting season in Fulton County (6 April), 50 of the nest structures were present. One structure deployed in a pond and in a lake were destroyed via ice movement. The remaining 50 structures were equally distributed in both ponds ($n = 25$) and

lakes ($n = 25$). All 50 structures were considered available to mallards and other waterfowl during the 2001 nesting season.

Nest Structure Use and Wetland Conditions

Use of artificial nest structures was minimal as monitored by monthly inspections. While fecal material on the outside of the structures revealed their use by Canada geese as loafing platforms, no evidence of use by mallards was found inside nest structures during spring/summer 2001. During late March and early April, field crews witnessed a female mallard loafing on one of the nest structures on several occasions; however, this structure had no other evidence of use. One structure was used by a wood duck that laid five eggs, but the nest was subsequently abandoned. Three structures were used by tree swallows (Tachycineta bicolor). Two of these nests were successful in fledging young, and the third pair made a nest bowl but failed to lay eggs.

Wetland conditions were good to excellent during spring/summer 2001. Nearly all of the basins were bankfull during the first nest check (7-9 May) when the estimated degree of surface water was 97.2%. Spring rains increased the amount of water in basins prior to the second nest check (5-11 June) when basins were 99.9 percent inundated. The water levels in the ponds and lakes remained high (99.4%) through the third nest check on 9-10 July.

JOB NO. I.3. Assessment of Mallard Recruitment.

OBJECTIVE:

To assess whether there is significant recruitment from mallards nesting on the study area.

METHODS

We compared the number of ducklings produced by our marked sample of females with the number of females killed during the nesting season. This comparison provided a simple estimate of mallard production each year without considering the effects of the annual female survival rate on mallard populations.

Recruitment (R) was defined as the number of females recruited into the fall population per female in that year's spring population (Cowardin et al. 1985). We estimated recruitment ($R = HGS_d/2$) according to the Mauser and Jarvis (1994) modification to equation 5 of Cowardin and Johnson (1979:23), where H = hen success (the probability that a hen will have one successful nest in one or more attempts (Cowardin et al. 1985)), G = mean brood size at hatch, and S_d = duckling survival from hatch to 20 days. We assumed a 50:50 sex ratio for the 20-day survival data, hence the division of HGS_d by two in the recruitment model. We only collected duckling survival data to 20 days because most mallard duckling mortality occurs within this period (Orthmeyer and Ball 1990, Mauser et al. 1994).

We used equation 4 (Cowardin and Johnson 1979:23) after Mauser and Jarvis (1994) to determine the proportional change in population size (C) where $C = S(1 + DR/S_b)$, S was defined as the annual survival of adult females (0.57 ± 0.01 , Smith and Reynolds 1992:311), D was the ratio of the annual survival of yearlings to adults [annual yearling female mallard survival was estimated at 0.59 ± 0.02 (Smith and Reynolds 1992:311)], and S_b was the summer survival of yearling and adult female mallards (0.83, Anderson 1975:23) and assumed to be equal.

RESULTS

Recruitment 2001

Three mallard females were killed during the 2001 nesting season (Table 7), and 38 ducklings were produced by the marked sample of females. Duckling survival to 20-days posthatch from 1998-2001 was $\hat{s} = 0.445 \pm 0.042$ (Fig. 4); therefore, we estimated 17 ducklings survived the period. Assuming a 50:50 sex ratio and that duckling survival to 20 days did not vary by sex, 8 female ducklings survived. Upon preliminary examination, 2.83 female ducklings were produced for every female lost during the nesting season. Thus production exceeded female mortality during the 2001 nesting season, and as a result, the spring 2002 mallard population will likely increase over the spring 2001 breeding population.

Mallard recruitment (R) in 2001 was estimated at 0.704 females per hen in the spring population translating to a proportional increase of seven percent ($C = 1.07$) in the mallard breeding population from 2001 to 2002 (Table 8). The high hen success (41.7%) and female survival ($\hat{s} = 0.744 \pm 0.119$, Table 7) in 2001 combined with high duckling survival ($\hat{s} = 0.445 \pm 0.042$, Fig. 4) during 1998-2001 suggests an increased mallard breeding population in central Illinois during spring 2002.

DISCUSSION

Hypothetically, let us assume that the spring 1998 mallard population at MSD was 100 females and that no immigration or emigration of female mallards occurred. Based on the above calculations (Table 8), the spring 1999 population would have increased by 11 percent raising the population level to 111 females. The subsequent decline in production in 1999 caused an estimated 18.8 percent decrease in the spring 2000 mallard population lowering the number of female mallards to 90. The 2001 female population was further affected by poor production in

2000 when the population again declined by 22.2 percent. Our predicted spring 2001 female mallard population would have declined to 70 from the original 100 observed in 1998. Mallard production during the 2001 nesting and brood rearing seasons provided a 7.0 percent increase in our estimated population level, raising the number of females to 75. Even though we observed a productive year by mallards during 2001, we expect only a slight increase in the mallard breeding population in spring 2002. The female mallard population at MSD may only be 68 percent of that observed during spring 1999.

We predicted that the spring 2001 breeding population of mallards in central Illinois would be reduced considerably from the 1998 and 1999 populations due to poor production in 1999 and 2000. This estimated decline was apparent during spring 2001 when field crews observed a reduced number of females present in the population. While actual numbers of resident female mallards were not known, the noticeable decrease in the number of females captured in 2001 illustrated this point (Table 1). The increased number of days field crews attempted to capture resident mallards and the corresponding increase in trap-days further substantiated this point. The number of female mallards caught per trap-day in 1998 and 1999 were ≥ 0.200 while the 2001 value slipped to 0.053. The apparent success in capturing females in 1999 declined 77 percent during spring 2001 (Table 1).

The fluctuating resident mallard populations in central Illinois during the 1998-2001 nesting seasons may reflect mallard population cycles in nontraditional breeding areas. Petrie (1999) suggested that the wetlands of nontraditional breeding areas were more stable, which would allow for more consistent population growth. The apparent decline in recruitment during the 1999 and 2000 breeding seasons suggested that the mallard breeding population in central Illinois was decreasing. The population may have recovered some in 2001. Further monitoring

of mallards during springs 2002 and 2003 (PR Project W-130-5-6) will allow a more detailed examination of the nesting ecology of resident mallards and their population status in central Illinois.

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Table 1. Numbers of trap-days and mallards (*Anas platyrhynchos*) captured in central Illinois during March-April, 1998-2001.

Year	Days trapped	Trap-days	Females captured	Draques captured	Mallards captured	Females/ trap-day	Draques/ trap-day	Mallards/ trap-day
1998	22	195	39	50	89	0.200	0.256	0.456
1999	23	191	44	33	77	0.230	0.173	0.403
2000	25	197	38	36	74	0.193	0.183	0.376
2001	31	322	17	74	91	0.053	0.230	0.283

Table 2. Tracking status of female mallards equipped with radio transmitters during March-April, 1998-2001, in central Illinois.

Status	Number of hens			
	1998	1999	2000	2001
Female captured	38	43	38	17
Nested and tracked successfully	27	33	24	12
Migrants	10	5	6	3
Did not nest	0	1	1	1
Killed before nesting	0	3 ^a	1	1 ^a
Radio fell off/failed	1	1	4	0
Nested but unsuccessfully tracked	0	0	2	0

^a One hen in 1999 and 2001 was killed within two days of transmitter attachment and was excluded from data analysis.

Table 3. Means (\pm SE) of morphological measurements and the body condition indices of resident mallards in central Illinois, 1998-2001.

Measurement ^a	1998		1999		2000		2001	
	Male ($n=10$)	Female ($n=28$)	Male ($n=16$)	Female ($n=37$)	Male ($n=9$)	Female ($n=32$)	Male ($n=4$)	Female ($n=13$)
Bill width (mm)	24.2 (0.2)	22.8 (0.2)	23.9 (0.2)	23.1 (0.1)	24.0 (0.2)	23.0 (0.1)	24.3 (0.5)	23.3 (0.2)
Culmen 1 (mm)	55.1 (0.8)	51.9 (0.5)	56.3 (0.8)	52.3 (0.3)	54.7 (1.0)	51.4 (0.4)	56.8 (1.4)	51.3 (0.6)
Culmen 2 (mm)	63.9 (0.9)	59.5 (0.4)	64.0 (0.8)	59.0 (0.4)	63.6 (1.2)	58.6 (0.4)	66.8 (1.5)	59.0 (0.8)
Tarsus width (mm)	5.3 (0.1)	5.2 (0.1)	5.2 (0.1)	5.0 (0.0)	5.4 (0.2)	5.1 (0.1)	5.3 (0.1)	5.0 (0.1)
Tarsus length (mm)	47.6 (1.0)	47.4 (0.4)	52.0 (0.5)	48.9 (0.3)	51.7 (1.0)	48.7 (0.4)	52.7 (1.0)	48.0 (0.6)
Total tarsus (mm)	55.3 (0.8)	53.6 (0.3)	56.4 (0.4)	53.6 (0.3)	57.1 (0.7)	54.1 (0.4)	57.3 (0.7)	53.5 (0.5)
Mass (g)	1,223.5 (26.9)	1,121.4 (15.9)	1,155.6 (18.5)	1,062.7 (13.3)	1,242.2 (17.7)	1,075.0 (13.5)	1,205.0 (53.2)	1,058.5 (28.7)
Wing chord (mm)	289.0 (2.9)	267.6 (1.3)	290.2 (2.1)	270.2 (1.2)	289.3 (1.9)	272.5 (1.1)	288.0 (2.4)	270.5 (3.1)
Body condition ^b	4.23 (0.09)	4.19 (0.06)	3.98 (0.06)	3.93 (0.04)	4.30 (0.08)	3.95 (0.05)	4.18 (0.17)	3.91 (0.08)

^a Bill and leg measurements described by Byers and Cary (1991).

^b Mass (g)/wing chord (mm).

Table 4. Mallard nesting season dates and lengths in central Illinois, 1998-2001.

Year	First nest initiation	Last nest hatched or destroyed	Nesting season length (days)
1998	April 4	July 1	89
1999	April 6	July 17	103
2000	April 12	July 20	100
2001	April 6	June 30	86

Table 5. Fate and number of mallard nests from radio-equipped females in central Illinois during April-July, 1998-2001.

Nest fate	Year			
	1998	1999	2000	2001
Hatched	10	7	4	5
Coyote (<u>Canis latrans</u>)	15	10	7	0
Raccoon (<u>Procyon lotor</u>)	8	3	5	2
Mink (<u>Mustela vison</u>)	0	0	1	1
Snake	1	3	1	1
Striped skunk (<u>Mephitis mephitis</u>)	0	0	1	0
Opossum (<u>Didelphis virginiana</u>)	0	0	0	1
Turtle	0	1	0	0
Unknown mammal	4	12	8	4
Unknown	3	7	17	2
Abandoned ^a	6	1	0	0
Mowed/hayed	1	3	0	0
Agricultural equipment	0	0	0	1
Total	48	47	45	17

^a Five nests were abandoned due to researcher influence in 1998 and one in 1999.

Table 6. Kaplan-Meier nest survival estimates, 95% confidence intervals, and log-rank statistics for female mallards monitored in central Illinois during April-July, 1998-2001.

Year	Female age	No. of nests		Nest survival	95% CI	χ^2	P
		at risk	failed				
1998	Adult	28	15	0.3647	0.1663 - 0.5631	4.980	0.026
	Yearling	15	12	0.1429	0.0000 - 0.3262		
1999	Adult	26	22	0.1067	0.0000 - 0.2351	1.132	0.251
	Yearling	19	15	0.2105	0.0272 - 0.3938		
	Combined	45	37	0.1559	0.0473 - 0.2645		
2000	Adult	33	30	0.0606	0.0000 - 0.1613	0.070	0.792
	Yearling	6	5	0.1667	0.0000 - 0.4648		
	Combined	39	35	0.0641	0.0000 - 0.1672		
2001	Adult	13	8	0.3385	0.0698 - 0.6072	0.004	0.950
	Yearling	4	3	0.2500	0.0000 - 0.6743		
	Combined	17	11	0.3167	0.0880 - 0.5454		

Table 7. Kaplan-Meier survival estimates, 95% confidence intervals, and log-rank statistics for female mallards equipped with radio transmitters in central Illinois during March-August, 1998-2001.

Year	Female age	<u>No. of females</u>		Female survival	95% CI	χ^2	P
		at risk	failed				
1998	Adult	19	4	0.6241	0.2476 - 1.0000	0.005	0.943
	Yearling	9	2	0.7500	0.4499 - 1.0000		
	Combined	28	6	0.6721	0.4001 - 0.9441		
1999	Adult	17	3	0.7161	0.4182 - 1.0000	3.800	0.051
	Yearling	20	9	0.5455	0.3254 - 0.7656		
	Combined	37	12	0.5994	0.3916 - 0.8072		
2000	Adult	24	4	0.7929	0.6049 - 0.9810	0.005	0.946
	Yearling	8	1	0.8571	0.5978 - 1.0000		
	Combined	32	5	0.7997	0.6343 - 0.9651		
2001	Adult	9	3	0.6250	0.3188 - 0.9313	1.604	0.205
	Yearling	4	0	1.0000	-		
	Combined	13	3	0.7438	0.5105 - 0.9771		
1998-2001	Combined	110	26	0.6633	0.4248 - 0.9019	1.620	0.654

Table 8. Estimates of parameters (SE) used to calculate recruitment (R) and change in population size (C) for breeding mallards in central Illinois, 1998-2001.

Parameter	Year			
	1998	1999	2000	2001
Hen success	0.37	0.21	0.15	0.42
Duckling survival ^a	0.500 (0.064)	0.388 (0.071)	0.401 (0.093)	0.445 (0.042) ^b
Brood size at hatch	8.20 (0.87)	8.29 (0.64)	9.50 (0.87)	7.6 (1.00)
Recruitment (R)	0.76	0.34	0.29	0.70
Adult female survival ^c	0.57 (0.01)	0.57 (0.01)	0.57 (0.01)	0.57 (0.01)
Juvenile female survival ^c	0.59 (0.02)	0.59 (0.02)	0.59 (0.02)	0.59 (0.02)
Female summer survival ^d	0.83	0.83	0.83	0.83
Population change (C)	1.11	0.81	0.78	1.07

^a Duckling survival was calculated to 20 days posthatch.

^b Duckling survival was averaged across years 1998-2001 for the 2001 estimate.

^c Smith and Reynolds (1992:311).

^d Anderson (1975:23).

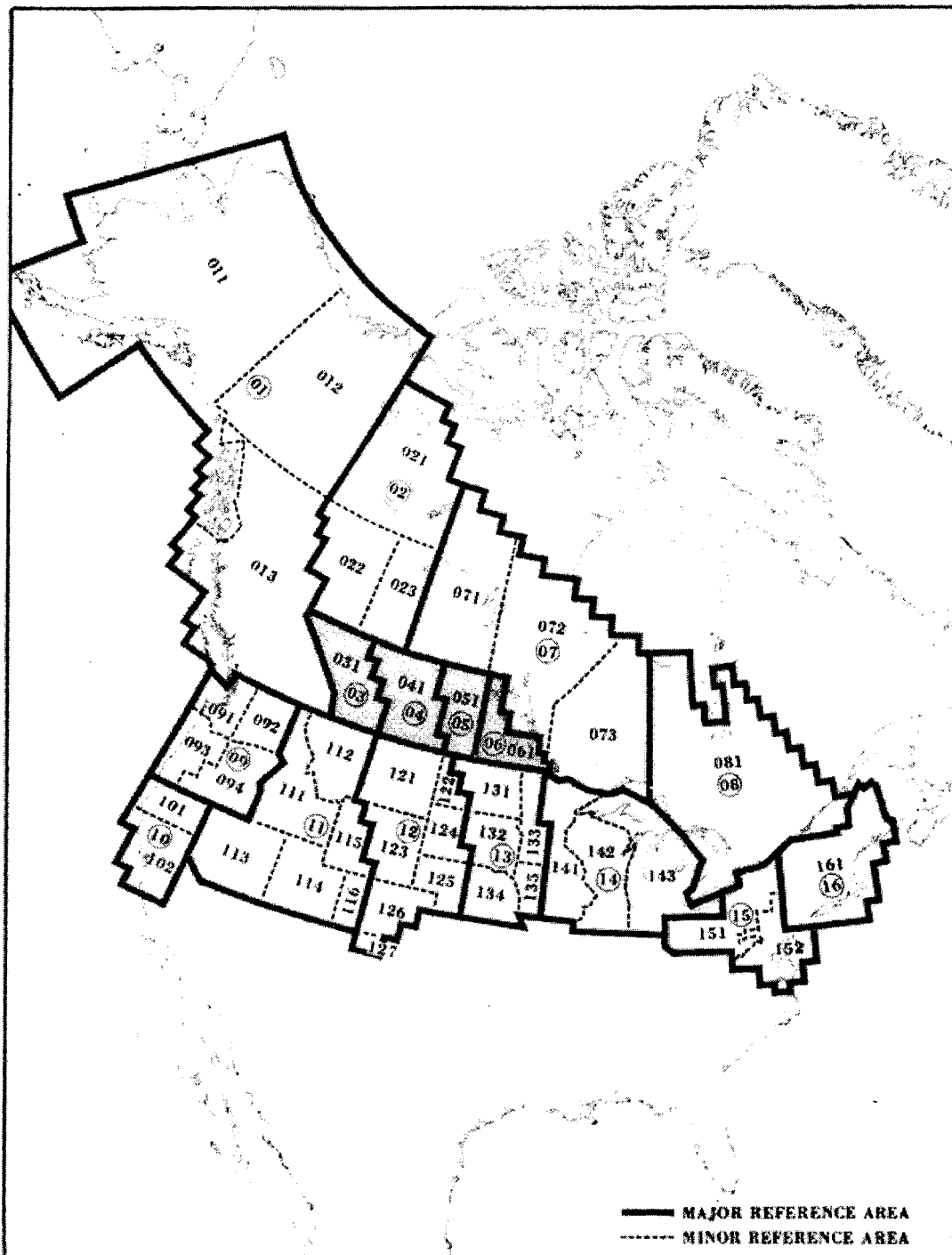


Figure 1. Breeding mallard reference areas in North America. Encircled numbers represent major reference areas (Anderson and Henny 1972, Pospahala et al. 1974).

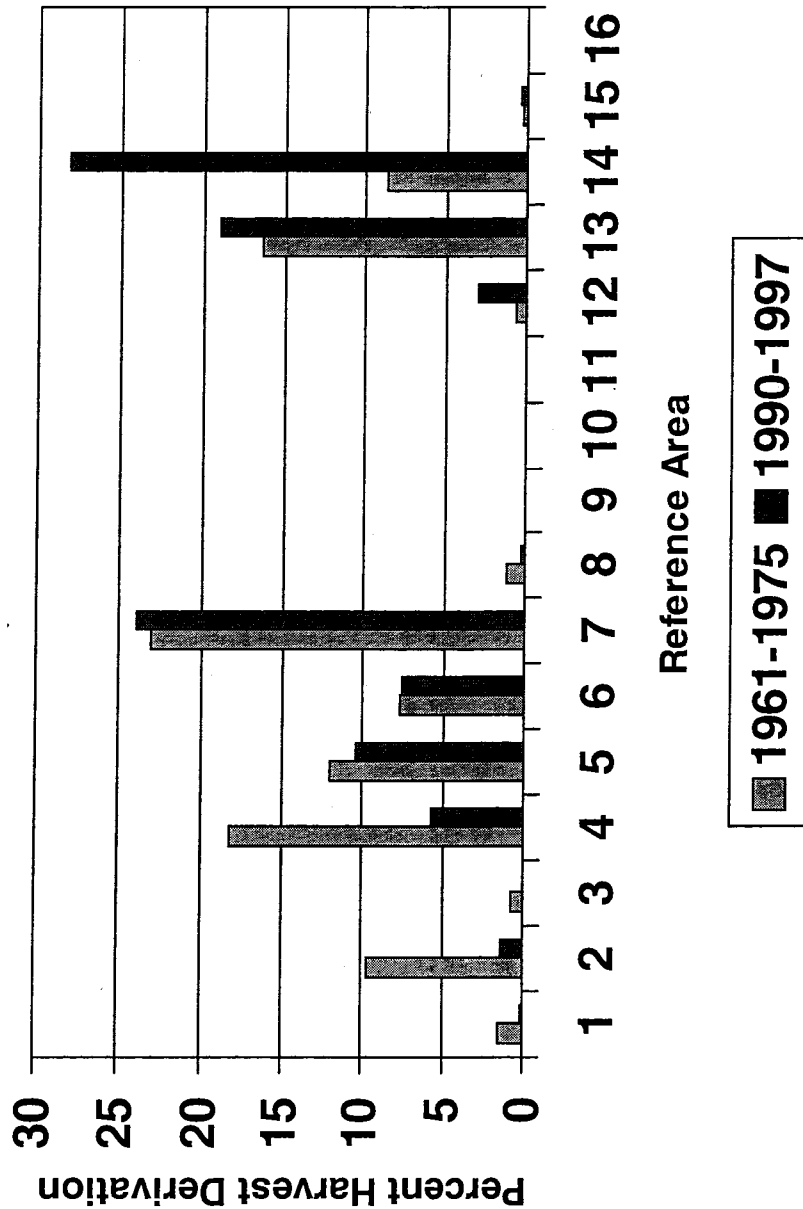


Figure 2. Percent derivation of the Illinois mallard harvest by major reference area (Anderson and Henny 1972, Pospahala et al. 1974; Figure 1). Sources of mallard harvest data were Munro and Kimball (1982) and Zuwerink and Gates (1999).

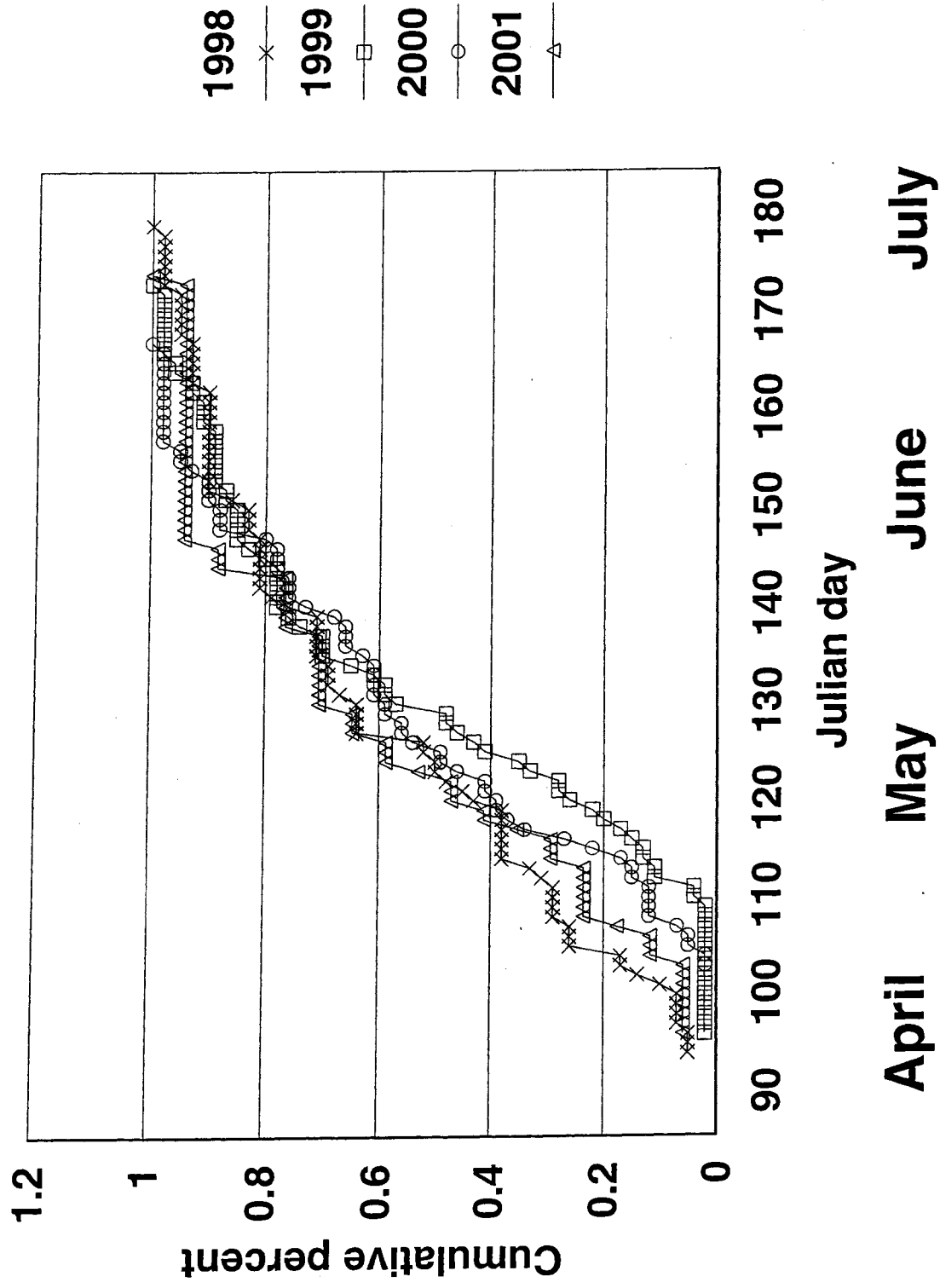


Figure 3. Percentage of mallard nests initiated by Julian day in central Illinois during spring/summer, 1998-2001.

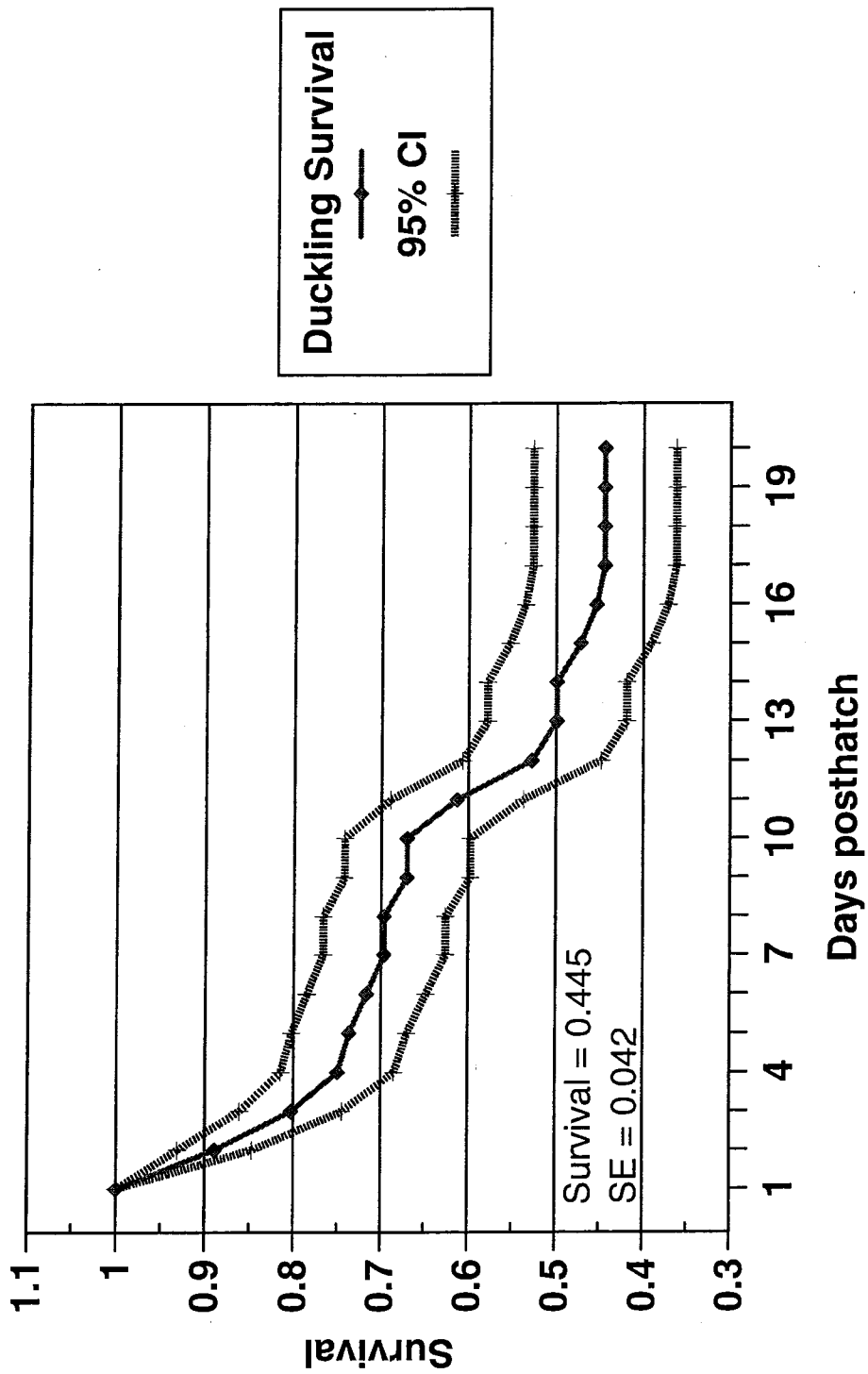


Figure 4. Kaplan-Meier survival estimate and 95% confidence interval for mallard ducklings in central Illinois, 1998-2001.

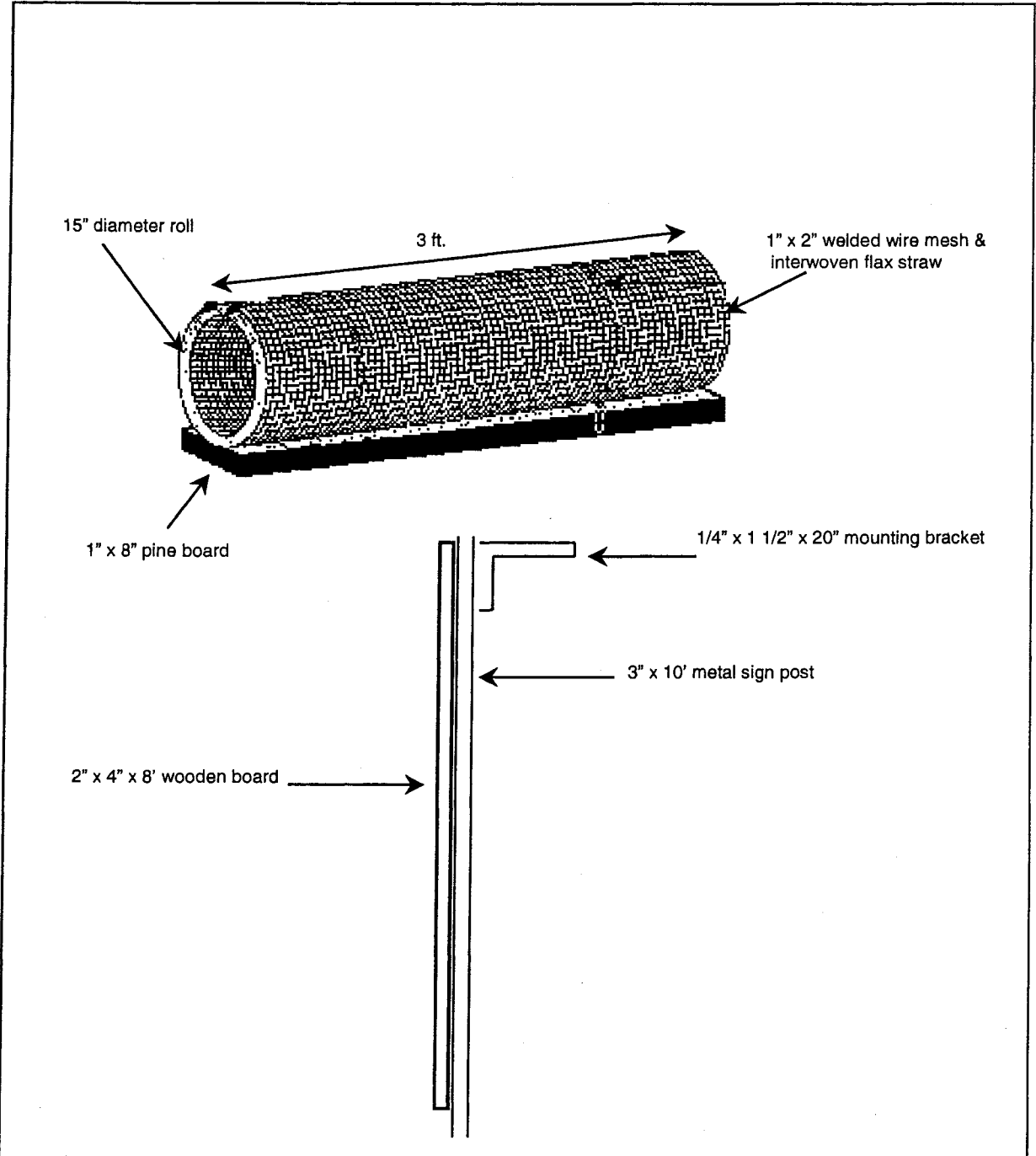


Figure 5. Cylindrical artificial nest structure (Hen House™) and support posts used at the Metropolitan Water Reclamation District of Greater Chicago, 2001 (Modified from Grondahl and Dockter, no date).

SUBMITTED BY:

A handwritten signature in black ink that reads "Stephen P. Havera". The signature is written in a cursive style with a large, stylized 'S' and 'H'.

Stephen P. Havera
Senior Professional Scientist
Illinois Natural History Survey

DATE: 29 August 2001



ILLINOIS
NATURAL
HISTORY
SURVEY



August 29, 2001

Dan Holm
Illinois Department of Natural Resources
Waterfowl Project Manager
700 S. 10th
Havana, IL 62644

RE: Annual Report-Project W-130-R-4; Mallard Investigations

Dear Dan:

Enclosed please find five copies of the annual report for W-130-R-4.

Sincerely,

A handwritten signature in black ink, appearing to read "S. Havera".

Stephen P. Havera, Ph.D.
Director
Forbes Biological Station

SPH:ay

Enclosure

c: Patrick W. Brown