Mallard Nest Success and Recruitment in Prairie Canada

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Introduction

Knowledge of factors that influence mallard (*Anas platyrhynchos*) recruitment is needed to understand population dynamics of the species. Nest success rate has a primary influence on mallard recruitment (Cowardin and Johnson 1979). Recent studies indicated that mallard nest success in much of the prairie pothole region of the United States is below 15 percent (Klett et al. in prep.)—the rate thought necessary for mallard populations in North Dakota to be self-sustaining (Cowardin et al. 1985). More than two-thirds of the prairie pothole region is in Canada, where waterfowl are subject to many of the same perils during nesting as in the United States. Nesting habitats throughout the entire region have been subjected to intensive and extensive agricultural disturbance. Current information on mallard nest success in Prairie Canada was scant when the recent evaluation of stabilized duck hunting regulations was initiated (Canadian Wildlife Service [CWS] and U.S. Fish and Wildlife Service [USFWS] 1987). Data on nest success were needed as part of the evaluation so we could estimate mallard recruitment.

Our study provided a current assessment of mallard nest success rates at scattered locations in Prairie Canada. Objectives of the study were: (1) to estimate temporal and spatial variation in mallard nest success in Prairie Canada; (2) to determine the principal causes of nest failure; (3) to determine species composition of principal predators of duck nests and obtain indices to the densities of those predators; and (4) to estimate mallard recruitment rates and total recruitment at each study location. In the present paper, we discuss findings relevant to objectives one, two and four. Relations between predator populations and nest success will be presented in future publications. Where appropriate, data for other duck species are incorporated into our findings.

Study Areas

Fieldwork was conducted during 1982–85 on 17 study areas in Alberta, Saskatchewan and Manitoba. They were located on air/ground segments of transects surveyed annually to estimate the size of duck breeding populations (Martin et al. 1979) (Figure 1). Each study area was 1 mile (1.6 km) wide by 10 miles (16 km) long and contained a diversity of the available habitats. We selected study areas throughout the grassland and parkland regions to assess geographic variation in nest success and predator populations. To obtain an adequate sample of mallard nests, we chose air/ground segments with relatively high numbers of wetlands and histories of relatively high

Figure 1. The prairie pothole region of Canada (modified from Kiel et al. 1972) showing the locations and names of areas studied during 1982–85. Stippled area is the parkland region; adjacent area to south is the grassland region.

densities of breeding mallards. Our resources were insufficient to work on all study areas each year, so we adjusted our work schedule to accommodate a maximum of 10 areas annually.

Habitat Classification

Habitat composition of individual study areas was determined by interpretation of color infrared aerial photographs taken in 1982. Photo interpretation was done by the U.S. National Wetlands Inventory, St. Petersburg, Florida. Habitats were placed in one of nine classes, five of which were described by Cowardin et al. (1985): hayland; wetland; cropland; right-of-way; and odd area. We modified the Cowardin et al. (1985) class for grassland, separating it into grass and brush (called grass-brush) components. We did this because Cowardin et al. (1985) found greater preference by mallards for nest sites in brush as compared to grass. Our class grass-brush consisted of areas of dense woody vegetation (<1.1 yard [1 m] tall) in native prairie. Additional classes we used were woodland, consisting of areas of shrubs and trees (>1.1 yard [1 m] tall), and barren, consisting of road surfaces and other places where nesting was not possible.

Habitat Availability

Cropland was abundant; the proportion of each study area in cropland averaged 59 percent. Twelve study areas comprised 50 percent or more cropland and 2 exceeded 80 percent. In cropland, only fields with standing stubble were considered to be nesting habitat because few ducks nest in tilled stubble or on fallow ground (Higgins 1977, Milonski 1958). Cropland seeded in spring resembled fallow ground until mid-June, when grain began rapid growth.

Grass composed more than 20 percent of seven study areas; the proportion of each study area in grass averaged 16 percent. It occurred primarily as native prairie pasture (native pasture) in the grassland region and as seeded pasture in the parkland region. Grass-brush was present in native pasture, but little was present in seeded pasture. It did not exceed 4 percent on any study area. Most of the pastures were heavily grazed in the driest years. The larger pastures were mostly public lands managed by the Prairie Farm Rehabilitation Administration (PFRA).

The proportion of each study area in wetland averaged 11 percent. Wetland provided nesting habitat for overwater-nesting ducks in wet years and for upland-nesting ducks in dry years. We estimated the amount of wetland habitat suitable for nesting cover on individual study areas each year on the basis of water levels in wetlands.

The proportion of each study area in odd area averaged 5 percent. Odd area habitat was least available in the grassland region, where farmed fields were large and clear of obstructions. It was more available in the parkland region, where tillage frequently was hampered by standing trees and piles of cleared timber.

Hayland was available on 11 study areas, but exceeded 7 percent on only 1 area. Less than 1 percent of the habitat on any study area was classified as barren.

Weather Conditions

Drought conditions prevailed throughout Prairie Canada during much of the study. On the areas studied in 1982, winter snowfall was adequate to provide some runoff, and a heavy snowstorm in late May improved wetland conditions markedly. Additional precipitation amounts during April–July were near-average and most basins contained water all summer.

In 1983, snowmelt provided some runoff, including that from a mid-May snowstorm in southeastern Saskatchewan and southwestern Manitoba. Additional precipitation amounts during April–July were below average on most areas; the exception was in central Alberta, where heavy rains during late June caused wetlands to overflow their basins. Except in Alberta, wetland water levels decreased on most study areas throughout the summer.

In 1984, severe drought prevailed on all study areas. Runoff from snowmelt was scant and many wetlands were dry at the beginning of the nesting season. April–July precipitation amounts were far below average on most study areas and wetland conditions continued to deteriorate throughout the summer. The driest study areas were in southcentral Saskatchewan.

In 1985, heavy runoff from snowmelt filled many basins to overflowing on the more northern and eastern study areas, but runoff was minimal on the southern and southwestern areas. Wetland water levels were low on areas with scant runoff. Precipitation amounts during April–July were below average on most study areas.

Mallard Breeding Populations

Mallards were counted annually in mid-May on each air/ground segment. We obtained field counts from the U.S. Fish and Wildlife Service's Office of Migratory Bird Management, and extracted data that pertained to the portion of the air/ground segment where we worked. We then extrapolated from the density of indicated pairs for that portion of the air/ground segment to arrive at the breeding population estimate for the entire study area.

Numbers of mallard pairs varied greatly among study areas and years. Annual estimates on individual study areas ranged from 2.1 to 33.4 pairs per square mile (0.8–12.9/km^2). Mallard breeding populations averaged 13.7 pairs per square mile (5.3/km^2) for all years combined, and ranged from an average of 8.3 pairs per square mile (3.2/km^2) in 1985 to 21.5 pairs per square mile (8.3/km^2) in 1983.

Predator Populations

Systematic surveys to determine the distribution and relative abundance of predator species known to affect duck nesting success in Prairie Canada were conducted on each study area during 1983–85 (CWS and USFWS 1987).

Eight species that are known to prey on duck eggs were sufficiently abundant to be of consequence to duck nest success. Those were the coyote (*Canis latrans*), red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), badger (*Taxidea taxus*), Franklin's ground squirrel (*Spermophilus franklinii*), American crow (*Corvus brachyrhynchos*) and black-billed magpie (*Pica pica*). Composition of the predator community and abundance of individual species varied considerably among study areas. Five or more species were present on each study area each year, and at least three species were abundant-to-common on each area every year. There was little annual change in composition and abundance of predators on most areas studied more than one year. The predator community was more diverse on eastern than on western study areas.

Field Methods

Duck nests were found during three systematic searches conducted at approximately 21–day intervals on each study area. Searches began during the first week of May, the fourth week of May and the second week of June. A nest was defined as a nest bowl that, when found, contained at least one egg tended by a hen. We searched for nests in all habitats except fallow and seeded cropland; a vehicle-pulled drag was the primary search method (Higgins et al. 1977). Where such a drag could not be used, searches were conducted by personnel on foot.

We attempted to find duck nests, especially mallard nests, in each habitat, and to search as much nesting habitat as possible on each study area. On study areas with few trees, we searched most of the available upland nesting habitat because the vehicle-pulled drags could be used effectively. On study areas where much foot searching was required, we sampled habitats by conducting complete searches of scattered 0.25–square mile (0.65 km^2) units, or portions thereof.

Nest searches were conducted between 0600–1400 hours. We marked most of the nests we found for relocation with an orange-flagged stick. Age of the nest was determined by candling eggs (see Weller 1956) when the nest was discovered. Type

of vegetation at the nest site was recorded. Nests were visited once every 7–10 days until the eggs hatched, were destroyed or abandoned.

Nest fate was classified as successful if at least one egg hatched. A destroyed nest was one that contained no whole or hatched eggs. An abandoned nest was one that contained at least one whole egg and no hatched eggs and was no longer tended by a hen. Nests that were abandoned within a few days after discovery were considered to be investigator-influenced and were not used to measure survival. Causes of nest destruction were recorded as predation, agriculture and other.

Analytical Methods

Habitat Preference

We define preference as the use made of a habitat for nesting, relative to the availability of that habitat. Preference was derived from estimated nest densities in each habitat. We used a linear model to reduce variability in the nest density estimates; the procedure (described in CWS and USFWS 1987) is based on two assumptions. First, that nests in all habitats had an equal probability of being found. Second, that habitat preferences of a species were similar among study areas and years.

Nest Success

We calculated daily survival rates by the Mayfield method as modified by Johnson (1979). Daily survival rates (DSR) were converted to hatch rates (P) because hatch rates are more easily interpreted [$P = (DSR)^I$, where I is the average duration of the laying + incubation interval]. We used an interval of 35 days for the mallard. Because the data were distributed among eight habitats, 17 study areas and four years, the survival estimates for mallards in some categories were lacking or imprecise due to small sample size. It was necessary, therefore, to supplement those data with estimates for other species by using a model similar to the one described by Klett et al. (in press). We used data for the blue-winged teal (*A. discors*), northern pintail (*A. acuta*), northern shoveler (*A. clypeata*) and gadwall (*A. strepera*). Besides an effect for species, we considered effects due to habitat, study area and year, and their interactions. We assumed that habitat effects were similar among study areas and years. This assumption was necessary in order to estimate nest success for all habitats and study areas; however, it precluded our drawing conclusions about subtle differences in habitat effects among study areas. To arrive at a composite estimate of annual nest success for all habitats on an individual study area, we weighted the nest success estimate for each habitat by the number of nests initiated in that habitat. We used the product of species preference, habitat availability and number of breeding pairs as an index to the relative number of nests initiated in each habitat.

Nest Fate

For each study area we determined the percentage of nest failures attributed to the various agents in each habitat class. We assumed that all duck nests that failed in a given habitat, regardless of species, had the same chance of falling victim to any of the agents. Therefore, we combined unsuccessful nests of blue-winged teals, northern pintails, and northern shovelers and gadwalls with mallards to increase sample size and reduce sampling error. Then, to arrive at the rate of loss for mallards on each

study area, we weighted the rate of loss in each habitat by the indices to the number of mallard nests initiated in each habitat, as described under nest success.

Results

Habitat Preference and Nest Success

During the four-year study, we found 4,138 nests of the five species that provided data suitable for analysis; 38 percent were of mallards. Mallards preferred to nest in grass-brush, followed by right-of-way, odd area, woodland, wetland, cropland, hayland and grass. They nested most successfully in woodland, followed by grass-brush, wetland, grass, hayland, odd area, right-of-way and cropland.

The estimate of mallard nest success (± S.D.) over all study areas and years averaged 12 percent (± 7), with a range on individual study areas from 2 to 29 percent. Of the 31 annual estimates of nest success on individual study areas, only 7 equalled or exceeded 15 percent.

There was considerable annual variation in mallard nest success on many areas studied more than one year. Average nest success for all study areas was highest in 1982, decreased slightly in 1983 and then showed a precipitous decline in 1984 (Table 1). Success increased in 1985. Annual variation was greatest on study areas where drought conditions were most severe. For example, on the Shamrock and Ceylon study areas in southcentral Saskatchewan between 1983 and 1984, nest success decreased from 16 percent to 2 percent and from 28 percent to 4 percent, respectively.

Nest success was correlated with the amount of grass available on study areas (grassland region, $r=0.80$, $P<0.05$; parkland region, $r=0.67$, $P=0.05$) (Figure 2). Contiguous blocks of native pasture contained the largest tracts of grass and were important nesting areas for ducks. Four of the seven estimates of mallard nest success that exceeded 15 percent were from study areas where duck nests were concentrated in large native pastures, including both PFRA and private holdings. Those four estimates were from the Shamrock study area (1982 and 1983), and the Goodwater and Ceylon study areas (1983). On those areas, 58–84 percent of the mallard nests and 52–82 percent of the nests of all five species were found in large blocks of native pasture (Table 2). Native pastures composed 17–28 percent of the habitat on those study areas. Of the remaining habitat, 50–59 percent was cropland. The highest density of duck nests observed was on the Ceylon study area in 1983; more than 250 nests, including over 100 of mallards, were found in 640 acres (259 ha) of native pasture.

Within native pastures, grass-brush composed principally of *Symphoricarpos* sp. and *Rosa* sp. provided the most important nesting sites for mallards and other ducks. On the Shamrock, Ceylon and Goodwater study areas, grass-brush composed only 2–3 percent of the available habitat yet contained 75 percent of the mallard nests (557) and 67 percent of the nests (N = 1,851) of all five species found during 1983–85.

Nest Fate

Nearly three-quarters of all mallard nests were destroyed by predators (Table 1). Predators were also implicated, both directly and indirectly, in the failure of some

Table 1. Outcomes of mallard nesting attempts (% ± S.D.) in Prairie Canada, averaged over study areas (n) by year.

	Percentage				
Outcome	1982 (n = 3)	1983 (n = 8)	1984 (n = 10)	1985 (n = 10)	Average
Successful	17 ± 12	14 ± 6	6 ± 4	13 ± 7	12 ± 7
Destroyed					
Predator	71 ± 17	67 ± 10	76 ± 8	71 ± 8	72 ± 10
Agriculture	3 ± 4	3 ± 2	3 ± 2	4 ± 2	3 ± 2
Other	1 ± 2	1 ± 1	<1	0	<1
Abandoned					
Predator	2 ± 2	7 ± 4	6 ± 2	6 ± 2	6 ± 5
Weather	2 ± 3	5 ± 6	<1	<1	2 ± 4
Other	3 ± 2	4 ± 5	9 ± 7	5 ± 5	6 ± 6

nests that were abandoned. An average of 6 percent of the abandoned nests had some eggs in the clutch destroyed by a predator. We suspect that some of the nests abandoned without evidence of egg destruction were also predator influenced because the remains of nesting hens were found at the nests. Weather had minor impact on mallard nest fate overall, but on several occasions, heavy precipitation on individual

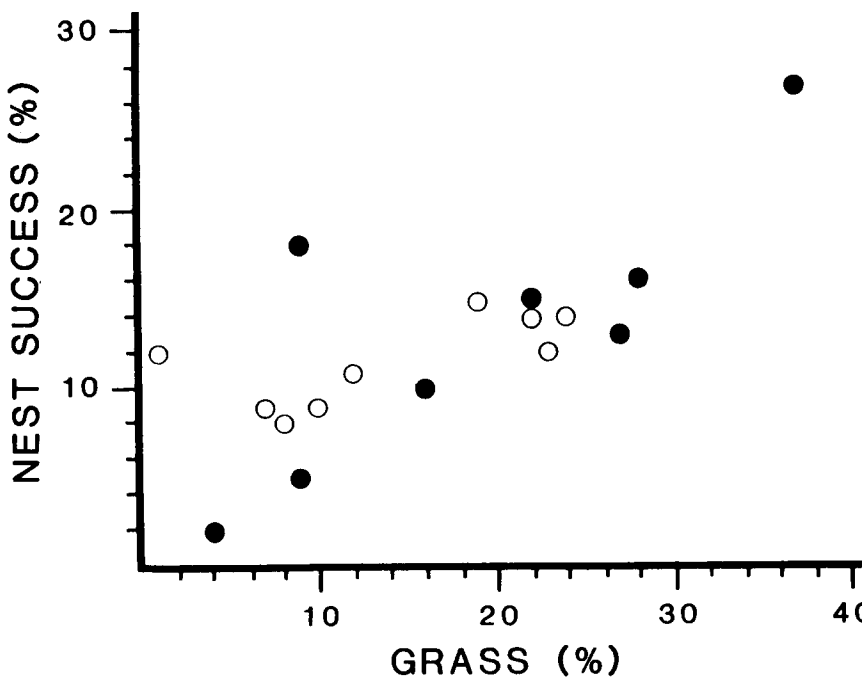

Figure 2. Mallard nest success in relation to availability of grass habitat on study areas in the grassland region (closed circle, r = 0.80, P<0.05) and parkland region (open circle, r = 0.67, P = 0.05).

Table 2. Number of duck nests[a] on selected study areas in the grassland region of Prairie Canada, and the proportion of those nests in contiguous blocks of native pasture.

Study area and year	Total nests on study area		Size of pasture block (acres)	Percentage of nests in pasture block	
	All ducks	Mallard		All ducks	Mallard
Shamrock					
1983	388	104	1,120	64	68
1984	148	56	1,120	64	63
1985	143	52	1,120	52	58
Ceylon					
1983	652	154	1,760[b]	75	81
1984	203	62	1,600	81	84
Goodwater					
1983	317	82	1,699[c]	82	59

[a]Includes mallard, blue-winged teal, northern pintail, northern shoveler and gadwall.
[b]Comprised of two units—one of 320 acres (129.5 ha) and one of 1,440 acres (582.8 ha).
[c]Comprised of two units—one of 480 acres (194.3 ha) and one of 1,120 acres (453.3 ha).

study areas impacted nest survival. Six percent of the mallard nests on each of two study areas were abandoned after a heavy snowfall in 1982, and 19 percent of the mallard nests on a third study area were flooded after heavy rainfall in 1984. Only 3 percent of the mallard nests failed from agricultural impact because few mallards nested in cropland.

Estimation of Mallard Recruitment

We estimated two parameters of recruitment—rate and number of young produced. Recruitment rate (R) is defined as the number of young females fledged to the fall population (Y), divided by the number of females in the spring population (F). The number of young produced is two times the product of breeding pairs (assumed to equal F) and recruitment rate. The value two is based on the assumption that sex ratio of young in the prehunting season population is equal.

Recruitment Model

We used a model developed by Cowardin and Johnson (1979):

$$R = \alpha P \exp\{\alpha(1-P)^2\}ZB/2$$

where,

α = an index to nesting intensity;
P = the probability that an individual nest will be successful;
Z = the survival rate of individual broods from nest site and brood water; and
B = the average size of broods at fledging.

Estimates of recruitment rate and young produced were calculated for each study area.

Direct measurement of nesting intensity α was not possible in this study, so we derived the values using the relation presented by Cowardin et al. (1985) between nesting intensity (α) and the number of semipermanent ponds containing water. Pond counts were obtained annually from the U.S. Fish and Wildlife Service's Office of Migratory Bird Management. Nest success rates (P) were obtained from our field observations. No data were available on brood survival (Z) and average brood size (B). They were treated as constants, and we used a brood survival estimate of 0.74 from Cowardin et al. (1985) and an average brood size of 4.9 from Cowardin and Johnson (1979). Sources of breeding population estimates were discussed earlier.

Recruitment Rate and Total Recruits

Recruitment rates and the number of young produced varied greatly among study areas and years. Estimated recruitment rates on individual study areas ranged from 0.04 to 0.94. Average recruitment rate ($\pm$ S.D.) for all study areas each year was 0.60 ($\pm$ 0.40) in 1982, 0.53 ($\pm$ 0.16) in 1983, 0.23 ($\pm$ 0.17) in 1984 and 0.46 ($\pm$ 0.16) in 1985.

Estimated numbers of young produced on individual study areas ranged from 8 to 356. Average estimate of the number of young produced ($\pm$ S.D.) on all study areas each year was 166 ($\pm$ 107) in 1982, 231 ($\pm$ 93) in 1983, 50 ($\pm$ 66) in 1984 and 80 ($\pm$ 42) in 1985.

The estimates of recruitment rate and number of recruits both reflect variation in hen success, because recruitment rate is the product of hen success, the constants for brood survival and average brood size used in the model. Hen success is a function of nest success and renesting rate (Cowardin et al. 1985), both of which were low during the study, especially during the 1984 drought. In reality, actual variation may have been greater than we estimated because brood survival and brood size probably varied among years and study areas, but we had no estimates for our study areas. It is reasonable that brood survival would vary with pond conditions and possibly with predator populations. Under extreme drought conditions, when all ponds are dry, brood survival could be reduced to zero.

Discussion

We observed much geographic and temporal variation in the results from this study. We expected to find low nest success on some study areas, but we also expected to find higher nest success than we observed on some areas. Where nest success was highest, the favorable rate could be attributed generally to the contribution from a relatively small portion of the study area. Characteristics in common among study areas with the highest nest success included a large block of land in native pasture, numerous wetlands that contained water and a predator community favorable to duck production.

We separated grassland (Cowardin et al. 1985) into grass and grass-brush components so we could distinguish mallard preferences for the purpose of modeling. However, it is difficult to discuss those components separately in relation to what they represented to upland-nesting ducks, because grass and grass-brush usually occurred together in native pasture. On study areas in the grassland region where success was highest, the amount of grass basically indicated the amount of native pasture that was available. Within native pasture, grass-brush was a minor component

in relation to availability, but was an important component in relation to preference and success of nesting ducks. Klett et al. (in prep.) did not separate grassland into the two components when they analyzed nest success data from the United States portion of the prairie pothole region, but they detected the same relationship that we observed between availability of grassland and nest success using grass.

Large pastures not only allow ducks to space their nests widely, thereby possibly reducing the chance of detection by predators, but also may influence the make-up of the predator community. For instance, large pastures may afford protection to the coyote, a species that does well in prairie environment, but that is vulnerable to human-inflicted mortality (Sargeant et al. 1987). The red fox is also highly adapted to living in prairie, but where the two species are sympatric, coyotes tend to exclude red foxes from large blocks of habitat (Sargeant 1982, Sargeant et al. 1987). The red fox is probably the most serious predator on upland-nesting ducks in the prairie pothole region (Sargeant and Arnold 1984), and its absence is a benefit to nesting ducks. All of the large pastures in our study areas were occupied by coyotes and had few red foxes; however, red foxes were common in most areas of cropland. The predator communities on our study areas comprised many of the same species that are held responsible for low nest success in the prairie pothole region in the United States (Sargeant and Arnold 1984).

Although much of the native grassland in Prairie Canada was converted to cropland long ago (Kiel et al. 1972, Archibald and Wilson 1980), loss of nesting habitat continues (Sugden and Beyersbergen 1984), especially in the areas marginally suited to grain farming (Boyd 1985). Boyd (1985) suggested that changes in "marginal farming" practices are presently the greatest threat to ducks, with regard to habitat loss, simply because the best farming areas have already been modified so extensively. Much of the native pasture that remains in Prairie Canada is in areas marginally suited to grain farming, and the potential threat to continental duck populations posed by the loss of this habitat is great.

Our study areas were not randomly selected, but we believe they are reflective of Prairie Canada. The average values for annual nest success and recruitment that we presented are unweighted means that represent one method of averaging; there may be other methods equally valid. Yet, the overriding message from the present study is clear—mallard recruitment was low throughout much of Prairie Canada during the study period, and on many areas the level of recruitment appeared insufficient for population stability (Cowardin et al. 1985). Our results also show that large native pastures containing brush are the best duck nesting habitat remaining throughout much of Prairie Canada. The potential of native pastures to produce ducks, especially mallards, far outweighs that which can be expected from comparable-sized areas of cropland, even under the best conditions. Protection of large tracts of native grassland is vital to the production of upland-nesting ducks in the prairie pothole region. The importance of brush to nesting ducks, especially mallards, must be considered when grassland management plans are developed.

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