Are Mallards Declining in North America?

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Whether mallard (*Anas platyrhynchos*) numbers have declined in recent years has been a subject of concern and debate among waterfowl biologists, wildlife managers, and administrators. Further controversy surrounds the reason for the presumed decline. One opinion holds that the decline, if it exists, is simply a reflection of a dry period, with fewer ponds available to support mallards. The opposing view is that mallards have declined more severely than wetland numbers, and have not responded to subsequent improvements in wetlands.

Verifying a decline seems relatively straightforward; after all, waterfowl have been counted in extensive and systematic surveys of major North American breeding grounds every year since 1955. Resolution of the debate is confounded, however, by the fact that the surveys were expanded several times in early years. Also, surveys began during what was apparently a wet period, with more basins containing water than have been recorded since; thus, mallard estimates from initial surveys may not be a representative starting point from which to draw comparisons.

We address 3 primary questions: (1) have numbers of breeding mallards in the surveyed area declined since the mid-1950s; (2) if so, are the changes due to variation in the number of wet ponds; and (3) has the relationship between mallard numbers and number of wet ponds changed in recent years?

METHODS

Data used were counts of mallards and wet ponds made by the U.S. Fish and Wildlife Service's Office of Migratory Bird Management and cooperating agencies during May aerial surveys of the primary breeding grounds each year from 1955 through 1985. Martin et al. (1979) described the procedures. Counts of mallards, but not ponds, were adjusted for visibility bias.

The surveyed area (Martin et al. 1979:fig. 1) encompassed >3,000,000 km^2 of the primary waterfowl breeding range in the north-central United States, the Prairie Provinces and Northwest Territories of Canada, and Alaska. The surveyed area (including Stratum 50 in western Ont., which was not covered regularly) contained from 78% (R. S. Pospahala, U.S. Fish and Wildl. Serv., unpubl. data, 1985) to 84% (Pospahala et al. 1974) of the North American mallard breeding population. These percentages were derived from a variety of sources, ranging from statistically designed sample surveys to "best guesses" of biologists familiar with the areas.

Because not all strata were surveyed each year, especially during the early period, the data set was incomplete. Missing observations made it difficult to detect any changes. Customarily, long-term averages are used in place of missing entries. For example, pond counts for Stratum 45 were not gathered during 1955–1957. To obtain the total pond count during 1955, one could use the average pond count in Stratum 45 from all the years in which it was made. This approach can give misleading results, however, especially if 1955 was, as it seemed to be, an unusually wet year, and if an average count from drier years was used.

To overcome the missing-value difficulty with pond counts, we used least-squares (LS) means. LS means are based on an assumed linear model, which here represents pond density as an additive combination of effects due to stratum and year. The assumption is that, if the other strata were wetter than usual in 1955, then Stratum 45 was wetter also. We used LS means, as well as customary values (those with missing values replaced by long-term averages), to estimate pond counts. LS estimates represent values expected had the design of the survey been fixed from the beginning, and thus account for imbalance in the design.

LS means were inappropriate for mallard numbers, because, for example, a high count of mallards in the prairie and parkland area would not imply high numbers also in Alaska. We tried 3 ways to overcome this difficulty: (1) we examined data for only Strata 21–40, for which complete records were available for 1955–1985; (2) we considered data from 1965–1985, when all strata were counted; and (3) we examined the data with missing counts replaced by averages for the same strata during other years.

A further difficulty is the erratic nature of some estimates of mallard numbers, caused by various biases, errors, and random variation. Estimates of mallard populations are perhaps the best available for any widely distributed species of wildlife, but are nonetheless inadequate for the detailed analyses often desired. Empirical Bayes (EB) techniques have been shown to overcome some of the problems due to variability in estimates; Johnson (1986*a,b*) found that EB estimators were appreciably more accurate than their customary counterparts. In essence, EB estimates are weighted averages of the customary values and the long-term average, where the weights depend on the relative variances of the 2 components. The assumption is that mallard numbers fluctuate around a long-term mean, so that the mean can contribute to the estimate for any particular year. EB estimates of mallards, as well as customary estimates, are included herein, although the weighting involved causes the EB estimates to be conservative about indicating a trend. Numbers in this report may differ from those in other published summaries, in part because we combined certain strata for the calculation of EB estimators (Johnson 1986*a*).

We tested whether or not the association between mallard densities and pond densities changed during 1955–1985. We divided that time span into 2 periods. For each transect within a stratum, we calculated a correlation coefficient between mallard and pond numbers for the 1955–1970 period and another for 1971–1985. Averages were taken across all transects in a stratum.

WHAT DO THE MALLARD NUMBERS TELL US?

Strata with Complete Records

Data from Strata 21–40 (Martin et al. 1979: fig. 1), for which complete records were available, indicated a peak in the late 1950s, a low in the early 1960s, another peak in 1970, and a decline since then (Fig. 1, top). EB estimates showed similar trends, but with lower peaks. Both the customary and EB estimates were negatively correlated with year ($r_{cus} = -0.51$, $P = 0.003$; $r_{EB} = -0.46$, $P = 0.009$), but results apply to only a portion of the surveyed area.

Years with Complete Records

Data for 1965–1985 indicated a modest peak in 1970, followed by an erratic decline (Fig. 1, middle). EB estimates again were similar to customary values, but with a less extreme peak. Correlation coefficients with year were -0.52 ($P = 0.015$) and -0.58 ($P = 0.006$), respectively, for the customary and EB estimates. Unfortunately, only two-thirds of the surveyed period was included, and no data from the early years, with the high counts, were used.

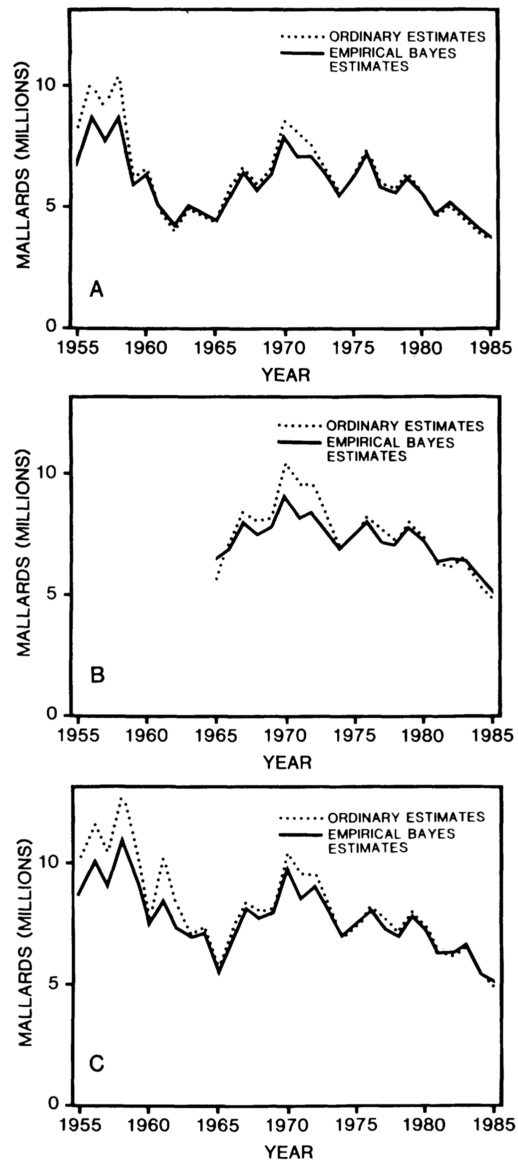

Fig. 1. Estimated mallard populations in surveyed area (Martin et al. 1979:fig. 1). Top: Strata 21–40, 1955–1985. Middle: Strata 1–49, 1965–1985. Bottom: Strata 1–49, 1955–1985.

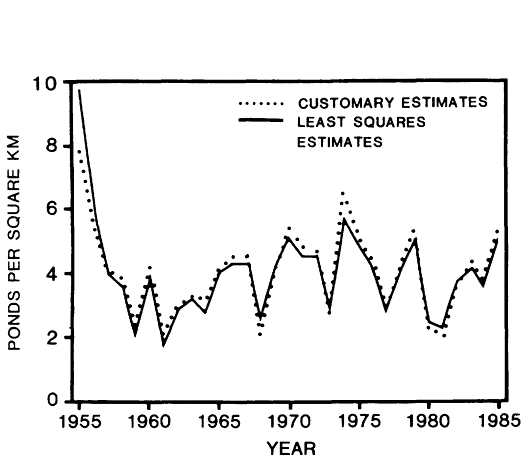

Fig. 2. Estimated density of ponds with water in Strata 26–49 (Prairie Pothole region), 1955–1985.

Missing Data Replaced by Averages

The third approach suggested a peak in 1958, followed by a decline to 1965, with a rise to 1970, followed by a decline through 1985 (Fig. 1, bottom). As before, both sets of estimates showed negative correlations with year (r_{cus} = −0.70, $P < 0.001$; $r_{EB} = -0.64$, $P < 0.001$). These conclusions rest in part on the assumption that mallard numbers in strata when surveys were not conducted were similar to those in other years. The advantage is that the analysis covers the entire surveyed area for the entire period.

The mallard data exhibit some evidence of periodicity. That pattern, together with the random-appearing fluctuations, makes it difficult to discern any trend. The negative correlations between mallard numbers and year suggest a downward trend, but such an interpretation relies on the trend being linear. Because the series of data is not linear, the correlation coefficients are highly sensitive to the choice of years. In conclusion, the mallard data themselves are equivocal about a trend, although the 1970–1985 decline was longer than that of 1958–1965.

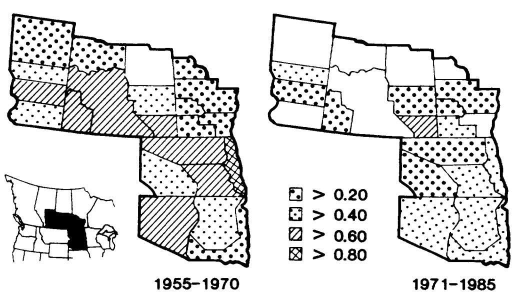

Fig. 3. Average correlation between mallard and pond densities, by stratum: Left: 1955–1970. Right: 1971–1985.

DO MALLARD CHANGES REFLECT NUMBERS OF PONDS?

Duck numbers in the primary breeding range parallel to some extent the numbers of wetland basins containing water (Crissey 1969, Johnson 1986*a*). Obviously the number of mallards in North America during a particular spring cannot depend strictly on the number of ponds that spring, but the pond count influences local distribution. Fortunately, ponds (Types III, IV, and V of Shaw and Fredine [1956]) have been counted along with waterfowl in Strata 26–49. These areas have the most dynamic wetland habitat; ponds farther north probably are less variable from year to year (Henny et al. 1972).

Pond densities during 1955–1985 varied considerably (Fig. 2). After a peak of about 8 ponds/km^2 in 1955, the initial year of the surveys, pond densities have varied around a mean of about 4/km^2. The LS estimates are similar to customary ones, except for being appreciably higher in 1955 and 1956.

During 1955–1970, correlations between mallard densities and pond densities were fairly strong throughout Strata 26–49, the area surveyed for ponds (Fig. 3). The mean correlation coefficient was 0.47, and values were especially high in North Dakota and southern Saskatchewan. In contrast, correlations were weaker during the recent period (Fig. 3). The mean fell ($P < 0.001$, t-test) to 0.27.

Thus in Strata 26–49 the number of mallards no longer parallels that of ponds in a given year to the extent it did formerly. Two possible

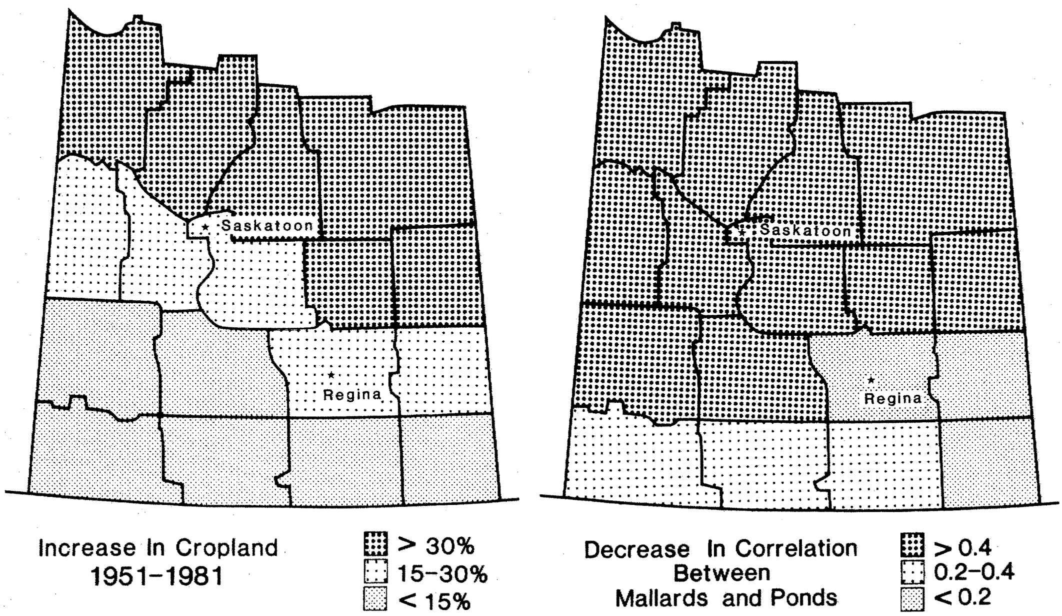

Fig. 4. Left: Increase in cropland in southern Saskatchewan from 1951 to 1981, by census division. Right: Decrease in correlation between mallard and pond numbers in southern Saskatchewan, by census division.

reasons for this change are (1) mallards are reduced in number so that they no longer fill their habitat as before or (2) mallards may not have changed in number, but only in distribution, and are no longer drawn to the pond-surveyed area. A change in distribution could result from either deteriorated habitat in the pond-surveyed areas or improved habitat elsewhere.

Distributional changes alone seem unlikely. An analysis estimated that 1.85 million mallards occurred in nonsurveyed areas in 1984 compared with an average of 1.55 million in those areas in 1955–1973 (R. S. Pospahala, U.S. Fish and Wildl. Serv., unpubl. data, 1985). This increase, primarily in eastern North America, was not substantial enough to offset the decline in the surveyed area. Moreover, within Strata 1–25, where mallards but not ponds were surveyed, mallard numbers have decreased: the average for 1955–1959 was 3.16 million mallards, compared with 2.22 million in 1981–1985.

We also attempted to determine if the quality of habitat in the pond-surveyed area might have deteriorated, thus causing the weakened correlation. Mallards generally nest in uplands, and intensified land use has been suggested as a cause of decreased nesting success and declining populations (Cowardin et al. 1983). From information for southern Saskatchewan on the area of cropland in 1951 and in 1981, we inferred that land use has intensified in various census divisions (Fig. 4). The decrease in correlation between mallards and ponds, however, occurred not only in census divisions with large increases in cropland, but also in several with modest changes (Fig. 4). This measure of land-use intensity is admittedly only an indirect index to the quality of habitat; ignored are considerations such as no-till and winter wheat agriculture, availability of nesting sites in wetland fringes and other areas, varying predator populations, and effects of pesticides and other agricultural chemicals. The relation is not clear-cut, and we conclude that

Table 1. Comparison of annual percent change in mallard numbers during 1971–1985 as predicted by a model (given in text) based on 1955–1970 data to actual changes.

Year	% change	
	Predicted	Actual
1971	15.8	−5.2
1972	3.6	0.2
1973	7.7	−11.0
1974	−10.6	−15.8
1975	33.1	9.7
1976	4.2	6.5
1977	1.1	−4.8
1978	−9.7	−6.5
1979	11.2	9.7
1980	15.6	−5.2
1981	−16.5	−15.6
1982	−6.7	−1.1
1983	9.8	6.3
1984	6.2	−15.9
1985	−0.3	−8.4

intensified land use can account for only part of the reduced correlation between mallards and ponds in Saskatchewan. More generally, the diminished correlation between mallard numbers and pond numbers seems to reflect a decreased population, rather than changes in distribution.

ARE MALLARD NUMBERS STILL DRIVEN BY PONDS?

Of all the environmental variables that can affect mallard numbers, the one given most attention is the number of May ponds. We developed a regression model relating annual changes in the estimated continental mallard population to pond counts during the 2 previous years. The model implies that the change in mallard numbers from, say, 1965 to 1966 is affected by pond numbers during the current year (1965) and the previous one (1964). The 1965 pond count reflects the extent and quality of habitat during the current breeding season. The 1964 count is an indirect measure of the age structure of the population in 1965; high counts indicate favorable conditions for breeding the year before, and thus a high proportion of yearlings in the present population. Yearlings are less effective reproductively (Krapu and Doty 1979, Cowardin et al. 1985), so a high pond count in 1 year might favor a population increase the next year, but a decrease 2 years later because of the high proportion of yearlings in the breeding population.

The model, fitted to the 1955–1970 data ($R^2 = 0.35$, $P = 0.09$), was

$$\log\left(\frac{\text{Mallards}_t}{\text{Mallards}_{t-1}}\right) = -0.195 + 0.044\text{Ponds}_{t-1} - 0.020\text{Ponds}_{t-2},$$

where t denotes the year. Each regression coefficient is significant ($P < 0.10$) and of the anticipated sign: positive for the pond count the previous year, negative for the one 2 years earlier. We used this model, together with the pond numbers in the recent period, to predict the annual change in mallard numbers each year during 1971–1985. The model predicted an average annual increase of 4.3% over the 15-year period, whereas actual numbers show an annual decline of 3.8% (Table 1). This result suggests that the numbers of mallards in recent years are less than we might expect based on the numbers of ponds.

SUMMARY AND CONCLUSIONS

Despite the importance of knowing whether or not the mallard population is declining, such questions are not easily addressed. Part of the difficulty lies in posing an objective and answerable question. A query such as "have mallard numbers declined linearly from 1970 to 1985?" can readily be dealt with, but the choice of endpoints (1970 and 1985) and of the nature of decline (linear) appears capricious.

We attempted to pose objective questions and to account for the fluctuations in distribution and abundance of mallards possibly induced by variations in pond numbers. Three approaches brought us to similar conclusions.

The mallard counts themselves were consistent with a real decline, although the series was too short to be definitive. The pattern of correlations with pond numbers has weakened from 1955–1970 to 1971–1985, suggesting that mallards are no longer filling their primary habitat to the former extent. That this change was one of numbers rather than simply distribution was supported by the absence of major increases elsewhere in the mallard's range and information on land-use changes in Saskatchewan. Our final approach was based on a simple population dynamics model. That model, with coefficients estimated from data in the early period, indicated that mallard numbers during 1971–1985 were lower than what would be expected from the pond counts.

Taken together, the 3 approaches suggest a decline in the North American mallard population that is not simply a reflection of reduced numbers of wet ponds. We do not address the question of whether the decline is due to increased mortality or reduced productivity.

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