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Survival and recovery rates of Mallards and Northern Pintails from the Northwest Territories, 1966–95

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Abstract

Little is known about the survival of waterfowl in the boreal forest. The effects of the boreal climate, the lower productivity of northern wetlands, the longer migration route, and the spring subsistence harvest on these northern populations are unclear. The objective of this study was to determine survival and recovery rates of Mallards *Anas platyrhynchos* and Northern Pintails *Anas acuta* banded at Mills Lake, Northwest Territories, Canada (61°N, 118°W), the only location in the Northwest Territories where extensive banding of dabbling ducks has been carried out. Specifically, we wanted to determine if survival of these birds had changed during the past 30 years and whether survival of boreal ducks was similar to that of southern populations of the same species. Sufficient banding data were available for survival analyses for Mallards during 1966–73, 1978–84, and 1987–95 and for Northern Pintails during 1970–74, 1976–80, and 1982–92. Survival estimates for Mallards over the three time periods averaged 0.69 (range of averages: 0.63–0.72) for adult males, 0.61 (0.54–0.66) for adult females, 0.50 (0.42–0.56) for young males, and 0.62 (0.40–0.80) for young females. Survival estimates for Northern Pintails over the three periods averaged 0.74 (0.71–0.77) for adult males, 0.63 (0.58–0.68) for adult females, 0.53 (0.44–0.62) for young males, and 0.63 (0.55–0.78) for young females. There were no significant differences among survival estimates in different periods for birds of the same species, sex, and age. In general, survival estimates for the Mills Lake birds were similar to those for southern populations. The only exception to this was that young Mallards banded at Mills Lake may have had lower survival during some periods. Recovery rates, an index of harvest rate, for the Mills Lake birds were similar to or lower than those of southern populations. Although limited by the geographic extent of banding, our results provide no evidence that boreal populations of Mallards and Northern Pintails are suffering from heavier harvest rates than southern populations or that other survival-related conservation problems are occurring in the north.

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Introduction

The boreal forest provides breeding and moulting habitat for more than 25% of the North American population of dabbling and diving ducks. Loss of waterfowl habitat in the prairies and parklands from intensified agriculture and periodic drought has made the boreal forest increasingly important in the conservation and management of North American waterfowl. However, relatively little is known about the survival or harvest rates of boreal forest ducks compared with prairie and parkland populations.

The survival of waterfowl in the boreal forest may be influenced by factors unique to this ecosystem. The relative harshness of the climate, the lower productivity of the wetlands, the longer distance for migration, and the impact of spring subsistence hunting are factors that may result in lower survival for boreal waterfowl than for prairie and parkland waterfowl. In contrast, habitat loss or degradation in the south and the associated increase in predation may result in lower survival for southern populations (Hestbeck 1990).

Knowledge of survival and harvest rates of waterfowl populations is vital for proper management. Survival rates can provide information on (1) whether a population is maintaining itself and (2) how well a population is doing compared with other populations or time periods. Low or decreasing survival may indicate overharvest or declining habitat availability or quality. Harvest rates can be estimated from the proportion of banded birds that are recovered and may indicate if a population is being overharvested.

We calculated survival and recovery rates for Mallards *Anas platyrhynchos* and Northern Pintails *Anas acuta* banded at Mills Lake, Northwest Territories, Canada, during 1966–95. Our objectives were to determine if overharvest or other conservation problems were occurring in the north by (1) comparing survival and recovery rates among different cohorts of birds banded at Mills Lake and (2) comparing survival and recovery rates between Mills Lake birds and "southern populations"[b] of the same species.

Methods

Approximately 32 000 Mallards and 31 000 Northern Pintails were banded in August and September at Mills Lake, Northwest Territories, Canada (61°N, 118°W) between 1955 and 1995 (Appendix 1). This is the only location in the Northwest Territories where extensive duck banding has been carried out. Ducks were captured using baited traps and equipped with standard aluminum Canadian Wildlife Service/U.S. Fish and Wildlife Service leg bands. Of the birds banded at Mills Lake, approximately

[b] The term "southern populations" in this paper refers to Mallards and Northern Pintails breeding south of 60°N.

3900 Mallards and 2400 Northern Pintails were shot by hunters and had their band numbers reported to either the Canadian Wildlife Service or the U.S. Fish and Wildlife Service. We used the data from these band recoveries for our survival calculations.

Survival analyses based on band recoveries require large samples of marked birds. Brownie et al. (1985:186–190) recommended using minimum samples of 300 birds for each sex and age class during every year for five consecutive years. Although we were unable to meet these criteria for all survival analyses, we believe that sample sizes were large enough to allow us to calculate reliable estimates for Mallards during 1966–73, 1978–84, and 1987–95 and for Northern Pintails during 1970–74, 1976–80, and 1982–92.

Survival estimates were calculated using band recovery methods described by Brownie et al. (1985) and Conroy et al. (1989). We used only hunter-killed birds that were of normal or "control band" status (i.e., status 300 or 304) when banded. For these results, a *survival estimate* refers to the estimated proportion of birds of a given sex or age class that survived from the time of banding in one year to the time of banding in the following year. A *recovery rate* is defined as the estimated proportion of banded birds alive at the time of banding that were killed by hunters during the subsequent hunting season and had their band numbers reported to the Bird Banding Office of the Canadian Wildlife Service or the Bird Banding Laboratories of the U.S. Fish and Wildlife Service (Brownie et al. 1985).

The band recovery approach involved selecting the multinomial model that best fit the data and then generating maximum likelihood estimates of survival and band recovery rates using the preferred model. Male and female ducks typically have different survival estimates (Conroy and Eberhardt 1983; Rienecker 1987), so we considered the two sexes separately. We used the BROWNIE procedure of the computer program MULT (Conroy et al. 1989) to determine survival estimates of adult (after hatch year) and young (hatch year) ducks. This software tested for the fit of the band recovery data to three models: H1 (both survival and recovery rates are year dependent), H02 (survival rates are constant each year, but recovery rates are year dependent), and H01 (both survival and recovery rates are constant each year). Further details are described by Brownie et al. (1985) and Conroy et al. (1989).

We used the χ^2 test described by Sauer and Williams (1989) to compare estimates from different samples (program CONTRAST; Hines and Sauer 1989). Estimates based on the models of best fit were used in comparisons, and P-values ≤ 0.05 were considered to be significantly different.

Results

Comparisons among time periods — Mallards

Survival estimates from the models of best fit for Mallards ranged between 0.40 and 0.80 for the different time periods (Tables 1 and 2). There were no significant differences among survival estimates in different periods for birds of the same sex and age (Table 3); thus, we were able to calculate long-term survival estimates for 1966–95. Adult males, adult females, and young females had long-term survival estimates for 1966–95 that were above 0.61, but young males had an estimate of approximately 0.50 (Tables 1 and 2).

Recovery rates from the models of best fit for Mallards were 0.07 or lower (Tables 1 and 2). Recovery rates varied significantly in different periods for adult males, adult females, and young females, but not for young males (Table 3). In cases where there was a significant difference, the most recent period (i.e., 1987–95) had the lower recovery rate.

Comparisons among time periods — Northern Pintails

Survival estimates from the models of best fit for Northern Pintails ranged between 0.44 and 0.78 for the different time periods (Tables 4 and 5). There were no significant differences among survival estimates in different periods for the birds of the same sex and age (Table 6); thus, we were able to calculate long-term survival estimates for 1970–92. Adult males had a long-term survival estimate of 0.74, the highest long-term estimate compared with the other cohorts. Adult and young females had long-term survival estimates of approximately 0.63, whereas for young males the estimate was approximately 0.53.

Recovery rates for Northern Pintails were 0.06 or lower (Tables 4 and 5). Recovery rates varied significantly during different periods for birds of the same sex and age (Table 6). In all cases where there was a significant difference, the more recent time period had the lower recovery rate.

Comparisons between different sex and age classes

Adult Mallards and Northern Pintails had survival estimates similar to or higher than those of young birds of the same sex (Tables 7 and 8). Recovery rates for adults were lower than or not significantly different from those for young birds. In general, there were no significant differences in survival between males and females. However, adult male Mallards and Northern Pintails banded during the most recent period had higher survival than adult females of the same species. Recovery rates for males were higher than or not significantly different from those for females during the same period.

Discussion

Changes in survival and recovery rates during 1966–95

One method of monitoring the well-being of a population is to look at changes in the survival of individuals in the population over time. There were no apparent changes in survival for Mallards or Northern Pintails banded at Mills Lake during 1966–95, suggesting that they are surviving as well in recent years as in the past. This is surprising, given that waterfowl population levels, bag limits, and hunting season lengths in Canada and the United States have varied greatly during 1966–95 (U.S. Fish and Wildlife Service 1988).

Recovery rates for Mallards and Northern Pintails banded at Mills Lake were generally lower in recent years than in the past. Recovery rates for waterfowl banded shortly before the hunting season can provide an index of the harvest rate. Band reporting rates seem not to have significantly changed during 1966–95 (Conroy and Blandin 1984; Nichols et al. 1991); thus, the harvest rates of Mallards and Northern Pintails banded at Mills Lake may have decreased in recent years.

Mallards banded at Mills Lake compared with southern populations

A second method of monitoring a population is to compare its survival with that of other populations. We compared Mallards banded at Mills Lake with Mallards banded on the Canadian Prairies during 1962–88 (Chu and Hestbeck 1989; Smith and Reynolds 1992). Comparable survival estimates were not available for more recent years.

Our results suggest that adult Mallards banded at Mills Lake had survival estimates similar to those of adults banded on the Canadian Prairies (Figs. 1 and 2; Appendix 2). Hestbeck (1990) examined midcontinental Mallard populations from many areas ranging from the southern United States to northern Canada and found that the survival of adult ducks was higher in the north than in the south. The reason for this north–south gradient in survival was unclear, but it may be related to increased loss and degradation of waterfowl habitat in the south (Hestbeck 1990). Recovery rates for adult Mallards banded at Mills Lake were similar to or lower than recovery rates for adults banded on the Canadian Prairies (Figs. 3 and 4; Appendix 2). Hestbeck (1990) also noted little difference between recovery rates for northern and southern Mallards. Thus, there was no evidence that adult Mallards from Mills Lake were being more heavily harvested than their southern counterparts.

In contrast to adults, young Mallards banded at Mills Lake sometimes had significantly lower survival estimates than young banded on the Canadian Prairies during corresponding periods (Figs. 1 and 2; Appendix 2). We are uncertain why this occurred. Recovery rates for young Mallards at Mills Lake were similar to or lower than those of young banded on the Canadian Prairies (Figs. 3 and 4; Appendix 2), suggesting that fall harvest rates were comparable for the boreal and prairie birds. More research examining other sources of mortality for young Mallards might explain why young from Mills Lake had lower survival during some periods.

Northern Pintails banded at Mills Lake compared with southern populations

Most banding of Northern Pintails has been done at wintering areas, so we often had to compare our survival estimates for birds banded before the hunting season with estimates for birds banded during the hunting season. We believe that these comparisons were valid because the difference between the survival estimates of ducks banded before and during the hunting season is usually small (Nichols and Hines 1987; Rienecker 1987). Adult Northern Pintails banded at Mills Lake had survival estimates similar to those of adult Northern Pintails banded on the wintering grounds during corresponding periods (Figs. 5 and 6; Appendix 3). Survival estimates for birds banded before the hunting season, but from slightly earlier periods, were also within the same range as other estimates.

Northern Pintails banded on wintering areas between 1972 and 1985 had recovery rates ranging from 0.01 to 0.04 for adult males and from 0.01 to 0.02 for adult females (Hestbeck 1993). The recovery rates for adult Northern Pintails banded at Mills Lake were also within this range. Recovery rates for birds banded on wintering areas are typically lower than recovery rates for birds banded before the hunting season (Nichols et al. 1982). Thus, harvest rates for Mills Lake adults are perhaps even lower than those of other populations.

Data for comparing the survival of young Northern Pintails banded at Mills Lake and elsewhere were not available. Nevertheless, most survival estimates for young banded at Mills Lake were similar to estimates for young banded in California before the hunting season, but during slightly earlier periods. Young males banded at several places in California during various periods between 1948 and 1979 had survival estimates ranging from 0.50 to 0.63 (Rienecker 1987). Although young males banded at Mills Lake during 1976–80 had slightly lower survival (0.44) than this, the long-term survival estimate for young males during 1970–92 was within this range. Young females banded in California had survival estimates ranging from 0.36 to 0.69 (Rienecker 1987). Young females banded at Mills Lake had survival estimates within this range or higher.

Young males banded between 1948 and 1979 in California had recovery rates of 0.09, and young females had recovery rates of 0.07 (Rienecker 1987). Although these recovery rates are from a slightly earlier period than our results, it is still worth noting that these recovery rates are higher than our results for young males and females. Thus, there is no evidence that young from Mills Lake were being more heavily harvested than other populations.

Comparisons between different sex and age classes

The general patterns of survival and recovery rates for Mallards and Northern Pintails of different sexes and ages shown by the Mills Lake birds resembled those found in other studies (e.g., Anderson 1975; Nichols and Hines 1987; Rienecker 1987; Hestbeck 1993). We found that adult males usually had the highest survival, that adult females usually had lower recovery rates than adult males, and that young birds often had lower survival and higher recovery rates than adults. Some studies have found that female ducks had lower survival than male ducks (e.g., Nichols and Hines 1987; Rienecker 1987). We also found that adult females had lower survival than adult males during the most recent period. However, there were no significant differences between the survival of males and females of the same age in earlier periods.

Management implications

Survival estimates of Mallards and Northern Pintails banded at Mills Lake showed no apparent long-term changes during 1966–95, and most estimates were similar to those for southern populations. Recovery rates for Mills Lake birds, and hence harvest rates, appear to have decreased during 1966–95. Harvest rates for Mills Lake ducks were not higher than those from southern populations. We caution, however, that the precision for some of our survival and recovery rates was poor,[c] suggesting that some changes or differences may not be detected by our analyses. In addition, our results may not be representative of all boreal ducks because the data were from only one banding location. Nonetheless, other information also suggests that waterfowl from more northern latitudes are surviving at least as well as or better than southern birds (Hestbeck 1990).

Although there was no evidence that Mallards and Northern Pintails were experiencing heavier hunting pressure or other conservation problems in the north, careful monitoring of northern populations is still recommended. Local hunting pressure may increase and the quality and availability of waterfowl habitat may decrease as the human population and industrial developments increase in the north. Northern waterfowl populations may also be influenced by activities outside of the Northwest Territories. Northern populations use many of the same areas as southern populations during migration and winter, and therefore they may be exposed to similar hunting pressure and other mortality risks in these areas. Thus, perhaps it is not surprising that most of the survival and recovery rates for birds banded at Mills Lake were similar to those of their southern counterparts. Management strategies for boreal ducks need to consider both the mortality factors and habitat conditions within the boreal forest as well as on their migration routes and wintering areas in the south.

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[c] The coefficient of variation (CV) for a survival estimate is $CV(\hat{s}) = SE(\hat{s})/\hat{s}$, where $\hat{s}$ is the survival estimate and $SE(\hat{s})$ is the standard error of the survival estimate (Brownie et al. 1985:186). Sheaffer and Malecki (1995) suggest that a coefficient of variation of ≤5% for adults and ≤10% for young is an acceptable level of precision for survival estimates, a level of precision that was not met by many of our estimates.

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Table 1
Survival and recovery rates (± standard errors) of male Mallards calculated from band recoveries of hunter-killed birds banded at Mills Lake, Northwest Territories[a]

	Adult males		Young males	
Year(s)	Survival ± SE	Recovery rate ± SE	Survival ± SE	Recovery rate ± SE
1966	0.435 ± 0.137	0.068 ± 0.014	0.567 ± 0.204	0.023 ± 0.013
1967	0.771 ± 0.264	0.059 ± 0.018	0.399 ± 0.170	0.085 ± 0.024
1968	0.577 ± 0.189	0.040 ± 0.012	0.168 ± 0.124	0.052 ± 0.025
1969	0.522 ± 0.198	0.025 ± 0.009	0.244 ± 0.088	0.064 ± 0.012
1970	1.214 ± 0.600	0.075 ± 0.025	0.426 ± 0.197	0.088 ± 0.016
1971	0.480 ± 0.213	0.040 ± 0.016	0.962 ± 0.245	0.048 ± 0.013
1972	0.397 ± 0.136	0.056 ± 0.012	0.193 ± 0.144	0.095 ± 0.037
1973		0.072 ± 0.021		0.091 ± 0.033
Average (H1)[b]	**0.628 ± 0.060**	**0.054 ± 0.006**	**0.423 ± 0.066**	**0.068 ± 0.008**
H02 (1966–73)[c]	0.659 ± 0.030	0.053 ± 0.004	0.484 ± 0.064	0.068 ± 0.008
H01 (1966–73)[d]	0.661 ± 0.028	0.052 ± 0.005	0.501 ± 0.062	0.066 ± 0.007
1978	0.722 ± 0.181	0.045 ± 0.010	0.631 ± 0.184	0.047 ± 0.014
1979	0.728 ± 0.166	0.028 ± 0.008	0.435 ± 0.177	0.041 ± 0.020
1980	0.555 ± 0.086	0.042 ± 0.007	0.454 ± 0.135	0.054 ± 0.019
1981	0.866 ± 0.131	0.063 ± 0.009	0.617 ± 0.346	0.108 ± 0.051
1982	0.623 ± 0.124	0.039 ± 0.005	0.601 ± 0.228	0.044 ± 0.022
1983	0.773 ± 0.189	0.063 ± 0.012	0.737 ± 0.245	0.028 ± 0.014
1984		0.040 ± 0.008		0.055 ± 0.011
Average (H1)	0.711 ± 0.033	0.046 ± 0.003	0.579 ± 0.094	0.054 ± 0.009
H02 (1978–84)	**0.709 ± 0.024**	**0.043 ± 0.002**	**0.556 ± 0.070**	**0.054 ± 0.009**
H01 (1978–84)	0.729 ± 0.022	0.043 ± 0.003	0.465 ± 0.054	0.050 ± 0.006
1987	0.632 ± 0.139	0.042 ± 0.008	0.553 ± 0.152	0.029 ± 0.009
1988	0.622 ± 0.125	0.032 ± 0.007	0.000 ± 1.994	0.059 ± 0.059
1989	0.882 ± 0.122	0.032 ± 0.005	0.487 ± 0.106	0.025 ± 0.007
1990	0.611 ± 0.086	0.027 ± 0.004	0.660 ± 0.292	0.069 ± 0.030
1991	0.847 ± 0.174	0.032 ± 0.004	1.330 ± 0.609	0.044 ± 0.030
1992	0.735 ± 0.160	0.026 ± 0.005	0.519 ± 0.261	0.010 ± 0.010
1993	1.070 ± 0.070	0.033 ± 0.005	0.918 ± 0.980	0.029 ± 0.013
1994	0.187 ± 0.187	0.010 ± 0.010	0.327 ± 0.139	0.021 ± 0.008
1995		0.053 ± 0.007		0.059 ± 0.029
Average (H1)	0.698 ± 0.111	0.032 ± 0.002	0.599 ± 0.294	0.038 ± 0.009
H02 (1987–95)	**0.724 ± 0.018**	**0.034 ± 0.002**	**0.515 ± 0.064**	**0.044 ± 0.009**
H01 (1987–95)	0.734 ± 0.018	0.033 ± 0.002	0.512 ± 0.063	0.028 ± 0.004
Long-term average[e] (1966–95)	0.687		0.498	

[a] The survival estimate and recovery rate based on the best model (i.e., the simplest model that fit) are in boldface type.
[b] Both survival and recovery rates are year dependent. This is the average of the annual estimates.
[c] Survival estimates are constant each year, but recovery rates are year dependent.
[d] Both survival and recovery rates are constant each year.
[e] The "long-term" average is the average of the best models during the different time periods.

Table 2
Survival and recovery rates (± standard errors) of female Mallards calculated from band recoveries of hunter-killed birds banded at Mills Lake, Northwest Territories[a]

	Adult females		Young females	
Year(s)	Survival ± SE	Recovery rate ± SE	Survival ± SE	Recovery rate ± SE
1966	0.547 ± 0.328	0.018 ± 0.013	0.207 ± 0.175	0.096 ± 0.032
1967	0.402 ± 0.235	0.044 ± 0.025	0.363 ± 0.178	0.056 ± 0.022
1968	0.891 ± 0.420	0.045 ± 0.015	0.210 ± 0.224	0.073 ± 0.035
1969	0.451 ± 0.278	0.009 ± 0.006	0.179 ± 0.101	0.053 ± 0.011
1970	1.219 ± 0.809	0.062 ± 0.031	0.530 ± 0.290	0.063 ± 0.013
1971	0.673 ± 0.428	0.015 ± 0.008	0.757 ± 0.437	0.053 ± 0.014
1972	0.124 ± 0.104	0.019 ± 0.009	0.126 ± 0.151	0.104 ± 0.035
1973		0.040 ± 0.029		0.036 ± 0.025
Average (H1)[b]	0.615 ± 0.092	0.032 ± 0.007	0.339 ± 0.093	0.067 ± 0.009
H02 (1966–73)[c]	0.729 ± 0.059	0.024 ± 0.003	0.398 ± 0.088	0.067 ± 0.009
H01 (1966–73)[d]	**0.659 ± 0.049**	**0.028 ± 0.005**	**0.395 ± 0.082**	**0.061 ± 0.007**
1978	0.063 ± 0.048	0.009 ± 0.006	0.264 ± 0.118	0.050 ± 0.015
1979	1.632 ± 0.588	0.024 ± 0.013	0.630 ± 0.378	0.027 ± 0.019
1980	0.324 ± 0.114	0.029 ± 0.007	0.175 ± 0.130	0.035 ± 0.017
1981	0.745 ± 0.292	0.050 ± 0.015	1.801 ± 1.103	0.000 ± 0.131
1982	0.593 ± 0.334	0.022 ± 0.007	0.472 ± 0.402	0.026 ± 0.018
1983	0.471 ± 0.300	0.020 ± 0.011	0.690 ± 0.424	0.069 ± 0.024
1984		0.022 ± 0.009		0.025 ± 0.008
Average (H1)	**0.638 ± 0.102**	**0.025 ± 0.004**	**0.672 ± 0.219**	**0.033 ± 0.020**
H02 (1978–84)	0.562 ± 0.048	0.023 ± 0.003	0.597 ± 0.134	0.033 ± 0.006
H01 (1978–84)	0.601 ± 0.045	0.024 ± 0.003	0.440 ± 0.087	0.036 ± 0.006
1987	0.659 ± 0.565	0.033 ± 0.013	0.919 ± 0.728	0.022 ± 0.010
1988	0.547 ± 0.456	0.010 ± 0.008	0.000 ± 12.385	0.000 ± 0.189
1989	0.364 ± 0.177	0.007 ± 0.004	0.880 ± 0.313	0.017 ± 0.006
1990	0.384 ± 0.159	0.017 ± 0.005	0.476 ± 0.493	0.019 ± 0.019
1991	0.682 ± 0.454	0.018 ± 0.006	0.000 ± 10.757	0.000 ± 0.180
1992	0.549 ± 0.411	0.009 ± 0.006	0.446 ± 0.486	0.010 ± 0.010
1993	0.238 ± 0.262	0.008 ± 0.004	0.000 ± 3.322	0.009 ± 0.009
1994	0.399 ± 0.437	0.015 ± 0.015	0.842 ± 0.431	0.032 ± 0.011
1995		0.020 ± 0.005		0.039 ± 0.027
Average (H1)	0.478 ± 0.065	0.015 ± 0.003	0.445 ± 2.097	0.016 ± 0.029
H02 (1987–95)	0.575 ± 0.051	0.015 ± 0.002	0.808 ± 0.182	0.089 ± 0.008
H01 (1987–95)	**0.538 ± 0.046**	**0.015 ± 0.002**	**0.797 ± 0.176**	**0.020 ± 0.004**
Long-term average[e] (1966–95)	0.612		0.621	

[a] The survival estimate and recovery rate based on the best model (i.e., the simplest model that fit) are in boldface type.
[b] Both survival and recovery rates are year dependent. This is the average of the annual estimates.
[c] Survival estimates are constant each year, but recovery rates are year dependent.
[d] Both survival and recovery are constant each year.
[e] The "long-term" average is the average of the best models during the different time periods.

Table 3
Statistical comparisons[a] of survival and recovery rates for Mallards banded in different time periods

Survival estimates Comparisons	df	χ^2	P	Group with higher survival
1966–73, 1978–84, and 1987–95				
Adult males	2	2.446	0.294	—
Adult females	2	3.418	0.181	—
Young males	2	2.073	0.355	—
Young females	2	5.092	0.078	—
Recovery rates Comparisons	df	χ^2	P	Group with lower recovery rate
Adult males				
1966–73, 1978–84, and 1987–95	2	17.711	0.000	See comparisons below
1966–73 and 1978–84	1	3.432	0.064	—
1966–73 and 1987–95	1	11.366	0.001	1987–95
1978–84 and 1987–95	1	9.127	0.003	1987–95
Adult females				
1966–73, 1978–84, and 1987–95	2	10.346	0.006	See comparisons below
1966–73 and 1978–84	1	0.180	0.671	—
1966–73 and 1987–95	1	6.651	0.010	1987–95
1978–84 and 1987–95	1	5.642	0.018	1987–95
Young males				
1966–73, 1978–84, and 1987–95	2	3.898	0.142	—
Young females				
1966–73, 1978–84, and 1987–95	2	29.812	0.000	See comparisons below
1966–73 and 1978–84	1	1.848	0.174	—
1966–73 and 1987–95	1	29.797	0.000	1987–95
1978–84 and 1987–95	1	0.413	0.520	—

[a] Comparisons were done with the models of best fit. Significant χ^2-values ($P \leq 0.05$) indicate differences among estimates.

Table 4
Survival and recovery rates (± standard errors) of male Northern Pintails calculated from band recoveries of hunter-killed birds banded at Mills Lake, Northwest Territories[a]

	Adult males		Young males	
Year(s)	Survival ± SE	Recovery rate ± SE	Survival ± SE	Recovery rate ± SE
1970	0.530 ± 0.215	0.045 ± 0.020	0.798 ± 0.217	0.059 ± 0.016
1971	0.870 ± 0.243	0.041 ± 0.010	0.603 ± 0.240	0.091 ± 0.023
1972	0.832 ± 0.204	0.022 ± 0.006	0.320 ± 0.187	0.063 ± 0.022
1973	0.611 ± 0.276	0.018 ± 0.004	0.430 ± 0.350	0.039 ± 0.027
1974		0.017 ± 0.008		0.054 ± 0.015
Average (H1)[b]	0.711 ± 0.088[c]	0.028 ± 0.005	0.538 ± 0.128[c]	0.061 ± 0.009
H02 (1970–74)[d]	0.838 ± 0.070	0.022 ± 0.003	0.640 ± 0.115	0.061 ± 0.009
H01 (1970–74)[e]	0.801 ± 0.054	0.021 ± 0.003	0.576 ± 0.095	0.063 ± 0.009
1976	0.507 ± 0.156	0.019 ± 0.009	0.343 ± 0.094	0.027 ± 0.007
1977	0.888 ± 0.226	0.021 ± 0.005	0.000 ± 1.671	0.053 ± 0.030
1978	0.517 ± 0.169	0.018 ± 0.005	0.299 ± 0.163	0.056 ± 0.020
1979	1.019 ± 0.412	0.026 ± 0.008	0.473 ± 0.224	0.017 ± 0.009
1980		0.025 ± 0.009		0.083 ± 0.056
Average (H1)	0.733 ± 0.100	0.022 ± 0.003	0.279 ± 0.424	0.047 ± 0.014
H02 (1976–80)	0.750 ± 0.055	0.023 ± 0.003	0.401 ± 0.081	0.059 ± 0.016
H01 (1976–80)	**0.747 ± 0.044**	**0.023 ± 0.003**	**0.440 ± 0.083**	**0.031 ± 0.006**
1982	0.767 ± 0.281	0.012 ± 0.009	0.458 ± 0.271	0.078 ± 0.028
1983	0.845 ± 0.212	0.018 ± 0.006	0.453 ± 0.144	0.035 ± 0.009
1984	0.815 ± 0.242	0.019 ± 0.004	0.527 ± 0.233	0.043 ± 0.013
1985	0.676 ± 0.262	0.017 ± 0.005	0.708 ± 0.251	0.034 ± 0.007
1986	0.505 ± 0.165	0.010 ± 0.004	0.609 ± 0.134	0.041 ± 0.007
1987	1.097 ± 0.242	0.028 ± 0.004	0.950 ± 0.386	0.022 ± 0.010
1988	1.100 ± 0.576	0.007 ± 0.002	0.000 ± 6.231	0.016 ± 0.016
1989	0.357 ± 0.218	0.006 ± 0.003	0.260 ± 0.274	0.035 ± 0.017
1990	0.582 ± 0.315	0.013 ± 0.005	1.599 ± 1.278	0.024 ± 0.024
1991	0.574 ± 0.470	0.012 ± 0.005	0.000 ± 5.214	0.014 ± 0.014
1992		0.016 ± 0.011		0.035 ± 0.024
Average (H1)	0.732 ± 0.064	0.014 ± 0.002	0.556 ± 0.825	0.034 ± 0.005
H02 (1982–92)	**0.766 ± 0.028**	**0.015 ± 0.001**	**0.617 ± 0.078**	**0.034 ± 0.005**
H01 (1982–92)	0.747 ± 0.023	0.015 ± 0.001	0.632 ± 0.078	0.036 ± 0.004
Long-term average[f] (1970–92)	0.741		0.532	

[a] The survival estimate and recovery rate based on the best model (i.e., the simplest model that fit) are in boldface type.
[b] Both survival and recovery rates are year dependent. This is the average of the annual estimates.
[c] None of the models fits the data. We used the survival and recovery estimates based on the BROWNIE model H1 for comparisons.
[d] Survival estimates are constant each year, but recovery rates are year dependent.
[e] Both survival and recovery rates are constant each year.
[f] The "long-term" average is the average of the best models during the different time periods.

Table 5
Survival and recovery rates (± standard errors) of female Northern Pintails calculated from band recoveries of hunter-killed birds banded at Mills Lake, Northwest Territories[a]

	Adult females		Young females	
Year(s)	Survival ± SE	Recovery rate ± SE	Survival ± SE	Recovery rate ± SE
1970	0.667 ± 0.417	0.030 ± 0.015	0.628 ± 0.300	0.042 ± 0.012
1971	0.389 ± 0.137	0.012 ± 0.004	0.499 ± 0.221	0.025 ± 0.010
1972	0.509 ± 0.166	0.022 ± 0.005	0.538 ± 0.294	0.050 ± 0.018
1973	1.758 ± 1.309	0.012 ± 0.004	0.000 ± 9.442	0.050 ± 0.034
1974		0.005 ± 0.004		0.038 ± 0.011
Average (H1)[b]	0.831 ± 0.334	0.016 ± 0.003	0.416 ± 2.364	0.041 ± 0.009
H02 (1970–74)[c]	**0.575 ± 0.068**	**0.023 ± 0.004**	**0.569 ± 0.141**	**0.041 ± 0.009**
1976	0.629 ± 0.238	0.017 ± 0.007	0.535 ± 0.188	0.048 ± 0.010
1977	0.829 ± 0.353	0.011 ± 0.003	1.066 ± 0.846	0.000 ± 0.094
1978	0.312 ± 0.155	0.010 ± 0.004	0.263 ± 0.201	0.040 ± 0.017
1979	0.997 ± 0.655	0.019 ± 0.007	0.483 ± 0.364	0.026 ± 0.011
1980		0.012 ± 0.007		0.042 ± 0.041
Average (H1)	0.692 ± 0.171	0.014 ± 0.003	0.587 ± 0.240	0.031 ± 0.021
H02 (1976–80)	0.690 ± 0.076	0.011 ± 0.002	0.570 ± 0.150	0.031 ± 0.009
H01 (1976–80)[d]	**0.676 ± 0.057**	**0.013 ± 0.002**	**0.551 ± 0.136**	**0.040 ± 0.006**
1982	0.347 ± 0.181	0.021 ± 0.007	0.888 ± 0.501	0.027 ± 0.013
1983	0.406 ± 0.161	0.013 ± 0.005	0.476 ± 0.174	0.036 ± 0.008
1984	0.647 ± 0.330	0.018 ± 0.005	0.750 ± 0.423	0.027 ± 0.009
1985	0.841 ± 0.495	0.007 ± 0.004	0.703 ± 0.343	0.026 ± 0.006
1986	0.402 ± 0.218	0.007 ± 0.003	0.740 ± 0.317	0.022 ± 0.005
1987	0.912 ± 0.433	0.012 ± 0.005	0.392 ± 0.405	0.006 ± 0.006
1988	0.512 ± 0.388	0.004 ± 0.002	1.714 ± 1.702	0.000 ± 0.089
1989	0.388 ± 0.338	0.005 ± 0.004	0.000 ± 4.612	0.014 ± 0.010
1990	0.895 ± 0.793	0.008 ± 0.004	0.000 ± 24.668	0.000 ± 0.119
1991	0.128 ± 0.161	0.003 ± 0.002	0.000 ± 10.225	0.000 ± 0.096
1992		0.009 ± 0.010		0.000 ± 0.090
Average (H1)	0.548 ± 0.075	0.010 ± 0.002	0.566 ± 2.717	0.015 ± 0.018
H01 (1982–92)	**0.622 ± 0.033**	**0.009 ± 0.001**	**0.782 ± 0.130**	**0.024 ± 0.003**
Long-term average[e] (1970–92)	0.625		0.634	

[a] The survival estimate and recovery rate based on the best model (i.e., the simplest model that fit) are in boldface type.
[b] Both survival and recovery rates are year dependent. This is the average of the annual estimates.
[c] Survival estimates are constant each year, but recovery rates are year dependent.
[d] Both survival and recovery rates are constant each year.
[e] The "long-term" average is the average of the best models during the different time periods.

Table 6
Statistical comparisons[a] of survival and recovery rates for Northern Pintails banded during different time periods

Survival estimates Comparisons	df	χ^2	P	Group with higher survival
1970–74, 1976–80, and 1982–92				
Adult males	2	0.426	0.808	—
Adult females	2	1.344	0.511	—
Young males	2	2.419	0.298	—
Young females	2	1.876	0.391	—
Recovery rates Comparisons	df	χ^2	P	Group with lower recovery rate
Adult males				
1970–74, 1976–80, and 1982–92	2	11.875	0.003	See comparisons below
1970–74 and 1976–80	1	1.093	0.296	—
1970–74 and 1982–92	1	7.091	0.008	1982–92
1976–80 and 1982–92	1	6.061	0.014	1982–92
Adult females				
1970–74, 1976–80, and 1982–92	2	10.813	0.005	See comparisons below
1970–74 and 1976–80	1	3.729	0.054	—
1970–74 and 1982–92	1	8.992	0.003	1982–92
1976–80 and 1982–92	1	2.779	0.096	—
Young males				
1970–74, 1976–80, and 1982–92	2	8.016	0.018	See comparisons below
1970–74 and 1976–80	1	7.485	0.006	1976–80
1970–74 and 1982–92	1	6.432	0.011	1982–92
1976–80 and 1982–92	1	0.137	0.712	—
Young females				
1970–74, 1976–80, and 1982–92	2	7.875	0.020	See comparisons below
1970–74 and 1976–80	1	0.029	0.865	—
1970–74 and 1982–92	1	3.701	0.054	—
1976–80 and 1982–92	1	5.040	0.025	1982–92

[a] Comparisons were done with the models of best fit. Significant χ^2-values ($P \leq 0.05$) indicate differences among estimates.

Table 7
Statistical comparisons[a] of survival and recovery rates for Mallards of different sex and age classes

Survival estimates Comparisons	df	χ^2	P	Group with higher survival
Adults and young				
Males				
1966–73	1	5.339	0.021	Adults
1978–84	1	4.227	0.040	Adults
1987–95	1	10.002	0.002	Adults
Females				
1966–73	1	7.693	0.006	Adults
1978–84	1	0.020	0.889	—
1987–95	1	2.026	0.155	—
Males and females				
Adults				
1966–73	1	0.158	0.691	—
1978–84	1	0.455	0.500	—
1987–95	1	14.315	0.000	Males
Young				
1966–73	1	0.071	0.790	—
1978–84	1	0.252	0.616	—
1987–95	1	2.274	0.132	—
Recovery rates Comparisons	df	χ^2	P	Group with lower recovery rate
Adults and young				
Males				
1966–73	1	1.810	0.179	—
1978–84	1	1.381	0.240	—
1987–95	1	1.189	0.276	—
Females				
1966–73	1	17.956	0.000	Adults
1978–84	1	0.151	0.697	—
1987–95	1	1.411	0.235	—
Males and females				
Adults				
1966–73	1	12.948	0.000	Females
1978–84	1	14.988	0.000	Females
1987–95	1	50.753	0.000	Females
Young				
1966–73	1	0.428	0.513	—
1978–84	1	0.926	0.336	—
1987–95	1	5.717	0.017	Females

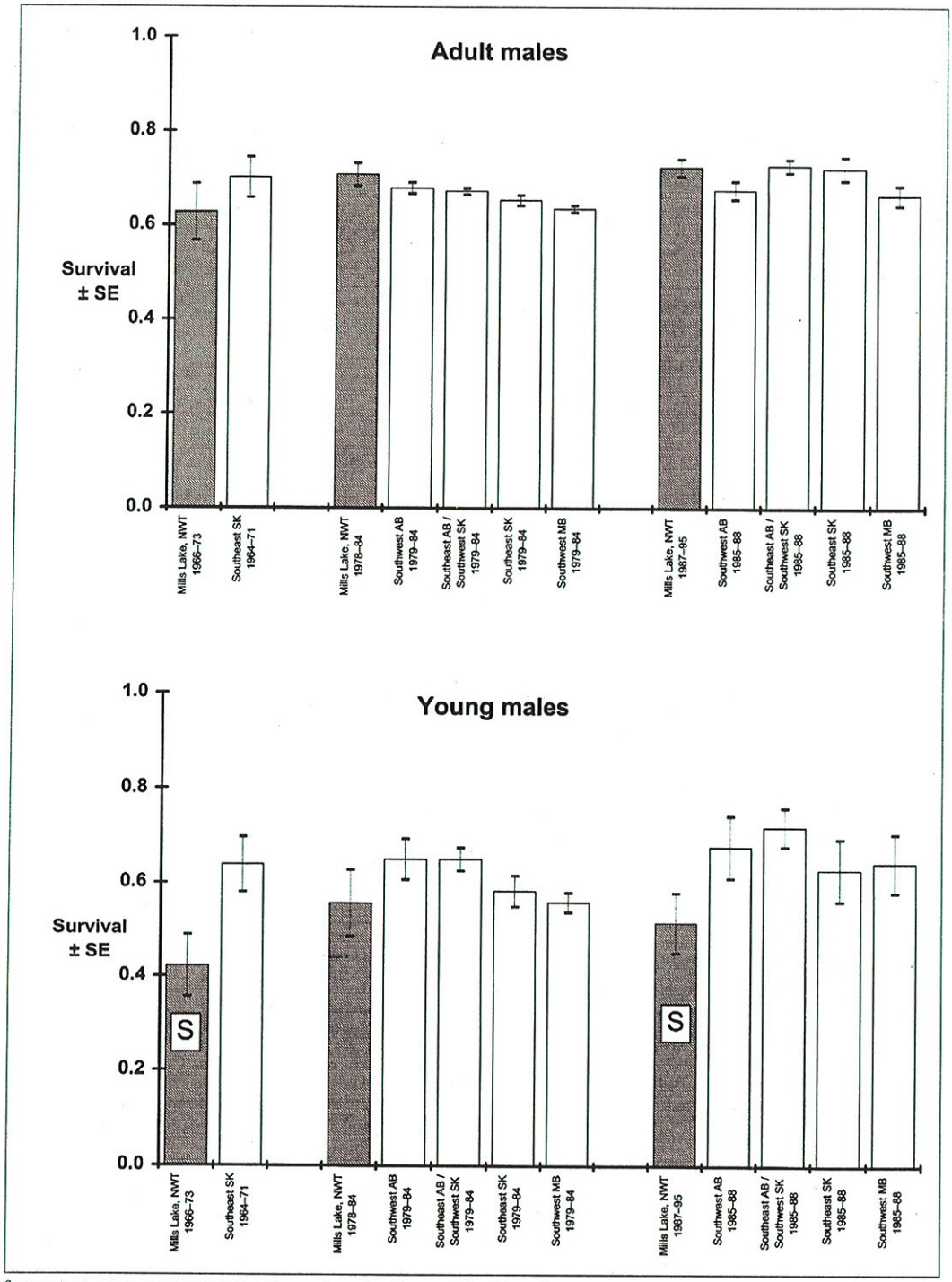
[a] Comparisons were done with the models of best fit. Significant χ^2-values ($P \leq 0.05$) indicate differences among estimates.

Table 8
Statistical comparisons[a] of survival and recovery rates for Northern Pintails of different sex and age classes

Survival estimates Comparisons	df	χ^2	P	Group with higher survival
Adults and young				
Males				
1970–74	1	1.247	0.264	—
1976–80	1	10.630	0.001	Adults
1982–92	1	3.265	0.071	Adults
Females				
1970–74	1	0.001	1.000	—
1976–80	1	0.724	0.395	—
1982–92	1	1.422	0.233	—
Males and females				
Adults				
1970–74	1	1.492	0.222	—
1976–80	1	0.961	0.327	—
1982–92	1	11.166	0.001	Males
Young				
1970–74	1	0.028	0.868	—
1976–80	1	0.480	0.489	—
1982–92	1	1.190	0.275	—
Recovery rates Comparisons	df	χ^2	P	Group with lower recovery rate
Adults and young				
Males				
1970–74	1	9.677	0.002	Adults
1976–79	1	2.021	0.155	—
1982–92	1	13.447	0.000	Adults
Females				
1970–74	1	3.537	0.060	—
1976–79	1	14.833	0.000	Adults
1982–92	1	26.380	0.000	Adults
Males and females				
Adults				
1970–74	1	0.776	0.379	—
1976–79	1	6.969	0.008	Females
1982–92	1	12.003	0.001	Females
Young				
1970–74	1	2.647	0.104	—
1976–79	1	0.771	0.380	—
1982–92	1	3.494	0.062	—

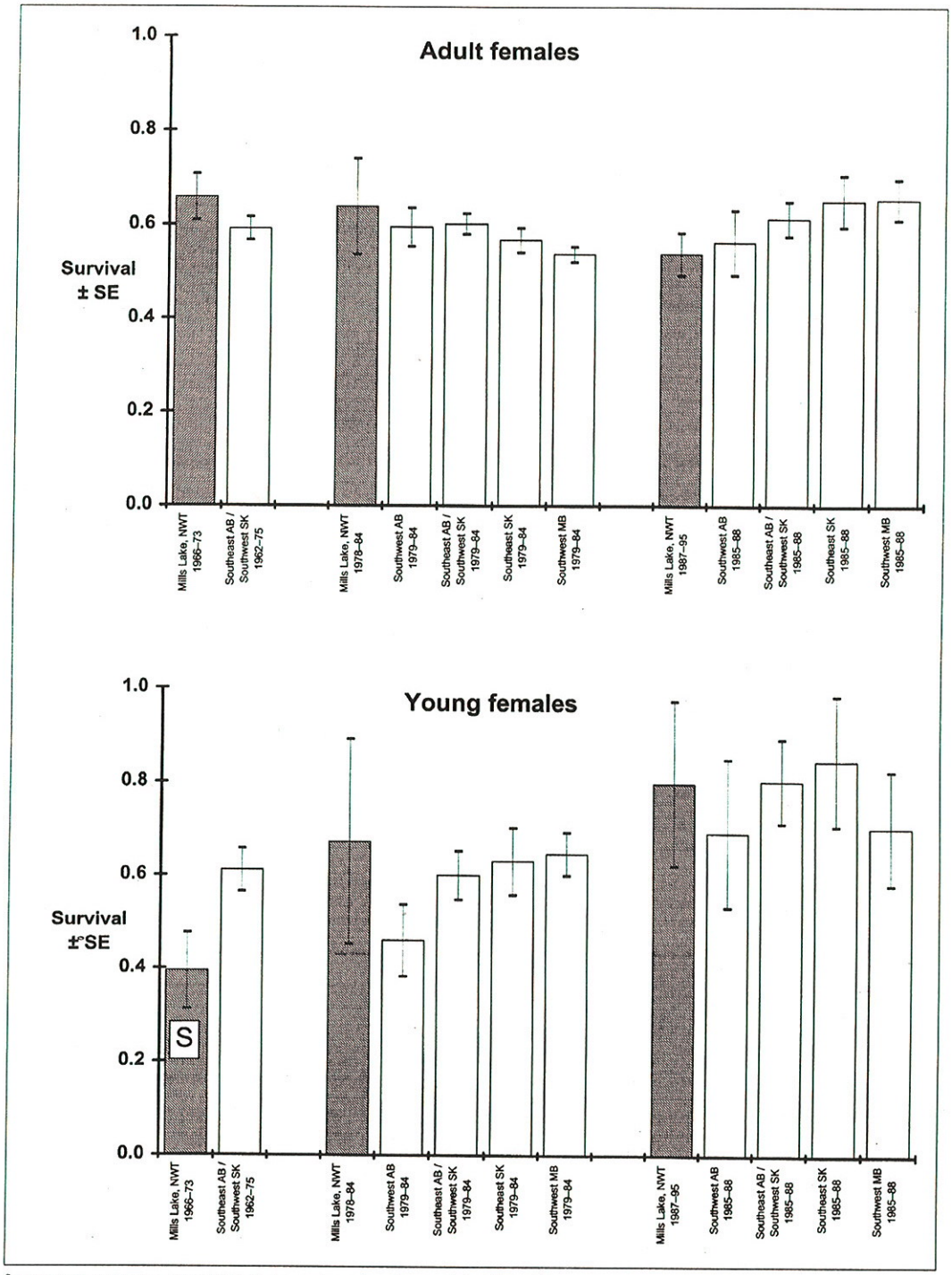
[a] Comparisons were done with the models of best fit. Significant χ^2-values ($P \leq 0.05$) indicate differences among estimates.

Figure 1
Survival estimates (± standard errors) of male Mallards banded at Mills Lake, Northwest Territories,[a] and the Canadian Prairies,[b] with Mills Lake estimates that are significantly different from Prairie estimates from corresponding time periods indicated by "S"



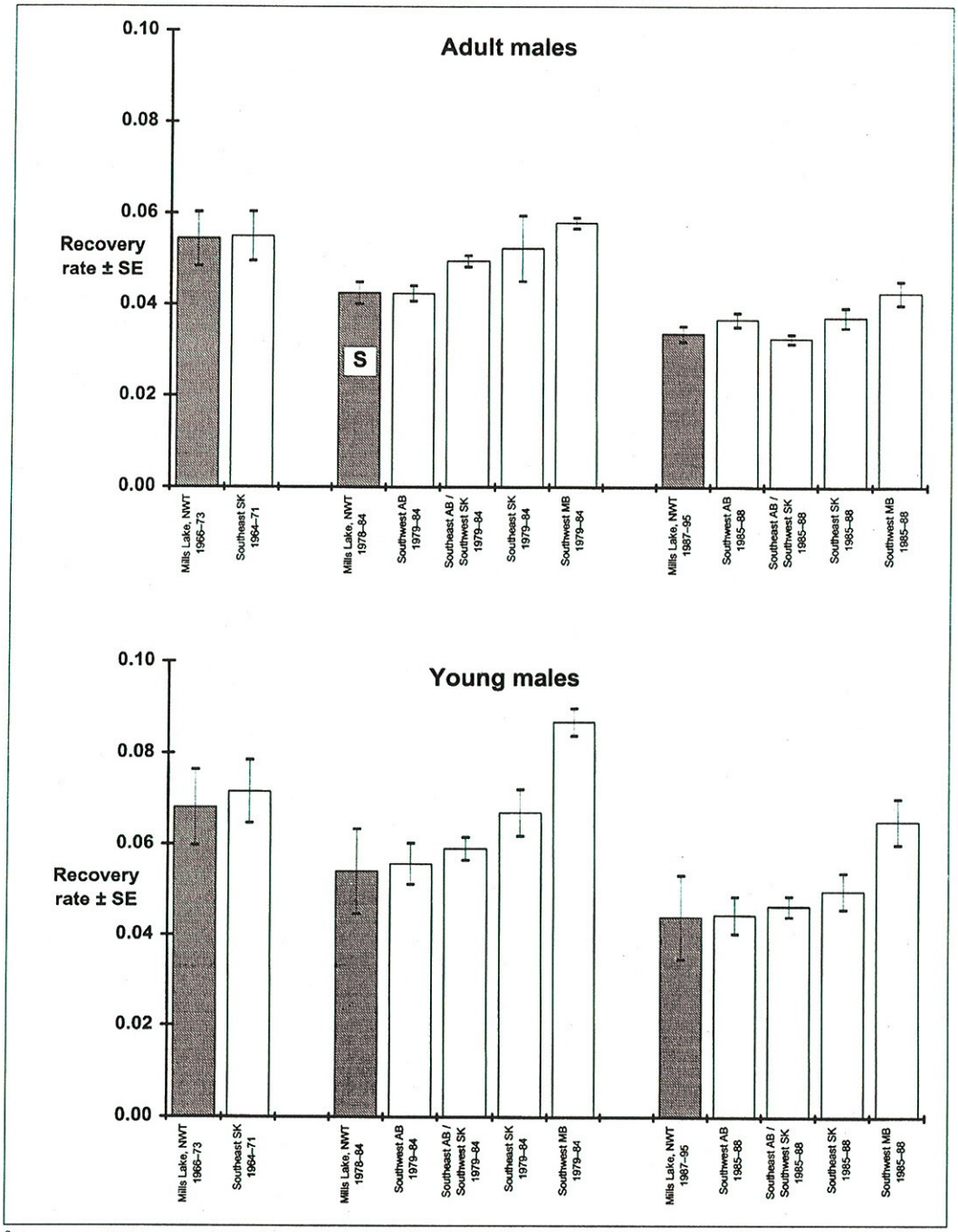
[a] Survival estimates from Mills Lake are based on the models of best fit.
[b] Survival estimates from the Canadian Prairies are from Chu and Hestbeck (1989) and Smith and Reynolds (1992).

Figure 2
Survival estimates (± standard errors) of female Mallards banded at Mills Lake, Northwest Territories,[a] and the Canadian Prairies,[b] with Mills Lake estimates that are significantly different from Prairie estimates from corresponding time periods indicated by "S"



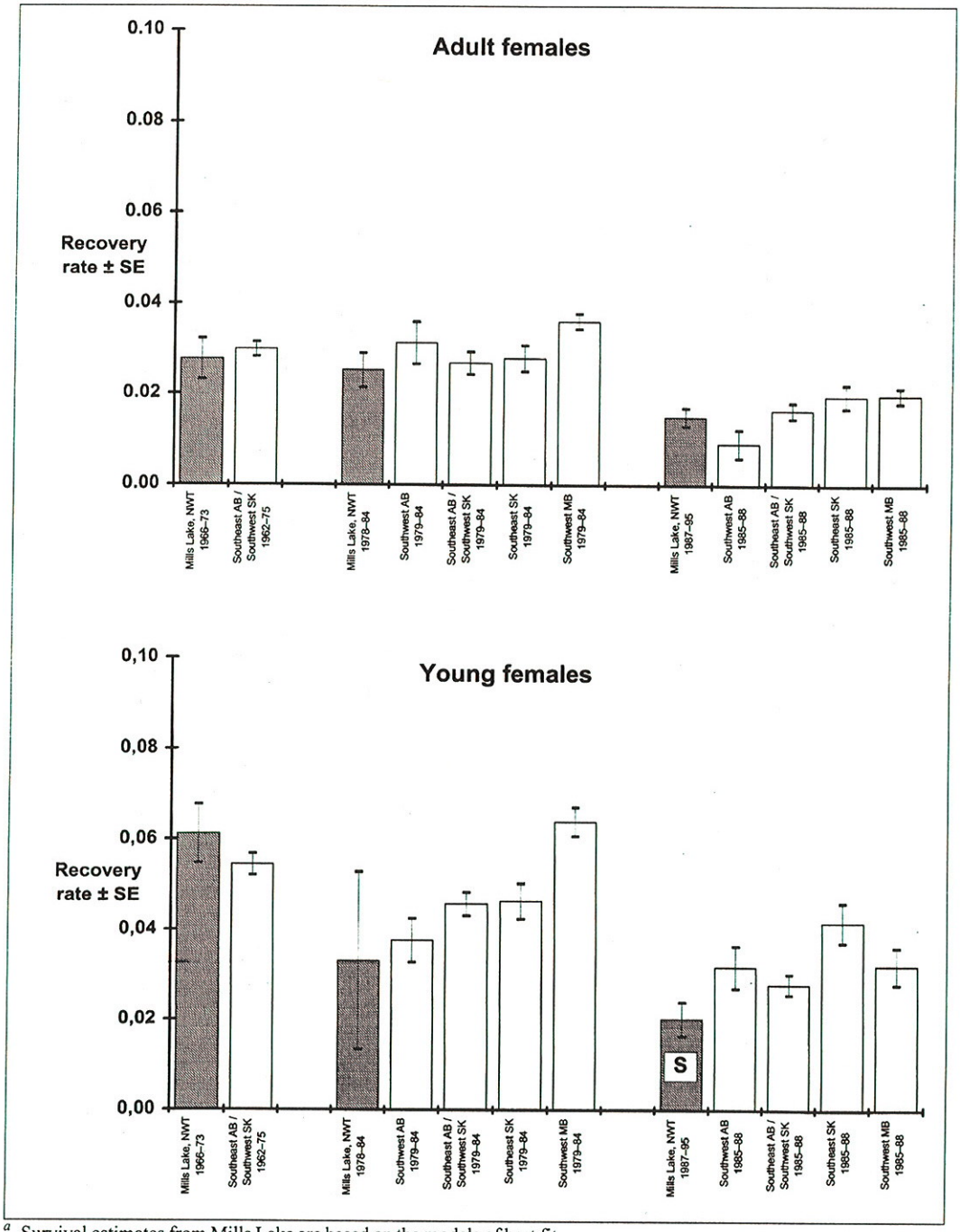
[a] Survival estimates from Mills Lake are based on the models of best fit.
[b] Survival estimates from the Canadian Prairies are from Chu and Hestbeck (1989) and Smith and Reynolds (1992).

Figure 3
Recovery rates (± standard errors) of male Mallards banded at Mills Lake, Northwest Territories,[a] and the Canadian Prairies,[b] with Mills Lake estimates that are significantly different from Prairie estimates from corresponding time periods indicated by "S"



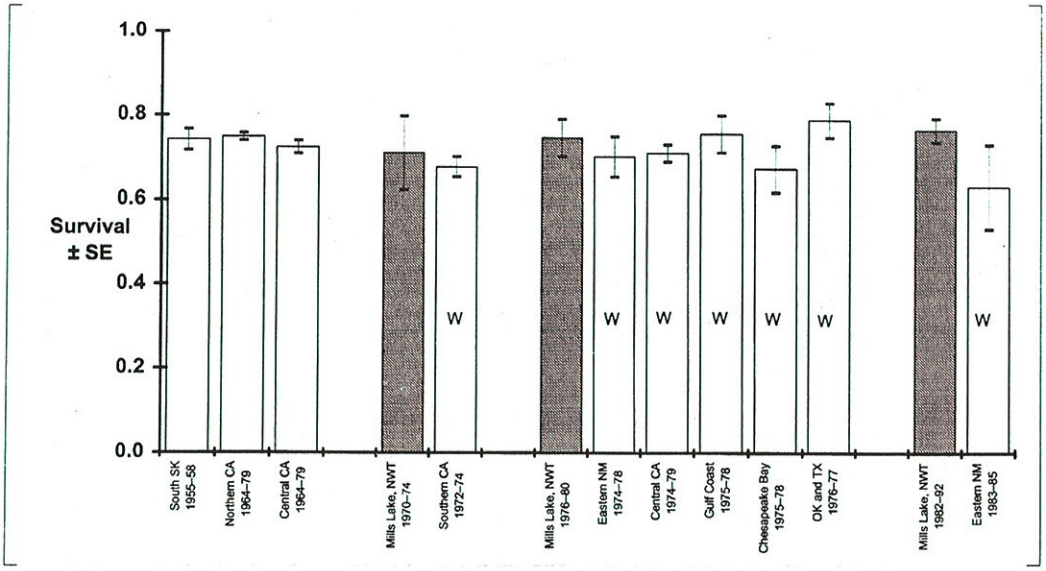
[a] Survival estimates from Mills Lake are based on the models of best fit.
[b] Survival estimates from the Canadian Prairies are from Chu and Hestbeck (1989) and Smith and Reynolds (1992).

Figure 4
Recovery rates (± standard errors) of female Mallards banded at Mills Lake, Northwest Territories,[a] and the Canadian Prairies,[b] with Mills Lake estimates that are significantly different from Prairie estimates from corresponding time periods indicated by "S"



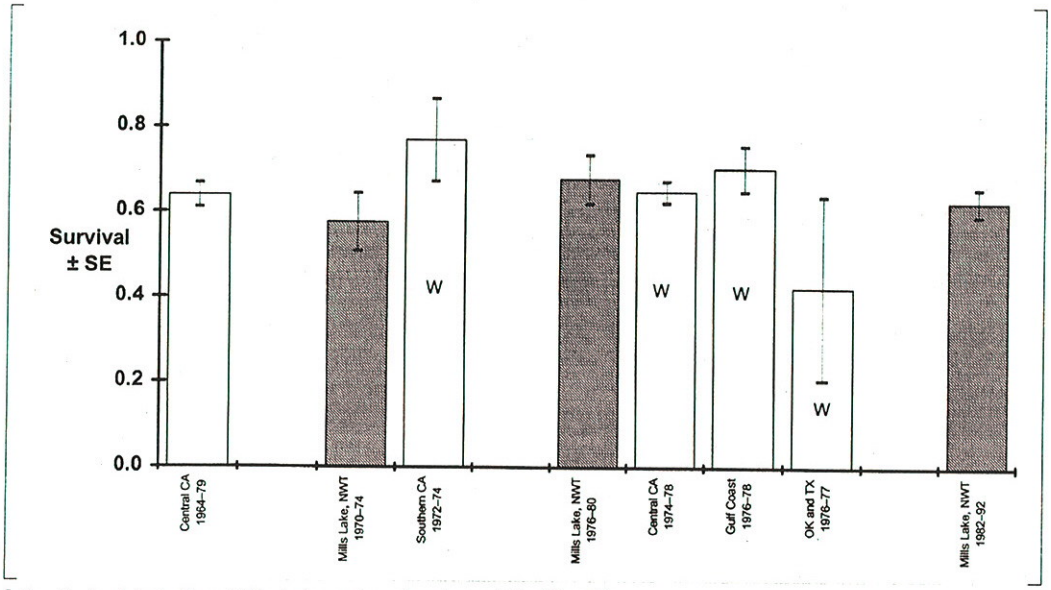
[a] Survival estimates from Mills Lake are based on the models of best fit.
[b] Survival estimates from the Canadian Prairies are from Chu and Hestbeck (1989) and Smith and Reynolds (1992).

Figure 5
Survival estimates (± standard errors) of adult male Northern Pintails banded at Mills Lake, Northwest Territories,[a] compared with adult male Northern Pintails banded on wintering areas (indicated by "W")[b] or before the hunting season[c]



[a] Survival estimates from Mills Lake are based on the models of best fit.
[b] Survival estimates from birds on the wintering areas are from Hestbeck (1993).
[c] Survival estimates from birds banded before the hunting season are from Anderson and Sterling (1974) and Rienecker (1987).

Figure 6
Survival estimates (± standard errors) of adult female Northern Pintails banded at Mills Lake, Northwest Territories,[a] compared with adult female Northern Pintails banded on wintering areas (indicated by "W")[b] or before the hunting season[c]



[a] Survival estimates from Mills Lake are based on the models of best fit.
[b] Survival estimates from birds on the wintering areas are from Hestbeck (1993).
[c] Survival estimates from birds banded before the hunting season are from Rienecker (1987).

Appendix 1
Numbers of Mallards and Northern Pintails banded at Mills Lake, Northwest Territories, 1955–95

	Number of Mallards				Number of Northern Pintails			
	Adult		Young		Adult		Young	
Year (s)	Male	Female	Male	Female	Male	Female	Male	Female
1955	4	6	300	406	1	2	29	70
1956	434	167	176	145	146	96	153	148
1957	26	52	671	578	13	18	141	226
1958	17	19	488	396	8	29	567	421
1959–63		(no banding)				(no banding)		
1964	148	136	303	276	21	31	34	46
1965	17	31	146	139	49	70	178	225
1966	307	110	133	83	15	57	203	310
1967	86	42	130	108	142	391	409	519
1968	147	148	77	55	50	140	38	44
1969	109	80	405	381	15	28	90	117
1970	42	33	307	351	111	134	221	285
1971	60	123	273	245	251	476	154	237
1972	190	158	63	77	289	571	127	140
1973	78	28	77	56	772	338	52	41
1974	5	6	45	26	66	135	240	319
1975		(no banding)				(no banding)		
1976	55	62	448	460	262	359	353	516
1977	738	388	30	31	685	727	28	57
1978	397	230	233	220	273	242	98	126
1979	168	86	97	75	159	181	214	230
1980	653	393	148	116	135	110	17	24
1981	385	151	37	29	12	8	0	1
1982	828	295	91	78	161	471	90	147
1983	204	91	145	116	452	456	457	604
1984	339	159	436	435	588	600	259	368
1985	4	5	42	46	350	206	756	683
1986	28	23	565	556	256	383	761	1 041
1987	690	184	343	231	879	279	223	173
1988	312	90	17	23	1 119	1 017	61	63
1989	1 001	365	566	470	219	161	113	142
1990	1 123	531	73	53	263	259	42	53
1991	953	302	45	25	234	361	73	73
1992	358	144	103	102	126	107	58	62
1993	907	272	170	109	286	218	32	45
1994	51	43	342	280	27	39	62	52
1995	967	753	68	51	10	3	1	2
Total	11 831	5 706	7 593	6 828	8 445	8 703	6 334	7 610

Appendix 2
Statistical comparisons[a] of survival and recovery rates for Mallards banded at Mills Lake, Northwest Territories,[b] compared with Mallards banded on the Canadian Prairies[c]

	Time periods compared					
Survival estimates Age and sex	Mills Lake	Canadian Prairies	df	χ^2	P	Group with higher survival
Survival estimates						
Adult males	1966–73	1964–71 (Southeast SK only)	1	1.002	0.317	—
	1978–84	1979–84	1	3.794	0.051	—
	1987–95	1985–88	1	1.603	0.205	—
Adult females	1966–73	1962–75 (Southeast AB/ Southwest SK only)	1	1.519	0.218	—
	1978–84	1979–84	1	0.373	0.541	—
	1987–95	1985–88	1	2.472	0.116	—
Young males	1966–73	1964–71 (Southeast SK only)	1	6.011	0.014	Prairies
	1978–84	1979–84	1	0.558	0.455	—
	1987–95	1985–88	1	4.596	0.032	Prairies
Young females	1966–73	1962–75 (Southeast AB/Southwest SK only)	1	5.281	0.022	Prairies
	1978–84	1979–84	1	0.157	0.692	—
	1987–95	1985–88	1	0.038	0.846	—
Recovery rates Age and sex	Mills Lake	Canadian Prairies	df	χ^2	P	Group with lower recovery rate
Adult males	1966–73	1964–71 (Southeast SK only)	1	0.006	0.940	—
	1978–84	1979–84	1	6.880	0.009	Mills Lake
	1987–95	1985–88	1	3.489	0.062	—
Adult females	1966–73	1962–75 (Southeast AB/Southwest SK only)	1	0.193	0.660	—
	1978–84	1979–84	1	1.676	0.195	—
	1987–95	1985–88	1	0.294	0.588	—
Young males	1966–73	1964–71 (Southeast SK only)	1	0.105	0.746	—
	1978–84	1979–84	1	1.874	0.171	—
	1987–95	1985–88	1	0.627	0.429	—
Young females	1966–73	1962–75 (Southeast AB/Southwest SK only)	1	0.963	0.326	—
	1978–84	1979–84	1	0.604	0.437	—
	1987–95	1985–88	1	9.356	0.002	Mills Lake

[a] Significant χ^2-values ($P \leq 0.05$) indicate differences in the estimates.
[b] Estimates from Mills Lake are based on the models of best fit.
[c] Includes southwest Alberta, southeast Alberta/southwest Saskatchewan, southeast Saskatchewan, and southwest Manitoba, unless otherwise indicated. Estimates are from Chu and Hestbeck (1989) and Smith and Reynolds (1992).

Appendix 3
Statistical comparison[a] of survival rates for adult Northern Pintails banded at Mills Lake, Northwest Territories,[b] compared with Northern Pintails banded on the wintering areas[c]

	Time periods compared						
Sex	Mills Lake	Wintering areas		df	χ^2	P	Group with higher survival
Male	1970–74	Southern CA	1972–74	1	0.130	0.718	—
	1976–80	Eastern NM	1974–78	1	0.188	0.665	—
		Central CA	1974–79				
		Gulf Coast	1975–78				
		Chesapeake Bay	1975–78				
		OK and TX	1976–77				
	1882–92	Eastern NM	1983–85	1	1.660	0.198	—
Female	1970–74	Southern CA	1972–74	1	2.671	0.102	—
	1976–80	Central CA	1974–78	1	0.855	0.355	—
		Gulf Coast	1976–78				
		OK and TX	1976–77				

[a] Significant χ^2-values ($P \leq 0.05$) indicate differences in the estimates.
[b] Estimates from Mills Lake are based on the models of best fit.
[c] Estimates from the wintering areas are from Hestbeck (1993).

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