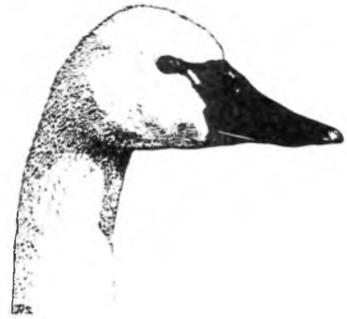
Population status and productivity of Tundra Swans *Cygnus columbianus columbianus* in North America



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Population indices from Midwinter Waterfowl Surveys conducted in the Atlantic and Pacific Flyways show that the Eastern Population, Western Population and the total North American Tundra Swan population have increased significantly (P<0.001) at annual rates of 2.4%, 1.8%, and 2.1%, respectively, during the period 1955-89. During 1980-89, the EP continued to increase and the WP may have possibly declined resulting in stable numbers for the total North American population; data are most reliable as an index to population trends when viewed over the long term. In the short term, considerable variability exist between periods because of inexplicable erratic changes in population indices. The EP and WP comprise 58% and 42% of North American's Tundra Swans, respectively. North Carolina and California winter nearly 70% of the continent's population, and these two subpopulations continue to increase both numerically and proportionately. Productivity estimates determined from observations of age-ratios and number of young per family in the EP and WP during fall and early winter show little change over the long or short term. These estimates were not well correlated with population changes, probably due erratic population indices as well as possible biases in productivity assessments. However, since productivity indices have not changed significantly over the period when numbers of Tundra Swans have increased, it may be valid to assume that present levels of productivity are adequate to sustain growth.

Tundra Swans *Cygnus columbianus columbianus* are the most numerous and widely distributed of the North American swans. They nest in tundra along coastal regions of Alaska and the central Canadian arctic, particularly near river deltas (Bellrose 1976). Nest sites are often widely scattered; however, in some locations of the Yukon Delta in Alaska, densities average over 0.4 nests per km^2 (Dau 1981). Migration routes are traditional and span the continent to unite breeding grounds with primary wintering areas along the Atlantic and Pacific coasts (Fig.1). Major migration stopovers occur strategically in the mid-continent Canadian Provinces of Alberta and Saskatchewan and in the north-central and western United States (Gunn 1973). Principal wintering sites occur along Atlantic coastal, estuarine, and inland habitats from New Jersey, the Chesapeake Bay region of Maryland and Virginia, south to Currituck and Pamlico Sounds of North Carolina and along the Pacific Coast from Puget Sound in Washington and the mouth of the Columbia River southward to the San Joaquin and Sacramento Valleys of California (Bellrose 1976).

Tundra Swans are managed as Eastern (EP) and Western (WP) Populations based on their wintering distribution. Guidelines for management of these populations are detailed in separate plans that were cooperatively developed by Flyway Councils, consisting of State and Provincial wildlife agencies, and the U.S. Fish and Wildlife Service (USFWS) and Canadian Wildlife Service (CWS). The two plans establish goals for maintaining populations at levels acceptable for providing maximum benefits to society, including aesthetic, educational, scientific, and hunting uses that are compatible with the status and welfare of the species. Each plan prescribes population levels and distribution patterns to be maintained consistent with available habitats and public demands and identifies management guidelines, strategies, and responsibilities for attaining those objectives. Continental objectives based on three-year average winter indices have been agreed to by Canada and the United States and identified in the North American Waterfowl Management Plan (CWS and USFWS 1986). Those objectives call for 80,000 EP and 59,000 WP Tundra Swans.

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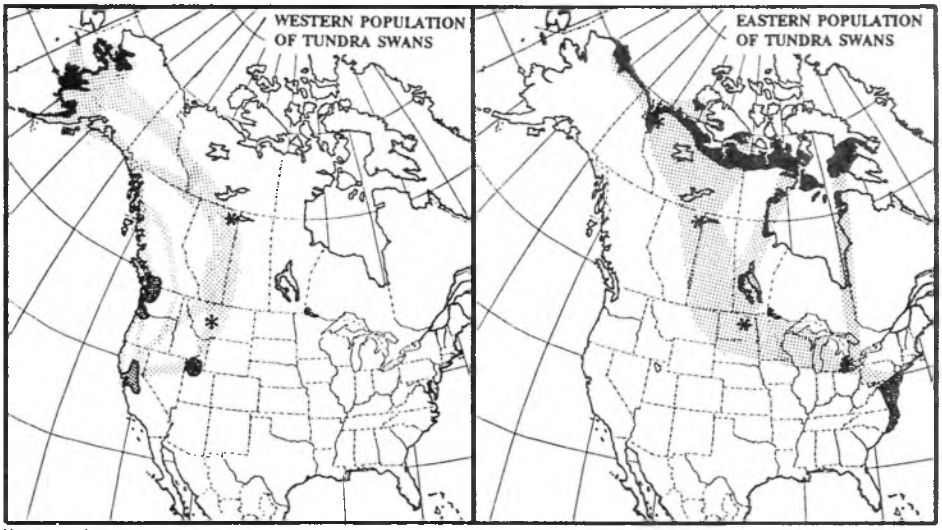

Figure 1. Map showing breeding, migration, and winter areas for Eastern and Western populations of Tundra Swans in North America (from Schroeder 1983). Major breeding areas are shown in black; principal migration corridors are shown in light stippling; migration stopovers are indicated by asterisks; and major wintering areas are in heavy stippling.

This paper summarizes the annual Midwinter Waterfowl Surveys and the fall age-ratio counts and updates the status of Tundra Swans previously reported by Bartonek *et al.* (1981), Munro (1981) and Lensink (1973). The relative importance of various causes of mortality affecting the status of Tundra Swans have not been well quantified, but what is known about hunting and non-hunting mortality, including subsistence harvest, disease, lead poisoning and other factors is provided in a review by Bartonek *et al.*1991.

Methods

Population Survey

Numbers of Tundra Swans and other waterfowl are estimated annually during a one or two week period in early January throughout the conterminous United States. The cooperative Midwinter Waterfowl Survey counts have been conducted since 1936 but only on a comparable basis since 1955. All waterfowl occurring within specified units and zones are counted annually for each State using a combination of aerial, ground, and water survey methods. These results are totaled by State, and summarized by each Flyway for the United States. These data provide an index to population trends but have low precision to estimate population size for most species due to visibility bias and lack of standard error calculations (Conroy *et al.* 1988). However, since swans are very visible, except when snow cover exists, the winter index for swans may closely estimate population size.

Tundra Swans winter almost exclusively within the United States; therefore, the Midwinter Waterfowl Survey is a practical means of monitoring trends in populations and measuring the status of the species. Less than 2% of the species is thought to winter outside the survey area in Alaska, Canada and Mexico (Bartonek *et al.* 1981). Unadjusted data were used to show the full range of variability rather than three-year running averages which are sometimes used to smooth population curves. Trends were assessed over time for each population using simple linear regression (SAS Inst., Inc. 1985).

Productivity Survey

Indices to productivity were derived from counts of grey-plumaged young and white-plumaged adults and subadults observed in flocks and from the number of young observed in family groups during fall and early winter. These productivity assessments were obtained by using ground observations and aerial photographs in New Jersey, Maryland, Virginia, and North Carolina for the EP and ground counts in Utah for the WP. Age-ratio estimates are based on counts taken at the same locations each year, but the sampling effort has not been comparable among years. Unweighted ratios of young per adult and numbers of young per family were analyzed among years and correlated with the winter survey data each year to detect trends using simple linear regression (SAS Inst.,Inc. 1985).

Results

Population Trends

Indices to the number of Tundra Swans in North America and in the EP and WP have risen significantly (P<0.001) and nearly doubled during the period 1955 to 1989. Average annual rates of increase during this 35-year period were 2.4% for the EP, 1.8% for the WP, and 2.1% for the populations combined (Figs. 2, 3 and 4). Presently, the EP and WP comprise 58% and 42%, respectively, of the total three-year average number of Tundra Swans surveyed during 1987-89.

During 1980-89, population trends were not significant (P>0.05) and annual rates of change were 2.3% for the EP, -2.3% for the WP and 0.1% for the combined total (Figs. 2, 3 and 4). These data indicate that the EP continues to increase at a rate consistent with their long-term trend, but the WP may be declining. Estimates for the WP appear to be consistently more variable than for the EP (Figs. 2 and 3). While swan numbers are highly variable in the short term, these independent data sets suggest that EP and WP populations may no longer be exhibiting similar trends. The total number of Tundra Swans in North America has stabilized during 1980-89 and no trend is apparent.

The distribution of EP Swans wintering in the Atlantic Flyway has changed over the long-term (Fig. 5). Since the late 1960s, the number of swans wintering in Maryland, in the vicinity of Chesapeake Bay, has declined while the number wintering further south along coastal North Carolina has increased steadily. The population in North Carolina has increased significantly (P<0.01) at an annual rate of 10.7%

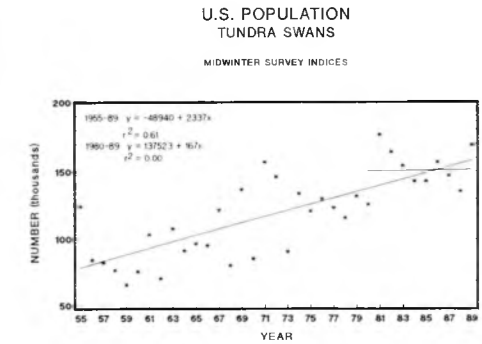

Figure 4. Trends in the total number of Tundra Swans in North America estimated from midwinter surveys during periods 1955-89 and 1980-89.

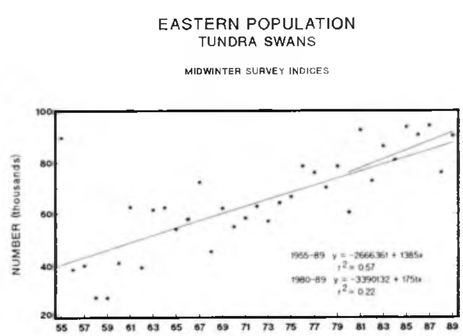

Figure 2. Trends in the number of Eastern Population Tundra Swans estimated from midwinter surveys during periods 1955-89 and 1980-89.

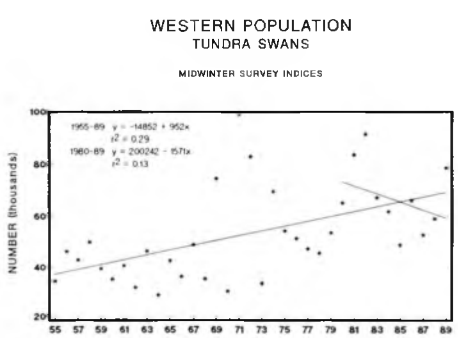

Figure 3. Trends in the number of Western Population Tundra Swans estimated from midwinter surveys during periods 1955-89 and 1980-89.

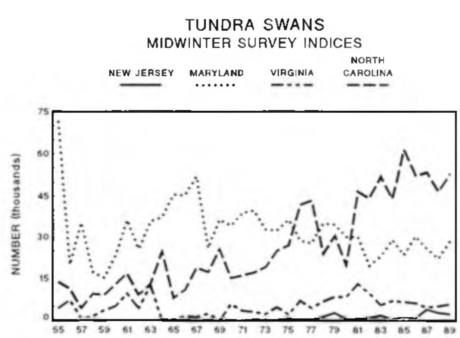

Figure 5. Distribution patterns of Eastern Population Tundra Swans wintering in the Atlantic Flyway during 1955-89.

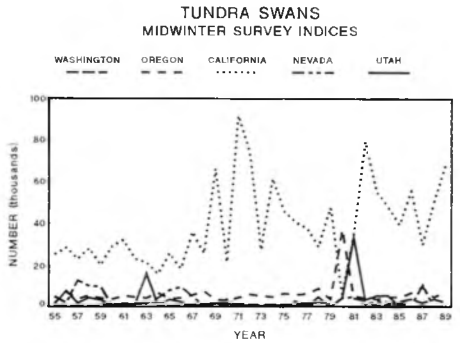

Figure 6. Distribution patterns of Western Population Tundra Swans wintering in the Pacific Flyway during 1955-89.

during the period 1955-89 and since 1980, at a slower rate of 4.7% ($P>0.05$) per year. During 1987-89, North Carolina wintered an average of 59% of the EP, while Maryland, Virginia, New Jersey and elsewhere wintered 29%, 6%, 4%, and 2%, respectively.

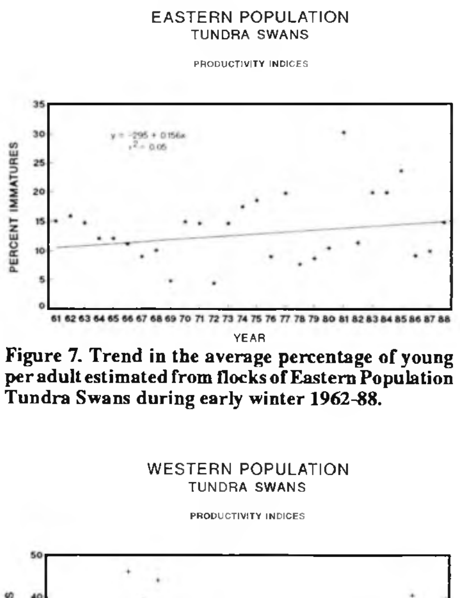

Figure 7. Trend in the average percentage of young per adult estimated from flocks of Eastern Population Tundra Swans during early winter 1962-88.

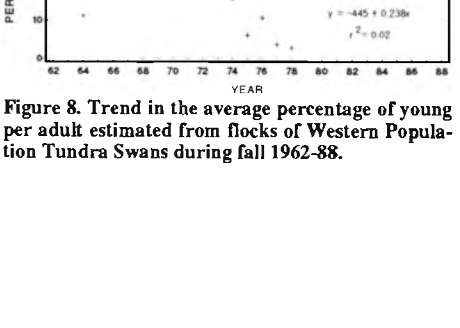

Figure 8. Trend in the average percentage of young per adult estimated from flocks of Western Population Tundra Swans during fall 1962-88.

Wintering WP Swans are widely distributed among 11 states in the Pacific Flyway, primarily in California, Oregon, Washington, Idaho, Nevada and Utah (Fig. 6). More than 70% of the WP winters in California along the coast and within the Central Valley. The California wintering population has increased significantly ($P<0.01$) over the period 1955-89 at an annual rate of 2.5% and 1.7% during 1980-89 ($P>0.05$). While the trend is not strong, the number of WP wintering in California appears to be slowly increasing. The number wintering in Oregon appears stable; swan numbers in Nevada, Utah, Idaho, and Washington vary with habitat conditions from year-to-year such as harsh winters and widely fluctuating water levels in arid portions of the West. In part, this variable winter distribution for the WP is believed to contribute to the erratic changes in population indices.

Productivity Trends

Estimates of young per adult observed in flocks of EP and WP Swans during fall and early winter 1962-88 are shown in Figs. 7 and 8, respectively. These unweighted percentages of young average 14.9% for EP and 33.8% for WP over the period 1975-88. Age-ratios are consistently higher and less variable in the WP than in the EP. These data may be more of an artifact of survey bias than true reproductive rates since WP estimates are derived mainly during fall stopover in Utah while EP estimates are obtained from winter counts. Over the long term, these indices show no significant trends ($P>0.05$) for either population. Additionally, the proportion of young observed in flocks during fall and early winter was not strongly correlated with midwinter survey indices for either the EP ($r^2=0.50$, $P>0.05$) or the WP ($r^2=0.21$, $P>0.05$).

Family groups averaged 1.9 and 2.4 cygnets per family for EP and WP, respectively, during 1975-88. There were no significant trends ($P>0.05$) during 1962-88 for either group (Fig. 9 and 10), but there is evidence of higher productivity among family groups in the WP segment.

Discussion

The number of Tundra Swans in North America appears to have doubled over the last 35 years. Independent counts in the Atlantic and Pacific Flyways show that the EP and WP have expanded at similar rates during this period. This similarity is particularly interesting since both

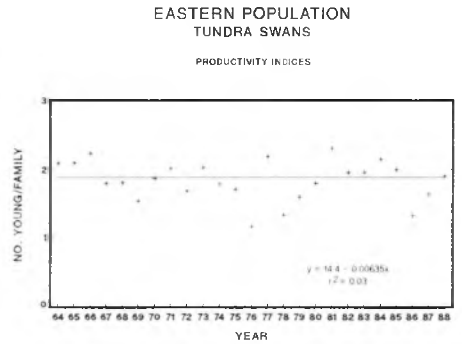

Figure 9. Trend in the average number of young per family estimated from family groups of Eastern Population Tundra Swans during early winter 1962-88.

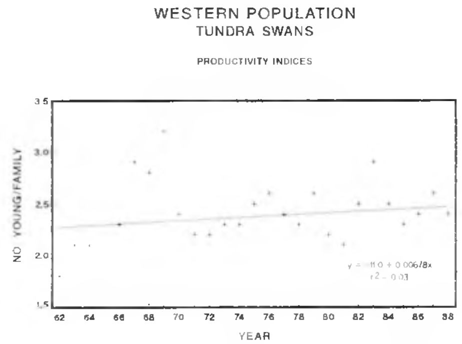

Figure 10. Trend in the average number of young per family estimated from family groups of Western Population Tundra Swans during fall 1962-88.

populations breed and winter in different regions of the continent and would not be expected to have similar survival and recruitment rates. While there is interchange between these populations, it is thought to be negligible (Schroeder 1983). Increasing winter indices for EP and WP Swans from the Midwinter Waterfowl Surveys agree closely with increasing breeding population indices gathered in western Alaska during 1965-89 (Conant *et al.* 1991). Considering the poor statistical reliability of winter indices for short-term trend analyses, the EP appears to be growing during the recent ten years at a rate consistent with that observed over the long-term, while the WP appears to be declining. Populations of Tundra Swans now exceed the goals of 80,000 and 59,000 as identified in the North American Waterfowl Management Plan (CWS and USFWS 1986) for the EP and WP, respectively.

Indices derived from observations of young in flocks from various locations and young in family groups have not been examined in detail to determine whether any serious bias exists or if these data are representative of annual changes in productivity. These counts could be biased if differential migration patterns exist between successful, unsuccessful and nonbreeding cohorts or if these groups mix disproportionately each year. Such biases could be of particular importance in assessing productivity in species like swans, which have a large nonbreeding subadult cohort. The consistently higher age ratios in the WP than in the EP may reflect differences in survey procedures rather than actual differences in production.

Productivity information from unweighted age-ratios did not correlate well with population indices from the Midwinter Waterfowl Survey. However, such correlation measurements are of questionable value considering the potential biases associated with age ratio counts and the many erratic population changes. Presently, it appears that our database on Tundra Swans is too deficient for monitoring changes in productivity or recruitment. However, since trends in percentages of young observed in flocks and in the number of young per family have not significantly changed during the period when numbers of Tundra Swans have increased, it may be valid to assume that present levels of productivity are adequate to sustain growth. Also, these data do not suggest that a change in productivity is responsible for the apparent downward trend in the WP during the 1980s. For example, there would be no downward trend in the WP if the January 1981 and 1982 indices were just erratic highs. Field studies are needed to verify the relationships between these reproductive indices and some actual measure of recruitment.

Since the population status of Tundra Swans is determined primarily by the dynamic functions of natality and mortality, more information on factors contributing to mortality is needed (Bartonek *et al.* 1991). Many of these factors are documented in various reports but have not been quantified adequately in order to evaluate the relative importance. Before the full impact of these mortality factors on population status can be assessed, studies are needed to document the timing and extent of mortality throughout the year. Once these findings are known, management action can be prescribed and implemented to maintain or achieve the desired population goals.

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