A CORRELATION BETWEEN *CYGNUS COLUMBIANUS COLUMBIANUS* TERRITORIES AND WATER BODIES IN WESTERN ALASKA

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Introduction

The purpose of this paper is to show the relationship of swan data gathered on routine waterfowl surveys to habitat features shown on topographic maps in Alaska. There is a possibility that knowledge of the biology and ecology of swans on their northern breeding habitat will be helpful in understanding factors that affect less highly visible waterfowl species. Intensive study of swans will be needed to develop and test their use as an 'indicator species'. This study is perhaps an early step toward that goal.

The systematic North American waterfowl breeding population surveys were begun some 35 years ago and have been standardized since 1955. This paper deals with just one of the 49 strata included in the Continental Survey or about 2% of the annual North American survey sample. Methods and biasses regarding swan data acquired on this survey in western Alaska were discussed by King (1973).

Methods

C. c. columbianus nests in Alaska on the western and northern tundras (Fig 1). Most of the habitat except the most northerly is covered by the annual waterfowl breeding pair surveys in late May or early June. The highest density of territorial swans is observed on the 6 734 208 ha of lowland tundra habitat on the Yukon Delta. The swans here are best described by Lensink (1973). A wealth of geese and ducks also nest in this area (King and Lensink 1971).

Eight survey transects have been laid out across the Yukon Delta habitat which are further subdivided into 65 segments each 25.7 km long (Fig 2). These lines are marked on detailed topographic maps for navigation by the pilot. Survey is immediately after the ice on the lakes is gone, about 1 June. Swans at this time are beginning incubation; thus the breeding population is distributed on nesting territories. A single-engine, high-wing aeroplane is flown at 30 m elevation and 160 km/hr along each transect. Thus it takes about 10 minutes for each of the 65 segments. The pilot on the left and an observer on the right record all waterfowl sightings within 200 m of each side of the aeroplane. This results in an actual sample of 1037 ha for each segment flown (USDI 1977). Swans are recorded as singles, pairs or flocks of three or more. Forty-nine segments have been flown every year from 1956 to 1977, and the remaining 16 were added in 1964. Segment averages used in the calculations are based on either 14 or 22 years of data. Trend is shown

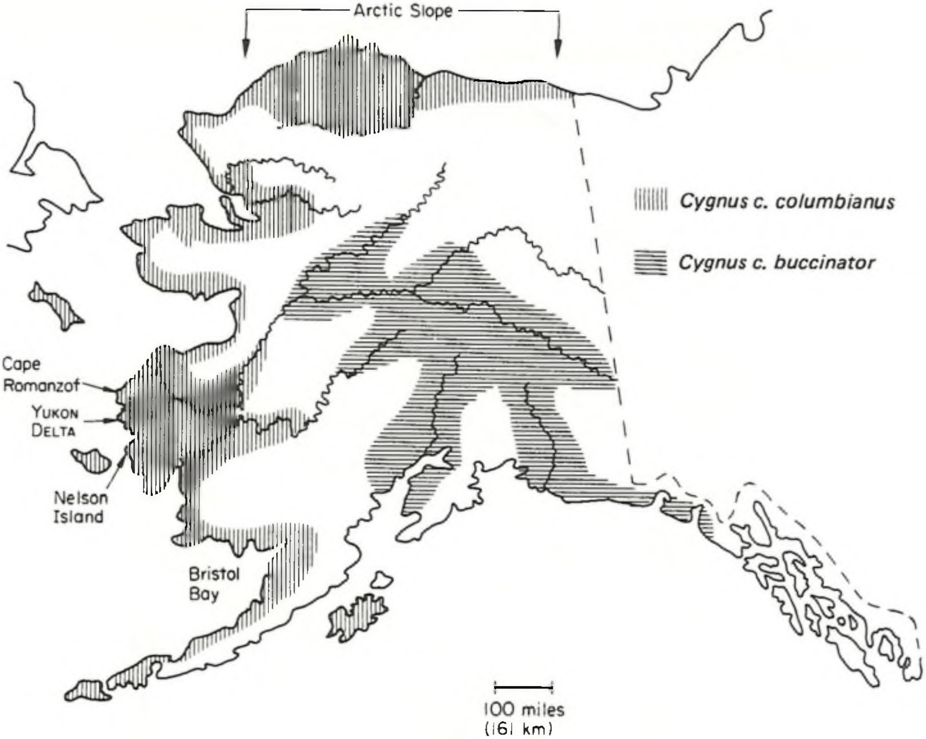

Fig 1. Approximate swan breeding range in Alaska (from King 1973).

using only the 49 segments flown in each of the 22 years.

The data for the ten variables listed in Table 1 were calculated from US Geological Survey topographic maps, scale 1:63 360. These maps were made from aerial photographs taken in the early 1950s. Swans are seldom seen on a water area too small to show on the map. Area values were calculated using an 'area graph' dot card with 100 randomly distributed dots per 6.45 sq cm and lake shoreline was calculated using a Numonics electronic digitizer.

Flocked swans in June represent non-breeding birds and are not included in our calculations. Birds seen as pairs appear to be defending territories, are often seen associated with nests and are well spaced. Single birds are sometimes seen associated with a nest and, if not, may represent one half of a nesting pair. For our calculations here we add single and paired birds on the assumption that they represent the breeding population.

Fig 2. A correlation of *Cygnus columbianus columbianus* territories and water bodies in Western Alaska.

Fig 2. The Yukon Delta showing location of each of the 65 line transect survey segments, each 25.7 km long. The number below each segment is the 22 year average number of swans seen there that appear to be on territory. The dotted lines group areas according to density, low averaging from trace (t)–3, medium 4–8 and high 9–18. (Adapted from King 1973).

Results

Correlations with environmental variables

The correlations between average swans per segment and ten environmental variables are summarized in Table 1. These long-term averages are an excellent measure of the value to swans of habitat crossed by these segments. Swan density

Table 1. Correlation coefficients between swan density and ten environmental variables

	Independent variables	Correlation coefficient with swan density	Significance
1.	Lake area per segment	0.230	$p < 0.10$
2.	Linear miles of lake shoreline/sq mile	0.673	$p < 0.001$
3.	Number of lakes/sq mile	0.703	$p < 0.001$
4.	Number of small islands/sq mile	0.464	$p < 0.001$
5.	River area per segment	−0.207	$p < 0.11$
6.	Linear miles of river shoreline per segment	−0.088	Not significant
7.	Linear miles of stream per segment	−0.076	Not significant
8.	Altitude	−0.203	$p < 0.11$
9.	Miles to nearest village	0.020	Not significant
10.	Population of nearest village	0.122	Not significant

correlated best with the variables related to lakes, numbers 1–4. The highest correlation is for linear miles of shoreline and for total number of lakes with the latter being slightly higher. These two variables are highly dependent with respect to each other ($R = 0.83$) and usually represent the same water conditions. A scatter diagram by segment of swans versus lakes (Fig 3) demonstrates the linear relationship between the two.

$y = 0.984 + 0.0672x$ or
swans/segment = 0.984 + 0.0672 lakes/square mile

Some of the outliers can be partially explained by the varying quality of the maps used to determine numbers of lakes. The precision with which swan density can be predicted with this equation will increase with the size of the area to which it is applied.

The other two items (numbers 5 and 8) that show some significance are the area of river water and altitude above sea level. As expected, both show a slight negative correlation with swan densities.

Swans are seldom seen on the murky waters of the Yukon and other rivers. The mean elevation for all segments is 10 m above sea level with a range of 2 to 43 m, sufficient to show that higher elevations generally have fewer swans and are quite likely drier.

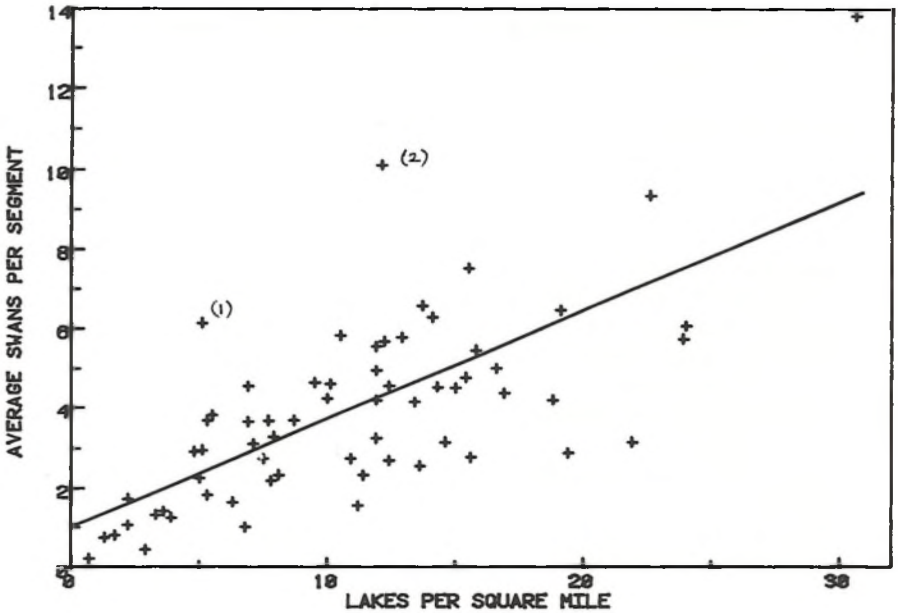

Fig 3. Scatter diagram of breeding swans versus lakes for 64 segments. Least squares fitted line has a correlation coefficient of R = 0.703. Outliers: (1) segment lies on Kashunuk River; (2) suspected map detail problem, habitat has swamps not showing as lakes.

The length of shoreline of running water in streams and rivers does not indicate any attraction for swans. The lack of correlation of any sort with the distribution and density of people may reflect that hunting pressure in summer relates to boat access rather than direct distance from communities.

A multiple linear regression analysis with these variables showed little gain over the simple linear regression.

Population trends

The ratio of singles to pairs varies considerably over the 22 year period (Fig 4). This may reflect that the proportion of swans nesting varies from year to year depending on weather conditions, number of first-year breeders, etc. Some separation of nesting pairs during this period is inherent as one bird sits on the nest and the other defends the territory. Lensink (1973) found that more than 50% of pairs evidently defending territories do not raise broods and probably do not attempt to nest. After the hatch in late June pairs are seldom separated. Thus early July surveys would provide a neater picture of annual numbers of pairs on territory. In spite of this difficulty we find no grounds in our data to indicate a long-term trend either up or down in the swan breeding population of the Yukon Delta.

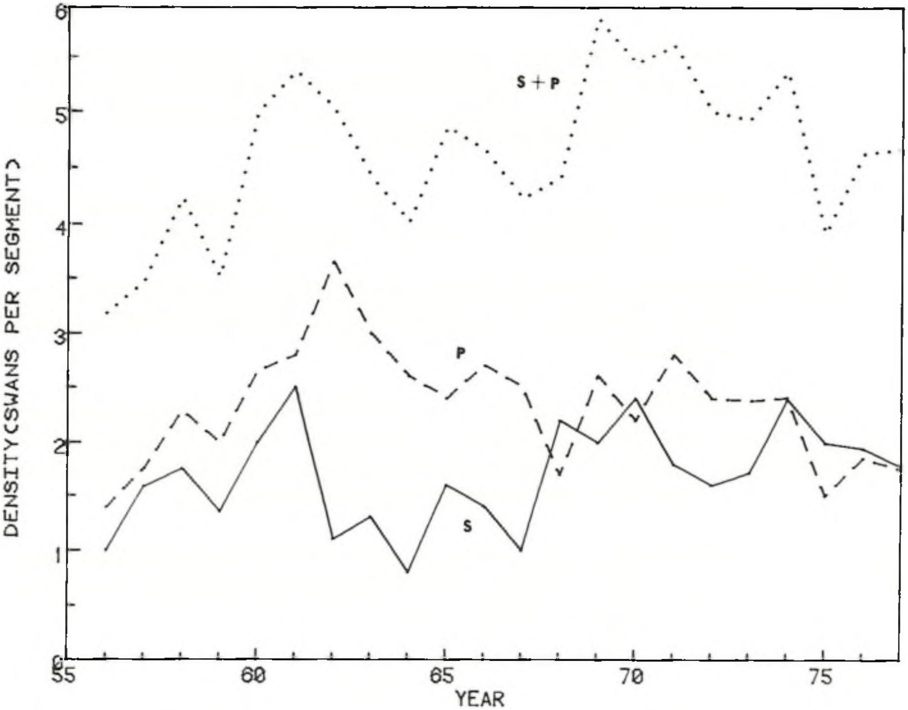

Fig 4. Average swans per segment. Singles (S): solid line. Pairs (P): dashes. Singles plus pairs (S + P): dots.

Stratification of habitat

We have stratified the swan nesting habitat of the Yukon Delta on the basis of average swan sightings per segment (Fig 2). We now know that the distribution of lakes correlates rather well with average swan distribution. A stratification of the habitat based on the distribution and density of lakes would be similar in shape but more refined. We find that there is no need to embark on the time-consuming process of calculating total edge effect on the margins of lakes as a simple count of lakes per unit area serves as well.

Discussion

No one familiar with northern swan habitats will be particularly surprised at the findings reported here. However, now that we have demonstrated these things factually we can use the knowledge to reorient and improve our ability to monitor waterfowl populations in the north where water areas remain relatively stable from year to year.

1. A more precise population estimate for the Yukon Delta swans could be obtained by using maps to stratify the area according to distribution of lakes and then designing a survey based on optimum allocation of sampling effort. Higher quality per unit costs of surveys would be achieved this way.

2. The same procedure could be used for all *C. c. columbianus* habitat and perhaps other tundra nesting swans wherever suitable quality maps exist.

3. The facts demonstrated here should be equally valid for ducks. Correlations between average duck numbers and distribution of water along standard survey transects could be calculated.

4. We could now draw a transect on a Yukon Delta map, count the lakes and predict a probable breeding population of swans that would be affected by a man-made project in the area. In this way 22 years of data could be utilized instead of the one or two which are usually obtained from pre-project studies.

Perhaps a final conclusion from this exercise is that if we keep our eye on these noble birds we can learn things that may ultimately improve our ability to conserve their smaller, less visible relatives nesting with them.

Summary

From 1956 to 1977 eight aerial survey transects consisting of 65 segments have been flown annually across the 6 734 208 hectares of the Yukon Delta tundra habitats on about 1 June. Swans and other waterfowl have been tallied within 0.2 km on each side of these 25.7 km long segments, providing an actual count of birds on 67 342 hectares or 1% of the entire Yukon Delta habitats. The transect lines have been plotted on US Geological Survey maps of scale 1:63 360. There is a mean of 43.9 lakes per segment with 29 km of lake shoreline. *C. c. columbianus* at the survey time are seen as singles or pairs evidently on breeding territories and as flocks of 3 or more non-breeding birds. The 22 year mean of singles and paired swans is 4.12 swans per segment. The correlation coefficient between swans and lakes is $R = 0.703$ ($p < 0.001$) and between swans and length of shoreline $R = 0.673$ ($p < 0.001$). Other physical factors such as length of streams and area of water showed little or no significant correlation. It is concluded that density of nesting swans within units of their breeding range can be estimated using numbers of lakes present on detailed maps. The more time-consuming process of determining length of lake shoreline yields little additional information. The annual averages show no significant population trend for swans observed on Yukon Delta territories during the 22 year period. The habitat is stratified according to average swan densities. Management implications are discussed.

References

Bellrose, F C (1976). *Ducks, Geese and Swans of North America.* Stackpole Books.