The distribution, fall migration routes and survival of Ross's Geese

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Introduction

In 1938 Angus Gavin discovered the breeding ground of the Ross's Goose *Anser rossii* at a lake near Discovery Lake (67° 33'N, 101° 49'W) in the Queen Maud Gulf lowlands, Northwest Territories (N.W.T.) (Gavin 1947; Scott 1951). In June 1976, nesting colonies of Ross's Geese, containing approximately 77,300 birds, were censused in the central Canadian Arctic (R. H. Kerbes, pers. com.). Small numbers of Ross's Geese also nest in Lesser Snow Goose *Anser c. caerulescens* colonies on the west coast of Hudson Bay (MacInnes & Cooch 1963; Ryder & Cooke 1973; Prevett & Johnson 1977) and on Southampton Island, N.W.T. (63° 42'N, 85° 45'W) (Barry & Eisenhart 1958).

This paper documents fall migration routes and temporal and geographic distribution of harvest based on recoveries of Ross's Geese banded in the central Arctic in 1963 and 1965–68. Estimates of age- and sex-specific survival, band recovery and vulnerability rates are provided.

Methods

During July and August of 1963 and 1965 to 1968 a total of 3,753 adult and young Ross's Geese were banded with aluminium leg-bands (Table 1) on the nesting grounds 150 km southeast of Cambridge Bay, N.W.T. (Figure 1). In 1966, jessknot neck-bands (Craighead & Stockstad 1956) were placed on 204 of the Ross's Geese banded. The method of capture and banding was similar to that used at the time for Lesser Snow Geese (Cooch 1958). All banded geese were released *en masse* to reduce dissolution of family groups and avian predation of goslings.

The geese were designated as adult (more than 1 year of age) or young (incapable of sustained flight) based on the presence of natal down. Sex was determined by cloacal examination (Hochbaum 1942).

Banding and recovery data were provided by the Canadian Wildlife Service. Analyses were aided through the use of the Statistical Package for the Social Sciences (Nie *et al.* 1975) performed on an IBM 360/50 computer. Only recoveries reported as shot were used. Direct recoveries (reported the first hunting season after banding) also include 2 Ross's Geese shot during May–July in the N.W.T. All recoveries during the second and subsequent hunting seasons are considered indirect. Four recoveries obtained in the N.W.T. during May–July of the second calendar year after banding are also tabulated as indirect recoveries.

This recovery analysis is based on the assumption that the distribution of recoveries provides a direct index to the distribution of harvest during the hunting season. Band reporting rate and the vulnerability of Ross's Geese to hunters is considered equal in all recovery locations; a premise of undetermined validity.

Recoveries of neck-banded and leg-banded geese were combined, since their direct recovery rates were not significantly different ($X^2 = 0{\cdot}304$; d.f. = 1; $0{\cdot}50 > P < 0{\cdot}75$). While Ankney (1975, 1976) concluded that aluminium neck-bands contributed to the starvation of more than an

Table 1. Number of Ross's Geese banded in the Perry River region in 1963 and 1965–1968 by age and sex class.

Year banded	Adult male	Adult female	Young male	Young female	Unknown sex	Total
1963	84	98	134	93		409
1965	155	146	184	186		671
1966	267	238	349	358	1	1,213
1967	168	162	281	295	4	910
1968	126	120	157	147		550
Total	800	764	1,105	1,079	5	3,753

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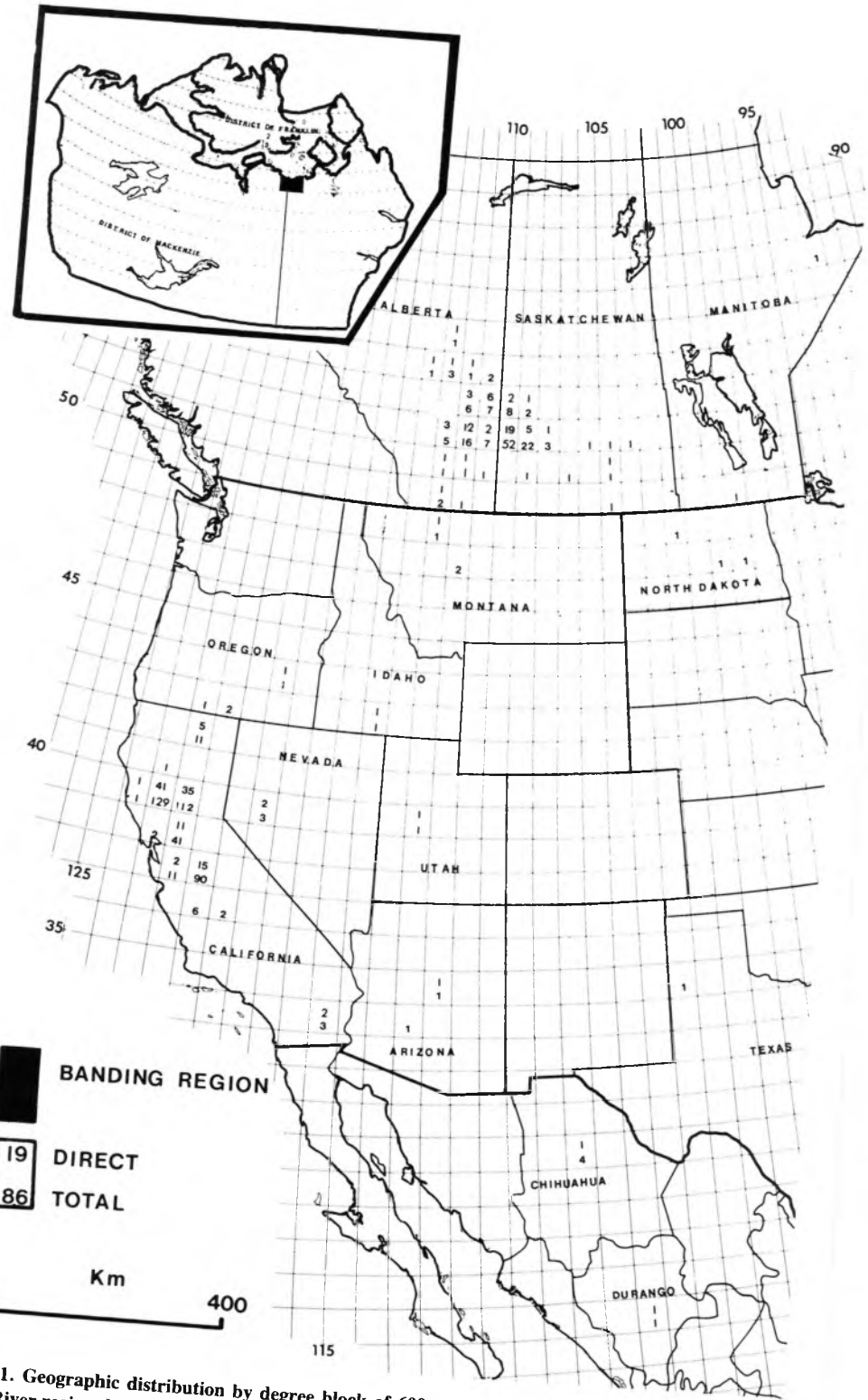


Figure 1. Geographic distribution by degree block of 600 recoveries of Ross's Geese banded in the Perry River region during 1963, 1965–1968 and recovered through to April 1977. East of the mapped area are 2 in Ontario, 1 in Missouri, 2 in Louisiana, and 12 in south-east Texas.

expected number of female Lesser Snow Geese during the breeding season, Boyd (1976) found that neck-bands did not alter the mortality rate of Lesser Snow Geese. The band reporting rate of neck-banded Giant Canada Geese *Branta canadensis maxima* was not materially different than for leg-banded birds (Raveling 1978). We have therefore assumed that neither the mortality rate nor the band reporting rate are significantly biased for neck-banded Ross's Geese.

Estimated survival and recovery rates were calculated using the methods of Brownie *et al.* (1978). Model H_{02} was selected because it demonstrated the best fit to the data. Its assumptions are (1) annual reporting and harvest rates (and hence recovery rates) are year-specific; (2) annual survival and harvest rates are age-dependent for the first year of life only; and (3) annual survival rates are otherwise constant from year to year. In general the band recovery rate calculated is comparable to direct recovery rates; however, the direct rates have larger standard errors (D. R. Anderson, pers. com.).

Results and discussion

Geographical distribution of band recoveries

Six hundred and four recoveries were obtained from five Canadian provinces, two districts of the Northwest Territories, 11 American and two Mexican states. A total of 192 direct recoveries have been received from three provinces, the District of Franklin, N.W.T., nine American states and two states in Mexico. No banded birds have been recovered in the sparsely populated area between the banding site and Lat. 57°N. Alberta, Saskatchewan and California account for 91% of the direct recoveries and 94% of the indirect recoveries (Table 2).

Table 2. Regional distribution of 604 band recoveries of Ross's Geese banded in the Perry River region in 1963 and 1965–1968 and recovered to April 1977.

Region	Number of recoveries Direct	Indirect	Total
Canada			
MacKenzie, N.W.T.	0	1	1
Franklin, N.W.T.	2	3	5
Alberta	33	22	55
Saskatchewan	29	65	94
Manitoba	0	2	2
Ontario	1	0	1
Quebec	0	1	1
Subtotal	65	94	159
United States			
Pacific Flyway			
Oregon	1	3	4
Idaho	1	0	1
California	112	301	413
Nevada	2	1	3
Utah	1	0	1
Arizona	1	1	2
Central Flyway			
Montana	1	2	3
North Dakota	0	3	3
Texas	5	3	8
Mississippi Flyway			
Missouri	0	1	1
Louisiana	1	0	1
Mexico			
Chihuahua	1	3	4
Durango	1	0	1
Total	192	412	604

Saskatchewan

Approximately 16% of the total continental harvest occurs within Saskatchewan (Table 2). Nearly all of the recoveries are from the west-central part of the province where 2 one-degree blocks (51°N 108°W, 51°N 109°W) account for 79% of the provincial harvest (Figure 1). The area is also important as a fall staging area to White-fronted Geese *Anser albifrons*, Canada Geese *Branta canadensis* and Lesser Snow Geese (Grieb 1970). During 1962 to 1967 this area consistently contributed 63·5% to 66·7% of the total provincial goose harvest (Korol & Dzubin 1968). On the basis of bag checks, Ross's Geese were estimated to comprise 5·4% of the geese harvested in this area in the fall of 1967. In 1969–1970, degree block 51°N 109°W supported the highest goose harvest in Canada and in 1974–1975 one of the 3 highest in Canada (Freemark & Cooch 1978).

Six recoveries, including one direct, are from south-central Saskatchewan. Ross's Geese have been observed during fall migration in this region of Saskatchewan (Lahrman 1970). The presence of recoveries east of 108°W supports Dzubin's (1965) prediction of increased occurrence east of the traditional migration route.

Alberta

The provincial kill of Ross's Geese in Alberta accounts for approximately 9·0% of the North American harvest. The number and location of recoveries within Alberta indicate a more widespread kill distribution than in Saskatchewan (Figure 1). Banded Ross's Geese have been recovered from much of eastern Alberta; however no recoveries have been obtained north of 54° 40′N. Dzubin (1965) reported a marked reduction in the use by Ross's Geese of the Peace-Athabasca delta (NE Alberta) after 1960. Since 1963 only 8 recoveries (15% of the provincial total) have been obtained north of the major harvest area in central Alberta, and none from the Peace-Athabasca region. It may be that band reporting rates are abnormally depressed in this area but it is more likely that few if any migrating Ross's Geese are shot there.

The greatest harvest occurs in degree block 51°N 111°W where 29% of the provincial recoveries occurred.

Montana

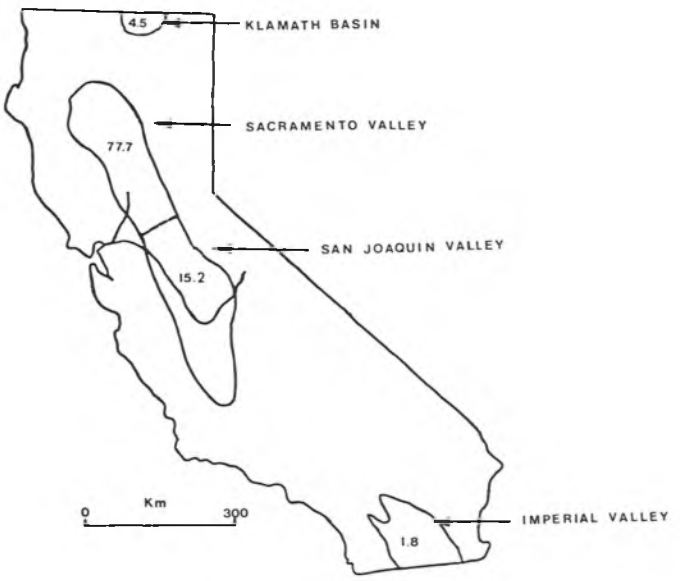
The most important staging area is the Freezeout Lake area near Great Falls (Dzubin 1965), and the 3 Montana recoveries are between the Alberta-Montana border and Great Falls (Figure 1). These few recoveries probably reflect the fact that only a few hundred Ross's Geese stop over during the fall (Bellrose 1976).

California

Fifty-eight percent of direct recoveries were from this state. Assuming equal band reporting rates prevail within all areas, an index of relative harvest can be derived from these (Figure 2). The Sacramento Valley had 78% of the 112 direct recoveries. The adjoining San Joaquin Valley accounted for 15·2%, the Klamath Basin and the Imperial Valley for 4·5% and 1·8% respectively.

McLandress (1979) suggests Ross's Geese wintering in California are comprised of 2 subpopulations; one segment traditionally wintering in the San Joaquin Valley and a larger segment which does not migrate farther south than the Sacramento Valley. It is this larger segment, which apparently remains mixed with Lesser Snow Geese, that has experienced an average annual increase of 7% during the last 13 years (McLandress 1979) despite such a disproportionate distribution of the harvest.

Figure 2. Percentage distribution of direct recoveries of Ross's Geese in California, 1963 to 1977.



Recoveries from other localities

Among the remaining recovery localities, of particular ecological significance is a direct recovery of a female banded as a young bird 7 August 1967 in the Perry River region and shot 42 days later at 55° 50′N 87° 30′W on the south coast of Hudson Bay (Figure 1). This is the first report of a direct recovery east of the central Arctic breeding grounds and indicates there is a movement of birds between these two areas. Lesser Snow Geese from the central Arctic follow a similar migration route (Dzubin 1979). It is probable that Ross's Geese present in fall staging areas on the Hudson Bay coast accompany Lesser Snow Geese from eastern Arctic colonies to sympatric wintering grounds along the Gulf coast of Texas and Louisiana (Prevett & MacInnes 1972).

The presence of two indirect recoveries of central Arctic Ross's Geese on the coast of Hudson Bay and James Bay (Figure 1) may have arisen from interspecific mating of Ross's Geese (Prevett & Johnson 1977) or through the association of Ross's Geese with flocks of Lesser Snow Geese or Canada Geese. Many of the Lesser Snow Geese banded on Baffin Island, N.W.T. and, to a lesser extent, west Hudson Bay and Southampton Island, have been recovered in southern James Bay (Dzubin 1974). We agree with Prevett & Johnson (1977) that Ross's Geese probably currently breed in all Lesser Snow Goose colonies in the Hudson Bay region. However, this may not be as recent an event as suggested by these authors, because the 2 indirect recoveries from the coast of Hudson and James Bay were birds shot in 1971 and 1974, that had survived 6 and 8 hunting seasons respectively.

In May 1976, an adult female Ross's Goose was recovered in degree block 69°N 132°W (near Tuktoyaktuk, N.W.T.). The bird had been banded as a young bird in the Perry River region 10 seasons earlier. Tuktoyaktuk is an important spring migration area for Lesser Snow Geese en route to major breeding colonies on Banks Island, N.W.T. (72° 30′N, 124° 50′W), where Ross's Geese occur and possibly breed (Barry 1964). It is possible that this recovery can be explained by the overlap in winter range in California and Mexico of Lesser Snow Geese from the western Arctic with Ross's Geese from the central Arctic (Dzubin 1965, 1979).

Two direct recoveries are available from the southeast corner of Victoria Island, N.W.T. Both birds, an adult male and female, were neck-banded as adults in the Perry River region on 26 July 1966 and shot 30 June 1967, suggesting they were a mated pair. Approximately 1,500 Lesser Snow Geese were censused in the southeast region of the island in 1960 (Barry 1961). It is probable that a few Ross's Geese nest in association with these.

Six direct recoveries from the Gulf coast of Texas and Louisiana support earlier reports (Prevett & MacInnes 1972) that this is an area of overlap for Ross's Geese from the central and eastern Arctic breeding grounds. All five from the Gulf coast of Texas were banded as young birds during the same drive and recovered together, suggesting they were members of one or more closely associated families.

Five recoveries, including two direct, were reported from two states in Mexico, and were probably associated with Lesser Snow Geese. In 1977, 51,395 of the latter were censused in the interior highlands of Mexico (Voelzer 1978), most of which apparently breed in the Queen Maud Gulf region (Barry 1967).

Temporal distribution of band recoveries

The temporal distribution (Figure 3) largely reflects the spectrum of hunting seasons along the migration route. Only California, Alberta and Saskatchewan are included in this analysis.

In Alberta the peak harvest, representing 30% of the recoveries, occurs between 15–21 September and tapers off through to the latter half of November.

Sixty per cent of the harvest in Saskatchewan occurs between 6–19 October. This peak is followed by a rapid decline to 2 November.

Eighty per cent of the California recoveries, which began in the week of 20–26 October, occurred after 7 December, with the peak in the week 5–11 January.

Canada vs. United States recovery distribution

Based on data obtained from the National Harvest Survey and the Species Composition Survey, the average annual retrieved kill of Ross's Geese in Canada in 1973–1975 was 5,800 birds or 46% of the total Canada–United States kill (Cooch 1978).

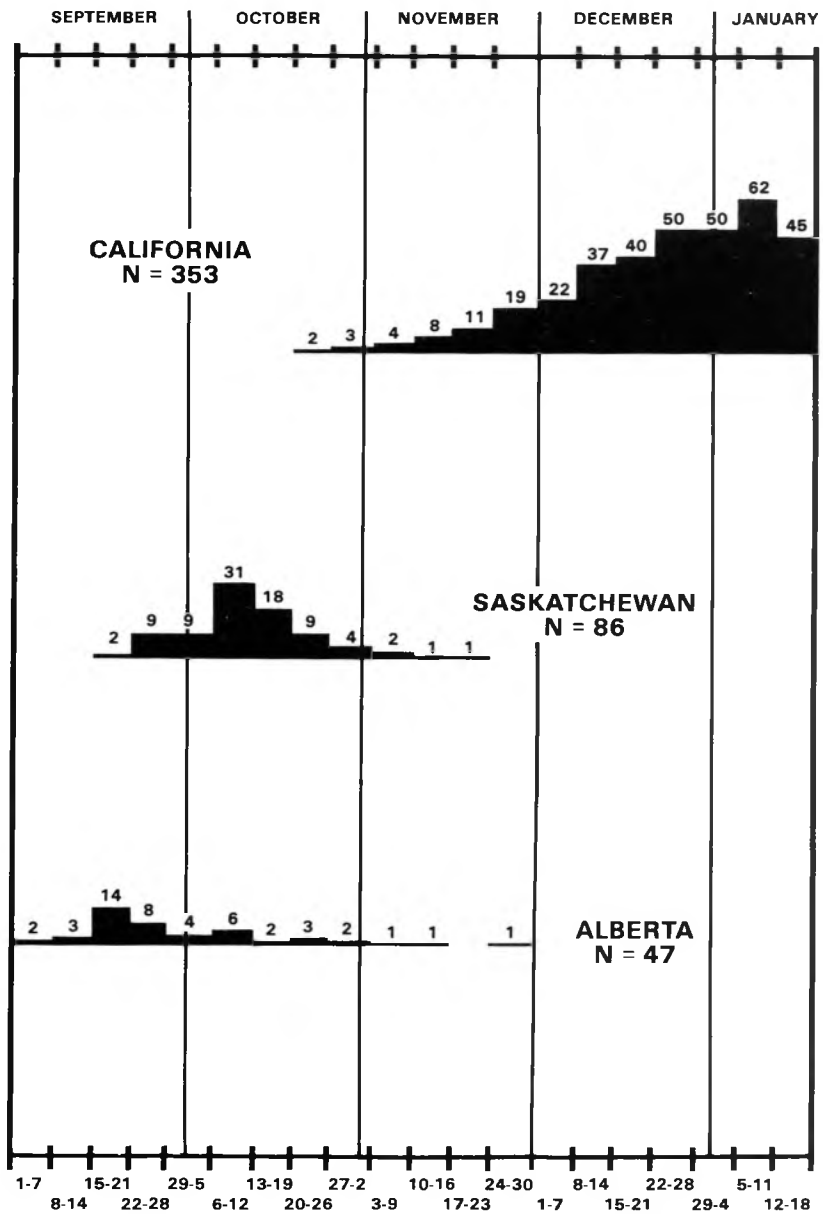


Figure 3. Temporal distribution of Ross's Goose band recoveries (direct and indirect) by 7-day interval 1 September–19 January (all banding years combined).

Only 26% of our recoveries have been obtained within Canada (Table 2). Possible geographical and/or temporal differences in band reporting rate, differences in method of harvest calculation, annual variation in size of the harvest or other factor(s) not presently manifest may account for a portion of this apparent discrepancy. It would therefore appear that the harvest within the United States is greater than is currently reported and may be as much as 75% of the continental harvest.

Band recovery rate

The band recovery rate, that is the prob-

ability that a banded bird alive when a given cohort is banded will be shot and its band reported during the next hunting season (Brownie *et al.* 1978), averaged 0·0318 for adults, with males and females differing by less than 0·010 (Table 3). Birds banded as young had an average recovery rate of 0·0515. Young females experienced the highest recovery rate (0·0540) compared with 0·0489 for young males.

The recovery rate is lower than that reported for Canada Geese (e.g. Raveling 1978) White-fronted Geese (e.g. Timm & Dau 1979) or Lesser Snow Geese (King & Hodges 1979). Comparison should, perhaps, be limited to closely related species banded at approximately the same time and recovered within the Pacific Flyway. Thus Lesser Snow Geese banded in the western Arctic in 1959–1963 and 1966 had a direct recovery rate of 0·064 (calculated from data in Dzubin 1974). A direct recovery rate of 0·077 was reported for Lesser Snow Geese banded in California in 1952–1963 and recovered throughout the western United States and Canada (Reinecker 1965).

Recovery rates thus indicated that the harvest of Ross's Geese was lower than for other species of geese from the Pacific Flyway, although additional evidence would be supportive.

Vulnerability rate

Vulnerability rates (Dzubin 1974) have not previously been reported for Ross's Geese, and were calculated on an age- and sex-specific basis using the direct recovery rates (Table 4).

The average vulnerability rate for 4 years of banding was 0·91 indicating that among birds banded as young and shot during the next hunting season, only a slight sex bias existed towards males. Adult males and females do not exhibit any apparent sex bias. A high proportion of banded females were shot in 1968. In 1965 and 1967 adult males were slightly more common in the harvest.

Young Ross's Geese are, on the average, 1·62 times as vulnerable to hunting as adults, males and females being 1·56 and 1·68 times as vulnerable as their adult counterparts. In 1967 there was a high proportion of young of the year in the harvest. As 1967 was not an abnormally productive breeding season (Korol & Dzubin 1968) and the number of young banded relative to adults was only slightly higher than usual that year (Table 1), it may simply be that young Ross's Geese are more vulnerable to hunting in certain years. The highest vulnerability rate attained indicates that they may be as

Table 3. Band recovery rate (F) of Ross's Geese from the Perry River region during 1965–1968.*

Year banded	Recovery rate (F) Adult male	Adult female	Young male	Young female
1965	0·0252	0·0196	0·0276	0·0267
1966	0·0389	0·0455	0·0513	0·0531
1967	0·0334	0·0260	0·0848	0·0893
1968	0·0275	0·0375	0·0321	0·0467
Mean	0·0313	0·0322	0·0489	0·0540
(95% C.I.)	(0·0219–0·0406)	(0·0226–0·0417)	(0·0354–0·0624)	(0·0396–0·0683)
Mean	0·0318		0·0515	

* Size of banded cohorts shown in Table 1. Birds of unknown sex or age omitted from the analysis.

Table 4. Vulnerability rates of Ross's Geese banded in the Perry River region during 1965–1968.*

Banding year	YM:YF	AM:AF	YM:AM	YF:AF	Y:A	M:F
1965	1·03	1·29	1·10	1·36	1·21	1·14
1966	0·97	0·85	1·32	1·17	1·24	0·91
1967	0·95	1·28	2·54	3·43	2·93	1·02
1968	0·69	0·73	1·17	1·25	1·21	0·71
Average	0·91	0·97	1·56	1·68	1·62	0·93

Y = Young; A = adult; M = male; F = female.

Calculated using band recovery rates from Table 3. Birds of unknown sex or age omitted from the analysis.

much as nearly 3½ times more susceptible to hunting mortality as adults. These vulnerability rates are relatively low compared with those for immature Lesser Snow Geese of 1·70 (recalculated from Dzubin *et al.* 1975), 1·90–2·95 (Dzubin 1974) and 3·7 (Reinecker 1965); for immature Dusky Canada Geese *B.c. occidentalis* of 2·19 (Chapman *et al.* 1969); for White-fronted Geese of 2·3 (Miller *et al.* 1968).

Survival rate

Estimated survival rates (Table 5) were calculated using banding data from 1965–1968 and recovery data through April 1977. The method employed estimates death from all causes during the interval between successive banding dates.

Adult Ross's Geese appear to survive very well with males having a slightly higher survival rate than females. Young males and females had survival rates barely half that of their adult counterparts. Confidence intervals are wide for all age and sex groupings but the sexes show similar variability within their respective age groups.

The mean survival rate of adult Lesser Snow Geese from colonies around Hudson Bay was 75% (Boyd 1976) and 76·30% for the Pacific Flyway (Reinecker 1965). Timm & Dau (1979) reported a 67·9% adult survival rate for White-fronted Geese while Dusky Canada Geese experienced an adult survival rate of 66·3% (Chapman *et al.* 1969). Adult Ross's Geese are subject to a survival rate of 84·21%, higher than these other North American species of goose. This may explain, in part, the recent population increases outlined by McLandress (1979).

The average survival rate (46·9%) exhibited by young Ross's Geese is similar to that reported for Lesser Snow Geese from the eastern Arctic of 41·1% (Boyd 1976), and from the Pacific Flyway of 50·9% (Reinecker 1965). There does not appear to be differential mortality factors operating on either male or female Ross's Geese during the interval between successive bandings. This is not surprising in a monomorphic species.

Fall migration routes

The major autumn migration route used by central Arctic Ross's Geese has been described in Dzubin (1965) and is illustrated in Figure 4. This route may be followed by approximately 90% of the birds. The segment between the breeding grounds and central Alberta-western Saskatchewan cannot be determined from band recovery information. It is assumed to be direct to the Peace-Athabasca delta, then south to eastern Alberta and western Saskatchewan (Bellrose 1976; Palmer 1976). From these prairie staging areas, the majority continue south along the traditional corridor into northwestern Montana. An unknown number fly southeast into North Dakota. Lesser Snow Geese from central Arctic colonies apparently follow a similar route south of Lat. 55°N., (Dzubin 1974) as do White-fronted Geese banded at the Anderson River, N.W.T. and at Kindersley, Saskatchewan (Barry 1967; Miller *et al.* 1968). Ross's Geese frequently accompany White-fronted Geese, Snow Geese and Canada Geese during the fall migration.

The three indirect recoveries from North Dakota are aligned in a northwest–southeast direction across the state (Figure 1), following the pattern of recoveries of central Arctic Lesser Snow Geese in that state (Dzubin 1974). In North Dakota, Ross's Geese have an opportunity to join the large contingent of Lesser Snow Geese and Canada Geese migrating south from the eastern Arctic. Associated with these are relatively small numbers of Ross's Geese from breeding sites in the Hudson Bay area (Prevett & MacInnes 1972).

Both Manitoba recoveries are from

Table 5. Survival rate (%) of Ross's Geese banded in the central Arctic 1965–1968 and recovered to 1977.

	Adult males	Adult females	Young males	Young females
Survival rate (S)	85·96	82·45	47·62	46·18
95% C.I.	73·97–97·96	70·77–94·13	33·56–61·67	32·58–59·79
Standard error	6·12	5·96	7·17	6·94
Mean	84·21		46·90	

areas reporting direct recoveries of Lesser Snow Geese from the McConnell River and La Perouse Bay (Dzubin 1974) and Ross's Geese from the McConnell River (Prevett & MacInnes 1972). The large number of geese converging in North and South Dakota in the fall serves to 'dilute' the relatively few Ross's Geese in the area, resulting in a low recovery rate of banded birds. From South Dakota, Ross's Geese from both the central and eastern Arctic appear to follow a route used by the majority of Lesser Snow Geese from these areas (Prevett & MacInnes 1972; Dzubin 1979). The migration corridor extends south to the coasts of Louisiana and eastern Texas. Prevett & MacInnes (1972) report no recoveries of Ross's Geese in between. There was only one recovery in this area of a Ross's Goose from the central Arctic. In addition a Ross's Goose banded in the Perry River region has been recaptured during the first hunting season after banding in western Nebraska (Ryder, unpubl. data). The lack of recoveries in this segment of the migration route may also be due to the dilution phenomenon.

Six direct and two indirect recoveries have been received from the Gulf coast of Texas and Louisiana. The migration corridor used may extend through Saskatchewan and North Dakota, or from the Perry River region to North Dakota via the Hudson Bay coast.

The migration route selected by most of the Ross's Geese from the central Arctic extends southwest from western Montana into Idaho where there is evidence of a second divergence of the migrant population (Figure 4), with a relatively small number of Ross's Geese separating from the main contingent and travelling south into Utah. They may associate with the population of Lesser Snow Geese using this route (Nagel 1969; Dzubin 1979). From northern Utah, Lesser Snow Geese travel southwest along the Colorado River to the Imperial Valley in California. Nagel (1969) considered that Lesser Snow Geese flew there en masse direct. The absence of recoveries from the intermediate area suggests that Ross's Geese may make a similar flight. Alternatively, the reported light harvest of Lesser Snow Geese in Utah (Nagel 1969) may be the most important factor. Kozlik *et al.* (1959) did not observe any of the Ross's Geese colour-marked in northern California in the Imperial Valley, leading the authors to suggest these birds may migrate east of the Sierra Nevadas.

The migration corridor used by the Ross's Geese wintering in Mexico is unclear, although two recoveries in Arizona suggests that they may come via Utah, from where Lesser Snow Geese have been recovered in Mexico (Nagel 1969). Alternatively, a recovery in northwest Texas and recaptures in southeast New Mexico and northwest Nebraska indicate that the fall migration may be through the Central Flyway, as depicted for Lesser Snow Geese by Bellrose (1976) and Palmer (1976).

Palmer (1976) illustrates a probable minor migration corridor between the Anderson River delta and the Peace-Athabasca area. He also indicates a minor migration corridor between Southampton Island and the west coast of Hudson Bay. A recovery at the south end of James Bay indicates that a minor migration corridor may also exist between Baffin Island and James Bay, although west Hudson Bay Lesser Snow Geese have also been recovered from this area. The west and south coasts of James Bay are followed by fall migrating Lesser Snow Geese from Baffin Island (Cooch 1958), and Ross's Geese may accompany these Snow Geese during migration.

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Summary

Analysis of band recoveries indicates that approximately 90% of the harvest of central Arctic Ross's Geese *Anser rossii* occurs in Alberta, Saskatchewan and California with the latter state accounting for approximately 58% of the North American kill.

Most of the population follow the traditional migration route to the Central Valley of California. Small numbers winter in Mexico and the Gulf coast area of Texas and Louisiana. Movement directly from the central Arctic to areas around Hudson Bay, as well as association on sympatric wintering grounds explains the expansion of Ross's Geese into the eastern Arctic. Survival rates of adult male and female and young male and female are approximately 86%, 82%, 48% and 46%, respectively. Immatures are 1·62 times more vulnerable to hunting mortality than adults.

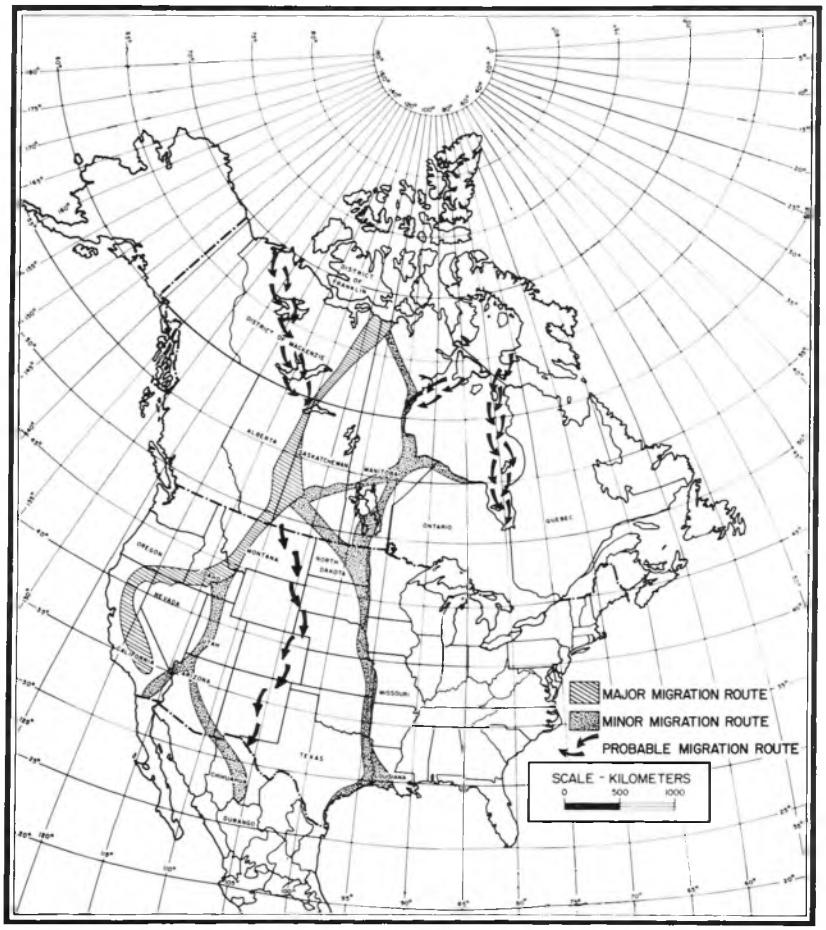

Figure 4. Fall migration routes of Ross's Geese in North America. Data from several sources.

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