

Survival and Recovery Rates of Canada Geese from Maryland and North Carolina 1963–1974

Robert E. Trost,¹ *New York Cooperative Fish and Wildlife Research Unit, Fernow Hall, Cornell University, Ithaca, NY 14853*

Richard A. Malecki, *New York Cooperative Fish and Wildlife Research Unit, Fernow Hall, Cornell University, Ithaca, NY 14853*

Larry J. Hindman, *Department of Natural Resources, Maryland Forest, Park & Wildlife Service, P.O. Box 68, Wye Mills, MD 21679*

Dennis C. Luszcz, *North Carolina Wildlife Resources Commission, Route 4, Box 404-A, Edenton, NC 27932*

Abstract: State and federal personnel banded 4,960 Canada geese (*Branta canadensis*) in North Carolina and 11,522 in Maryland from 1963–1974. Adult survival for Maryland geese was estimated as 81.96% (SE = 0.88%) and for North Carolina geese as 79.23% (SE = 0.96%) indicating that geese banded in Maryland had a higher average annual survival rate ($P < 0.01$). Recovery rates also indicated Canada geese from North Carolina (3.01%, SE = 0.16%) may have had higher rates of harvest compared to Maryland (2.39%, SE = 0.10%) ($P < 0.001$). Model simulations indicated that estimated differences in survival were probably not of sufficient magnitude to have caused the observed population shift.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 40:454–464

The distribution of Canada geese has changed in the Atlantic Flyway during the last several decades (Crider 1967, Hankla and Rudolf 1967, Trost and Malecki 1985). The most pronounced change occurred between the numbers of geese wintering in North Carolina and Maryland (Trost and Malecki 1985). Two mechanisms have been suggested to explain this change in distribution. Trost et al. (1980) defined these 2 hypotheses as “short-stopping” and “differential survival” based on previous concepts of Hankla and Rudolf (1967), Crissey (1968), and Raveling

¹Present address: U.S. Fish and Wildlife Service, Office of Migratory Bird Management, Laurel, MD 20708.

(1978). Our objective is to present annual survival and recovery rates for Canada geese from Maryland and North Carolina for the period 1963–74, and to relate these estimates to changes in winter distribution which occurred during this time. Maryland and North Carolina accounted for approximately 75% of the observed mid-winter Canada goose counts throughout this period. We limited our analysis to these 2 states because the largest shift in numbers occurred in these 2 states and because each had representative banded samples for the entire period.

We are indebted to state and federal managers and biologists who banded geese during these years and to hunters who reported recoveries of leg-banded geese. We also extend appreciation to colleagues who offered reviews of various drafts.

Methods

Canada geese were captured with rocket and cannon nets (Dill and Thornsberry 1950) over corn bait in Maryland and North Carolina from 1963–74. We assumed that geese banded in these states during these years were representative samples of the geese present. Computer programs and models of survival and recovery rates developed by Brownie et al. (1978) were used to estimate survival and recovery rates. Only geese banded post-season (i.e., 21 January to 10 March) were used. We also restricted recoveries of banded geese to individuals reported as either shot or found dead during the months October through March 1963–1983.

We developed a model of Canada goose population dynamics to aid in interpreting survival rates. Our model was based on the matrix approach (Leslie 1945, 1948) and allowed for age specific survival and recruitment rates. Survival rates were obtained from analysis of band recovery data and recruitment rates were obtained from previous studies of Canada geese.

Results and Discussion

A total of 4,960 Canada geese were banded in North Carolina 1963–1974 and 11,522 were banded in Maryland (Table 1). Tests of differences in recovery matrices between geese banded as yearlings and adults indicated no difference ($P > 0.10$ for all comparisons, Brownie et al. 1978:147) for either males or females in each area. Therefore, we combined recoveries for yearling and adult geese in subsequent analyses. Also, we tested recovery matrices for differences by sex and again could not reject the hypothesis of no difference ($P > 0.10$ in both cases, Brownie et al. 1978). Thus for each area we analyzed 1 banding and recovery matrix which combined all sex and age classes captured in each state during these years. A total of 682 recoveries from North Carolina and 1,446 from Maryland were suitable for analysis (Table 1).

The model selection procedures indicated that for Canada geese banded in North Carolina Model 3 was appropriate ($P > 0.40$ Model 3 vs Model 2) and for Maryland, Model 2 ($P > 0.30$ Model 2 vs Model 1). Goodness of fit tests indicated

Table 1. Numbers of Canada geese banded 1963 – 1974 in Maryland and North Carolina and reported as shot or found dead during the hunting seasons 1963–1982.

State	Year	Number banded	Year of recovery																					
			1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982		
MD	1963	748	15																					
MD	1964	801	20	12	10	13	5	3	7	3	6	3	5	4	2	2	0	0	2	0	0	0	0	
MD	1965	893		20	11	12	13	4	2	4	6	4	4	4	2	1	1	0	1	0	1	1	1	
MD	1966	254			17	21	12	7	13	10	7	5	3	2	2	2	1	2	0	0	0	0	1	
MD	1967	551				2	3	6	5	2	2	0	2	2	1	0	1	0	1	0	0	0	0	
MD	1968	303				8	12	6	5	6	5	6	12	5	3	4	2	1	0	0	0	1	0	
MD	1969	463					10	9	5	3	3	4	4	4	3	3	2	0	0	2	0	0	0	
MD	1970	1,201						10	12	4	6	8	4	4	4	6	3	2	0	2	1	0	0	
MD	1971	1,428						32	33	23	18	20	14	9	9	9	6	2	6	3	0	0	0	
MD	1972	835						28	26	16	21	11	7	15	12	7	7	3	4	7	3	4	4	
MD	1973	1,705						18	18	18	30	10	11	9	4	3	5	6	0	3	5	6	0	
MD	1974	2,340						39	50	28	50	28	26	20	20	9	12	5	3	12	5	3	3	
											72	43	33	38	33	18	25	13	8					
NC	1963	78	3	3	1	1	0	4	0	2	1	1	0	0	1	0	0	0	0	0	0	0	0	
NC	1964	245			4	3	5	2	3	2	2	1	0	0	2	0	0	0	0	0	0	0	0	
NC	1965	236			9	5	1	5	2	2	1	2	1	1	1	0	0	0	0	0	0	0	0	
NC	1966	86				3	1	1	0	1	1	0	1	1	1	0	0	0	0	0	0	0	0	
NC	1967	533					10	12	11	11	7	1	6	3	1	1	0	1	0	0	0	0	1	
NC	1968	562						12	13	12	13	8	8	5	2	2	1	0	2	0	1	0	0	
NC	1969	96						4	4	2	0	2	1	1	2	0	1	1	0	0	0	0	0	
NC	1970	1,555						43	40	18	25	21	11	15	12	10	7	8	2	4	4	4	4	
NC	1971	785						24	24	12	12	12	10	6	3	6	3	0	1	4	1	4	4	
NC	1972	127						6	6	2	2	2	1	1	1	1	1	0	0	1	0	1	0	
NC	1973	140						8	8	6	4	1	0	2	1	0	2	1	1	0	0	0	0	
NC	1974	517						21	18	21	18	10	11	10	11	10	2	0	7	4	7	4	4	

that observed data fit their indicated models ($P > 0.25$: for both comparisons). Model 2 assumes a constant survival rate and a time specific recovery rate and Model 3 is a simplification of Model 2 which assumes a constant survival and recovery rate (Brownie et al. 1978).

Mean annual survival rate for Canada geese banded in Maryland from 1963–74 was estimated as 81.96% (SE = 0.88) and North Carolina as 79.23% (SE = 0.96). The small annual difference of 2.73% was significant ($P < 0.01$, Brownie et al. 1978: 180–182) indicating that during the period of the largest shift in Canada goose populations in the Atlantic Flyway, geese from North Carolina survived less well than geese from Maryland. Estimated mean annual recovery rate for geese from Maryland was 2.39% (SE = 0.10) and North Carolina 3.01% (SE = 0.16) indicating that geese from North Carolina had, on average, a higher recovery rate ($P < 0.001$). Recovery rates are the product of harvest and reporting rates (Brownie et al. 1978). However, data derived from birds banded post-season also have a survival component incorporated into subsequent recovery rates. Therefore, the additional assumption of no difference in survival during the period prior to the onset of the hunting season between the 2 groups of geese must be made as well. Based on these assumptions it would seem that during the period of greatest population shift the harvest rate of North Carolina geese was greater than that of Maryland geese. We conclude that during 1963–1974 Canada geese from North Carolina suffered higher average annual mortality and also had a higher rate of recovery (perhaps indicating higher harvest) than geese from Maryland.

Although differences indicated above were significant, the magnitudes of the differences were not great. Although it seems that North Carolina geese survived less well than Maryland geese their mean rate of survival was not particularly low (i.e., 79.23%). However, the above survival and recovery rates pertain only to geese which have survived at least 1 hunting season. Therefore, we are unable to gain any inference about first year survival rates of Canada geese from this analysis. To investigate whether the small difference in annual survival might be responsible for the observed shift in numbers of geese wintering in Maryland and North Carolina, we developed a simple model of Canada goose population dynamics.

Model Development

The number of animals in any given population is a function of survival, recruitment, immigration, and emigration. We assumed that immigration and emigration were negligible in Canada goose populations because of the high degree of philopatry exhibited by Canada geese (Trost and Malecki 1985). However, this does not mean that movement within the range of a given population (i.e. Atlantic Flyway Canada geese) may not contribute to changing distributions. There has not been a breeding study of Atlantic Flyway Canada geese. Therefore, we employed values reported by other researchers for Canada geese in North America to estimate recruitment rate.

Recruitment

We defined recruitment as the number of young per adult in the fall population and allowed recruitment to be age specific. We assumed that the breeding population was composed of 3 age classes at the time of nesting. We defined these 3 age classes as (1) adults (≥ 3 years old); (2) 2-year-olds; and (3) yearlings (1 year old). Annual recruitment for geese ≥ 3 years old was estimated as 0.706 per adult based on the following assumptions: (1) 4.0 mean clutch size (Didiuk and Rusch 1979), (2) 70% mean nest success, (3) 90% hatchability, (4) 70% fledgling survival (to flight stage) (Malecki 1976), 80% of adults nested, and the breeding sex ratio was 50:50 (Bellrose 1976:160–163). Annual recruitment for geese ≥ 3 years old was estimated as the product of the above estimates (Table 2). Some 2-year-old geese also nest and we assumed that 10% would nest and that their mean clutch size was 3.75. Thus mean recruitment rate for 2-year-old geese was estimated as 0.083 young per 2-year-old (Table 2). We assumed no nesting would be attempted by yearling Canada geese (Bellrose 1976:143). Raveling and Lumsden (1977:62–63) provided figures which indicate that the post-season age structure of the Mississippi Valley Population was about 55% adults, 20% 2-year-olds, and 25% immatures during the 3 years of their study. We employed this estimate of age structure as the beginning age structure in our model.

Survival

We were unable to show that annual differences in survival were present in either Maryland or North Carolina ($P > 0.10$: composite test of Model 2 versus

Table 2. Equations used to estimate mean annual recruitment rates and numbers of Canada geese present in Maryland and North Carolina 1964–1974.

Recruitment(age) = $(N) (\%F) (ACS) (ANS) (\%E) (FS) (\%N)$ where:

- N = Number of geese in age class
- $\%F$ = Percent of No. female (i.e., 0.5)
- ACS = Average clutch size
- ANS = Average nest success
- $\%EH$ = Percent eggs which hatch in successful nests
- FS = Fledgling survival
- $\%N$ = Percent of available females that nest

Thus:

Recruitment (≥ 3 years) = $(N) (0.5) (4.0) (0.7) (0.9) (0.7) (0.8)$
 = $(N) (0.706)$

Recruitment (2 years) = $(N) (0.5) (3.75) (0.7) (0.9) (0.7) (0.1)$
 = $(N) (0.083)$

Total recruitment = Recruitment (≥ 3) + Recruitment (2)

N above is determined as follows:

Annual mortality rate (AMR) = $1 - \text{annual survival rate}$

N = (Number of geese alive in each age class at mid-winter) $(1 - (0.1 * \text{AMR}))$

The number of geese in each age class during the mid-winter count was estimated as follows:

- Nage (1) = Total recruitment * Immature survival rate
- Nage (2) = Nage(1) * Adult survival rate
- Nage (3) = [Nage(2) + Nage(3)] * Adult survival rate

Total mid-winter population = Nage(1) + Nage(2) + Nage(3)

Model 1). However, the number of geese banded in several years was small (Table 1) and our ability to detect differences was not great. Therefore, we performed simulations with constant survival rates derived from the appropriate model chosen by model selection procedures (Brownie et al. 1978) and annual estimates of survival derived under Model 1 which assumed annual variation in survival and recovery rates (Brownie et al. 1978). Goodness of fit tests indicated that observed data from both areas fit Model 1 ($P > 0.15$ for both comparisons). We had no information on immature survival rates from our analysis because all banding was post-season. Therefore, we assumed that immature survival rates were 20% less than adult survival based on the average difference reported by Stotts (1983:87) for Canada geese banded pre-season in Canada. Finally, we have no information, at present, as to how mortality is distributed throughout the year. We assumed approximately 10% of the annual mortality would occur prior to the onset of breeding and 90% would occur between the end of nesting and the next year's banding period (Table 2).

Model Results

Constant Survival and Recruitment

The model predicted a mean annual rate of increase (\bar{r} , Caughley 1977:109) for Maryland Canada geese of 7.5% (Fig. 1). This was equal to the growth rate observed (7.5%) during the same years as estimated by mid-winter counts (Fig. 1). Thus it would seem that the numeric increase in the Maryland goose population

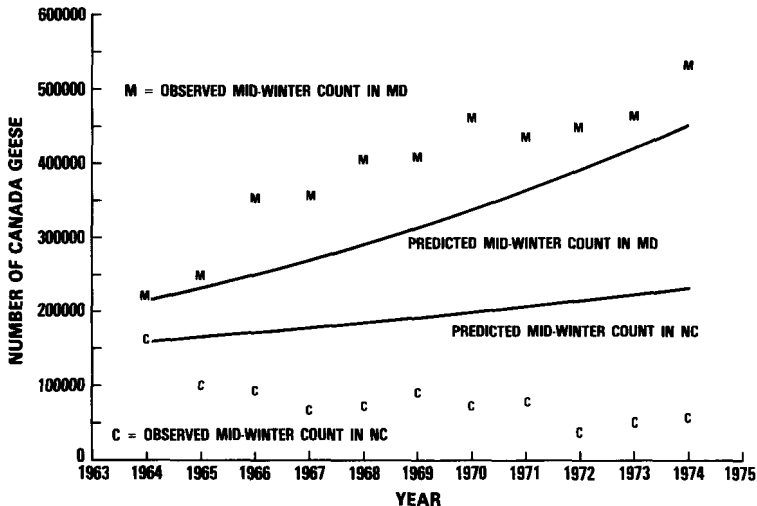


Figure 1. Numbers of Canada geese observed and predicted in Maryland and North Carolina, 1964–1974. Predicted numbers were derived from our model of population growth employing constant estimates of survival and recruitment (see text).

might be explained to a large degree by the estimated mean annual adult survival and other model assumptions. North Carolina predictions based on constant survival rate derived from analysis of band recovery data and other model assumptions indicated that geese in North Carolina should have increased at a mean annual rate of 3.8% (Fig. 1). However, geese in North Carolina actually declined at a mean annual rate of -9.6% (Fig. 1). Thus it would not seem that the observed decline in Canada geese could be credited to lower mean annual survival given the other model assumptions.

Time Specific Survival and Constant Recruitment

Although we cannot document annual differences in survival for Canada geese banded in Maryland and North Carolina, we feel it reasonable that such variation did exist. Therefore, we simulated growth rates of geese in Maryland and North Carolina based on annual estimates of adult survival derived under assumptions of Model 1 (Brownie et al. 1978) (Table 3). In cases where the annual survival estimate exceeded 100% we employed 100% as the annual survival estimate, even though 100% annual survival is biologically improbable. Model simulations indicated that Maryland geese should have increased at an annual rate of 4.8% during 1964-1974 (Table 4). North Carolina geese should have decreased somewhat as the estimate of the rate of annual increase was -1.4% (Table 3). Thus, using annual survival estimates and a constant recruitment rate, the model underestimated the growth rate of Maryland geese and overestimated the growth rate of North Carolina geese. However, if the total number of geese predicted by the model are summed and compared to the total number of geese in these 2 states in the mid-winter count, numbers are similar (Table 4).

Time Specific Survival and Recruitment

Annual variation in recruitment rates also occur in Canada geese (Owen 1980). We lack information on recruitment rates for geese in the Atlantic Flyway. We have previously assumed that the immature to adult (I:A) ratio in the harvest can be used as an index to the annual recruitment rate for Canada geese (Trost and Malecki 1985). To obtain annual recruitment estimates we adjusted mean recruitment rates presented above by a percentage determined by dividing the annual I:A ratio by the average I:A ratio within each state (Table 3). Annual recruitment estimates were then used in conjunction with annual survival estimates to simulate expected numeric changes of geese for the 2 states. The simulation indicated that Maryland geese should have increased at an annual rate of 4.1% while those in North Carolina should have declined at an annual rate of -2.6%. Results of this simulation were similar to those reported for the time specific survival and constant recruitment model (Table 4). When the 2 state projections were summed and compared to the total number of geese observed in these 2 states the results were similar (Table 4).

Table 3. Estimates of annual survival and recruitment for Canada geese from Maryland and North Carolina 1963 – 1973. Survival rates are the annual estimates of survival derived from Model 1 (Brownie et al. 1978). Recruitment rates were estimated by weighting the average recruitment rates presented in the text by the ratio of the observed immature to adult ratio (1:A) to the average I:A.

Year	Maryland				North Carolina			
	Survival (SE)	Immature to adult ratio	Recruitment rate ≥ 3 -years	Recruitment rate 2-year	Survival (SE)	Immature to adult ratio	Recruitment rate ≥ 3 -years	Recruitment rate 2-year
1963	85.11 (12.28)	1.74	0.814*	0.096	>100.00 (47.72)	1.21	0.954	0.112
1964	76.60 (10.34)	1.33	0.622	0.073	71.92 (18.51)	0.77	0.607	0.071
1965	98.00 (19.97)	1.17	0.547	0.064	86.77 (31.62)	0.86	0.678	0.080
1966	69.25 (15.05)	1.72	0.804	0.095	58.06 (19.68)	0.88	0.694	0.082
1967	63.63 (11.27)	1.76	0.823	0.097	86.59 (13.26)	1.49	1.175	0.138
1968	94.99 (17.08)	1.36	0.636	0.075	73.31 (19.83)	1.35	1.065	0.125
1969	76.48 (10.69)	1.06	0.496	0.058	83.53 (21.55)	0.32	0.252	0.030
1970	>100.00 (11.31)	1.74	0.814	0.096	91.05 (10.87)	0.72	0.568	0.067
1971	63.97 (7.50)	1.55	0.725	0.085	70.63 (18.58)	0.46	0.363	0.043
1972	87.35 (9.65)	0.60	0.281	0.033	55.61 (17.23)	0.34	0.268	0.032
1973	81.89 (7.16)	2.58	1.206	0.142	77.68 (16.96)	1.45	1.144	0.134

*Calculation of recruitment rate: $(1.74/1.51) \times 0.706 = 0.814$.

Table 4. Numbers of Canada geese observed and predicted to be present in Maryland and North Carolina 1964–1974. Predictions were made employing 3 models of population growth: Model 1 (time specific survival and recruitment rates), Model 2 (time specific survival and constant recruitment), and Model 3 (constant survival and recruitment).

Year	Maryland			North Carolina				
	N geese observed	N geese predicted Model 1	N geese predicted Model 2	N geese predicted Model 3	N geese observed	N geese predicted Model 1	N geese predicted Model 2	N geese predicted Model 3
1964	221,900	226,202	218,384	209,566	162,200	214,876	197,873	153,516
1965	242,000	218,106	218,175	225,705	99,500	190,212	183,810	159,423
1966	352,700	270,567	286,779	243,720	91,500	215,545	211,397	166,068
1967	356,900	254,531	255,820	262,455	65,900	160,004	155,616	172,478
1968	403,000	214,779	208,490	282,665	71,100	215,178	179,341	179,150
1969	408,800	262,986	266,867	304,592	92,500	219,586	171,633	186,187
1970	462,000	244,821	266,293	328,170	71,000	200,466	188,638	193,472
1971	437,300	349,894	355,335	353,548	76,900	237,662	228,310	201,025
1972	445,000	287,208	290,571	380,906	36,400	197,980	208,225	208,883
1973	463,300	281,616	336,932	410,383	49,500	122,278	146,067	217,050
1974	532,500	378,680	363,886	442,137	55,700	156,472	150,389	225,534

Management Implications

The conclusions based on the model are only as good as the model itself. The model illustrates the need for information concerning immature survival rates and estimates of annual recruitment rate. In 1985 the Canada goose was the number 1 waterfowl species in the Atlantic Flyway harvest. The paucity of information concerning the basic population parameters of this species is of concern. However, despite the lack of specific information, the preceding simulations were useful in interpreting observed differences in estimated survival rates for Canada geese banded in Maryland and North Carolina. In all simulations the predicted number of geese in Maryland was less than the observed number and no simulation predicted the decline in North Carolina. We infer that observed differences in adult survival were not the sole cause of the observed decline of geese in North Carolina. The fact that the total number of geese predicted for both states combined was close to the number observed suggested that movement of geese from North Carolina to Maryland may have been partly responsible. Movement has been suggested (Crider 1967) as the principle cause of changing goose distributions in reference to the Florida flock based on band recovery information. Based on the analysis and simulations, we suggest that neither "short-stopping" nor "differential survival" alone are responsible for changes in Canada geese in the Atlantic Flyway. Rather, both factors have probably led to the current distribution. Changes are likely to continue in the absence of changes in harvest strategy of Atlantic Flyway Canada geese.

Simulation results also appear to have more general inferences. First simulations indicated that the addition of annual variation to survival and recruitment parameters reduced the potential growth rate in every instance. This was predicted by Goodman (1984:19) on a theoretical basis. Since annual variation is the most likely biological condition, managers must note that observed growth will undoubtedly be less than predicted by mean survival and recruitment estimates. Also Canada goose populations would appear to be more sensitive to changes in survival than recruitment changes. For example, based on the model, an increase of approximately 5% (i.e., 0.80 to 0.84) in the annual survival rate has the same approximate effect on the population growth rate as a 50% (i.e., 0.706 to 1.059) increase in recruitment. This is consistent with Grier (1980:316) for bald eagles (*Haliaeetus leucocephalus*) who stated: "The outcomes of these simulations suggested that differences in survival rates may be relatively more important to the status of eagle populations than similar differences in reproduction." This is fortunate because managers can affect annual survival rates via harvest regulations whereas factors influencing recruitment rates are difficult to control. Therefore southern goose flocks may be increased by affording them protection from harvest. However, this management course will succeed only if it is possible for annual growth rate to exceed the annual rate of abandonment of the traditional migratory patterns.

Literature Cited

- Bellrose, F. C. 1976. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, Pa. 534pp.
- Brownie, C., D. R. Anderson, K. P. Burnham, and D. S. Robson. 1978. Statistical inference from band recovery data—A handbook. U.S. Fish and Wildl. Serv. Res. Publ. 131. 212pp.
- Caughley, G. 1977. Analysis of vertebrate populations. John Wiley and Sons, New York. 232pp.
- Crider, E. D. 1967. Canada goose interceptions in the southeastern United States, with special reference to the Florida flock. Proc. Annu. Conf. Southeastern Assoc. Game and Fish Comm. 21:145–155.
- Crissey, W. F. 1968. Informational needs for Canada goose management programs. Pages 141–147 in R. L. Hine and C. Schoenfeld, eds. Canada goose management. Dembar Educ. Res. Services, Madison, Wis.
- Didiuk, A. B. and D. H. Rusch. 1979. Ecology of broods of Canada geese in northern Manitoba. Final Rep., U.S. Fish and Wildl. Serv. Contract 14–16–0008–2102. 216pp.
- Dill, H. H. and W. H. Thornsberry. 1950. A cannon-projected net trap for capturing waterfowl. J. Wildl. Manage. 14:132–137.
- Grier, J. W. 1980. Modeling approaches to bald eagle population dynamics. Wildl. Soc. Bul. 8:316–322.
- Goodman, D. 1984. Risk spreading as an adaptive strategy in iterparous life histories. Theor. Popul. Biol. 25:1–20.
- Hankla, D. J. and R. R. Rudolf. 1967. Changes in the migration and wintering habits of Canada geese in the lower portion of the Atlantic and Mississippi Flyways—with special reference to the National Wildlife Refuges. Proc. Southeast. Assoc. Game and Fish Comm. 21:133–144.
- Leslie, P. H. 1945. On the use of matrices in certain population mathematics. Biometrika. 33:183–212.
- . 1948. Some further notes on the use of matrices in population mathematics. Biometrika. 35:213–245.
- Malecki, R. A. 1976. The breeding biology of the eastern prairie population of Canada geese. Ph.D. Thesis. Univ. Mo., Columbia. 160pp.
- Owen, M. 1980. Wild geese of the world. B. T. Batsford Ltd., London. 236pp.
- Raveling, D. G. 1978. Dynamics of distribution of Canada geese in winter. Trans. N. Am. Wildl. and Nat. Resour. Conf. 43:206–225.
- and H. G. Lumsden. 1977. Nesting ecology of Canada geese in the Hudson Bay lowlands of Ontario: Evolution and population regulation. Fish and Wildl. Res. Rep. 98. Ontario Ministry Nat. Resour. 77pp.
- Stotts, V. D. 1983. Canada goose management plan for the Atlantic Flyway; 1983–1995: Part II—History and current status. Atl. Waterfowl Council. 189pp. (Mimeo.)
- Trost, R. E., D. H. Rusch, and D. H. Orr. 1980. Population affiliation of Canada geese from six southern refuges. Proc. Annu. Conf. Southeast. Game and Fish Comm. 35:598–606.
- and R. A. Malecki. 1985. Population trends in Atlantic flyway Canada geese: Implications for management. Wildl. Soc. Bul. 13:502–508.