Dispersal Patterns of Giant Canada Geese in the Central United States

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Abstract: Populations of giant Canada geese (*Branta canadensis maxima*) have been established in most of the lower 48 United States. However, establishment and spread of these populations has led to an increasing number of human-goose conflicts. Knowing the pattern of dispersal of these populations may be useful to wildlife managers interested in minimizing nuisance problems. Consequently, we analyzed band recovery data from six Bird Conservation Regions (BCRs) of four midwestern states to determine if there was a common pattern of dispersal among these populations. We used negative binomial regression to test a series of models that included age at recovery, gender, number of years after initial population established, recovery year, and banding location (BCR) to explain dispersal distance. Mean dispersal distances were <100 km for all BCRs. We did not detect a consistent pattern of dispersal followed by giant Canada geese from different BCRs. However, dispersal distances decreased for birds recovered many years (>~12) after banding. The Central Mixed-grass Prairie (CMP) had considerably shorter dispersal distances than the Central Hardwoods (CH) BCR. The interaction of Recovery Year and Region (RYR*Region) model indicated reductions in dispersal distance during RYR 2 in the Eastern Tallgrass Prairie (ETP), RYR 7 in the ETP, and RYR 16 in the Mississippi Alluvial Valley (MAV). Otherwise, factors affecting dispersal distances varied little among BCRs and most geese were recovered at or near banding locations. Based on our results, giant Canada goose populations in one region or state are not dispersing to nearby regions or states.

Key words: band recovery, Bird Conservation Regions, *Branta canadensis maxima*, dispersal, giant Canada geese, human-wildlife conflict, regression,

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Attention has been given to establishment of resident populations of Canada geese all over North America for decades (Nelson 1963). Experimental transplants demonstrated giant Canada geese were best suited for establishing resident populations because they lacked the strong instinct to migrate to southerly wintering areas (Nelson and Oetting 1998). Although initially released on rural marshes and lakes,

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giant Canada geese quickly expanded to food-rich suburban areas where few predators occurred (Conover and Chasko 1988). Transplanted Canada geese were initially welcomed by the public, but nuisance problems have grown and management strategies have been ineffective in controlling them (Ankney 1996).

Determining dispersal patterns would allow wildlife managers to predict rate of spread of populations to other areas and allow them to apply proactive measures for controlling goose populations. Thus, we were interested in determining if and how far giant Canada geese disperse from their newly-established locations and what factors are related to that dispersal. We define dispersal as the permanent movement from the original banding location to the recovery location (sensu Greenwood and Harvey 1982). For both juvenile and adult banded geese, we assumed that these dispersal movements were to new breeding sites.

Our research focused on two questions: (1) do giant Canada geese make philopatric movements back to locations where original reintroduction stocks were transported from, such as the Great Lakes Region or north central Colorado, and (2) do giant Canada geese released from the same locations follow similar patterns of dispersal over time? We hypothesized, based on Converse (1985), that giant Canada geese would not make philopatric movements to areas of original capture but that dispersal patterns would be similar among geese from different regions.

Methods

Banding Data

We analyzed 1986–2000 band-recovery data of giant Canada geese from six Bird Conservation Regions (BCRs; Commission for Ecological Cooperation 1997) covering four states in the central United States. These data sets began either in 1985 or 1986 and continued through 2000. We obtained banding data from the Bird Banding Laboratory (BBL) in Laurel, Maryland. We selected band recovery records of known age (banded at hatching year) Canada geese with Status Code 3 (free flying wild bird with federal leg band and/or neck collar) from Kentucky, Missouri, Oklahoma, and Tennessee. We selected these states because they were located relatively close to one other, because of the large number of giant Canada goose band recoveries from these states, and because these states began goose introduction programs about the same time. We eliminated recovery observations made by any means other than hunting, being found dead, or live resighting. Because giant Canada geese were banded during summer when migratory geese were in northerly breeding areas, we selected banding data from May through September to ensure that only giant Canada goose banding observations were analyzed. We removed recovery observations from the months of April–October to ensure that recoveries made during molt migration were not analyzed as dispersals. We further sorted data and removed records with any “unknown” characteristics (age, sex, banding date, recovery date). We assumed all band recoveries came from geese that had dispersed and established a new home range. Also, band recovery data are the best available to address our question.

Resighting and recapture data were sorted and only the last resighting of each

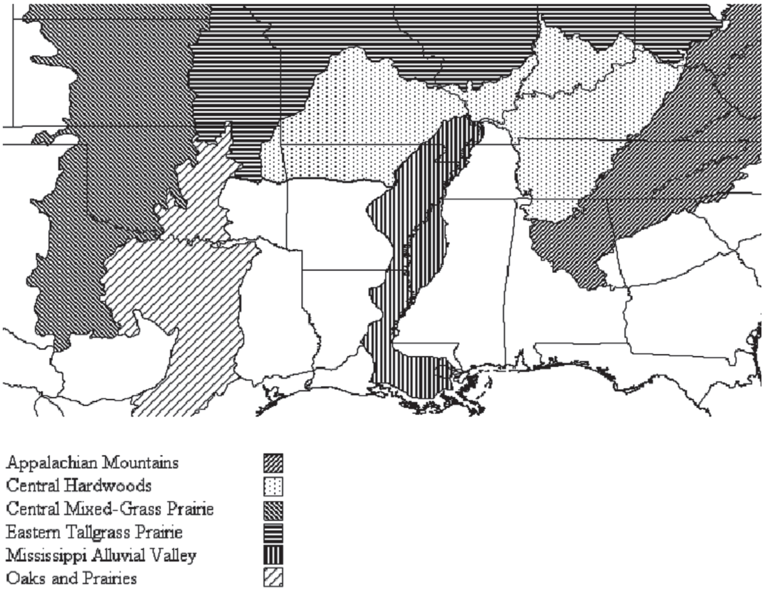

Figure 1. Six Bird Conservation Regions in the Central United States whose giant Canada goose band recovery data were used for dispersal analyses.

goose was kept. We recognize that using recoveries from the late fall–winter could have introduced some bias into our analyses if these residential giant Canada geese moved substantial distances from breeding grounds to their winter grounds. In examining distances between banding site and recovery location, we found that most geese were recovered in the same 10 minute block (see below). We used ArcView 3.2 (ESRI 1999) to separate banding locations into the six BCRs of interest. These BCRs consisted of: (1) the Appalachian Mountains (AM) of Tennessee and Kentucky, dominated by oak (Quercus spp.)-hickory (Carya spp.) and other deciduous forests, (2) the Central Mixed-Grass Prairie (CMP) of Oklahoma, characterized by extensive agriculture and high quality grasslands, (3) the Central Hardwoods (CH) of Missouri, Kentucky, and Tennessee, the most extensive oak-hickory forest in middle America, (4) the Eastern Tallgrass Prairie (ETP) of Oklahoma and Missouri, a predominantly agricultural area, (5) the Mississippi Alluvial Valley (MAV) of Missouri, consisting of vast agricultural areas and large hardwood floodplains, and (6) the Oaks and Prairies (OP) of Oklahoma, a complex of prairie, savanna, and shrub land (Commission for Ecological Cooperation 1997, Fig. 1). We chose to analyze these BCRs because goose reintroduction projects were started about the same time (1970–1980), goose populations have been steadily increasing, and banding operations were conducted annually.

We created an ArcView script (ESRI 1999) to measure the distance and angle between banding and recovery locations by first projecting an Azmuthal map centered on the individual banding location of each goose. Distance and angle to recovery location were then measured from the banding location point. The Azmuthal projection was chosen because it most accurately estimated distances and angular data from its center point (J. Wilson, Center for Advanced Spatial Technology, University of Arkansas, personal commununication). We refer to distance from banding location to recovery location as dispersal distance and the angle between banding location and recovery location as dispersal angle.

When we examined distribution of dispersal distances, we realized that a negative binomial distribution model was appropriate because most geese did not disperse. Negative binomial regression is well suited for analyzing data sets with large numbers of 0's and allows variance to exceed the mean.

Model Development and Evaluation

We formulated a global model and seven candidate models with predictor variables to explain dispersal distance. Candidate models were generated a priori using explanatory variables deemed to be biologically important in previous studies on geese (Lessells 1985, Hestbeck et. al. 1991). These variables included: gender, age at recovery, number of years after initial plant a goose was banded, recovery year, and BCR where banded. Variables were assessed for collinearity by creating distribution histograms. If two variables were highly correlated (>70%), we deleted the variable we determined more difficult to measure (Johnson et al. 2000).

Our global model was dispersal distance = RYR (Recovery Year) + BPP (Number of Years Banded Post-Initial Plant) + REGION + GENDER + AGE + GENDER *AGE + BPP*REGION + RYR*REGION. Definitions of explanatory variables are listed below.

Recovery Year.—We included year of recovery (RYR) to account for possible year effects (e.g., drought or flood). We assigned year of first band recovery a value of one and sequentially numbered each following year. All parameter estimates were made by comparing the RYR of interest to, arbitrarily, RYR 32.

Number of Years Banded Post-initial Plant.—We included number of years post-initial plant (BPP) because if local abundance increased as number of years after an initial plant of geese increased, we hypothesized geese occupying a BCR with preferred habitat would disperse at a slower rate than geese occupying a BCR with less preferred habitat. The first year of release for a BCR was assigned a value of one regardless of the calendar year, and each year thereafter was sequentially numbered. We compared dispersal distance from all BPP parameters to BPP 32 to interpret these parameter estimates.

Bird Conservation Region of Banding.—The Bird Conservation Region (BCR) in which a goose was banded was used to categorize observations and differentiate among areas with respect to quality of goose habitat. In general, we thought BCRs with much agriculture and abundant water bodies would have greater habitat quality that BCRs with mostly forests and few water bodies. Data from six BCRs were used and this variable is represented by REGION in the models.

Gender.—Because Lessells (1985) determined that male geese disperse longer distances than females, we hypothesized that we would observe the same pattern.

Age.—We included age at recovery in our global model because Greenwood et al. (1979), Part and Gustafsson (1989), and Spear et al. (1998) reported that age was related to dispersal distance. They reported birds of 1–2 years old congregated in their parents' breeding areas, birds 3–4 years of age dispersed most frequently and farthest, and birds > 5 years were sedentary. We categorized known-age geese into three groups (category one to three) based on the above life history of Canada geese.

We used PROC GENMOD (SAS 1996) to assess fit of the data to the global model. We ranked candidate models based on AIC statistics (Burnham and Anderson 1998) and estimated coefficients for each factor in the candidate model with the lowest AIC value and any models that were within 10 AIC of the lowest value. We converted point estimates calculated in SAS to percent change estimates to determine effect of each explanatory variable on dispersal distances. This was done by exponentiating point estimates of explanatory variables of the SAS model output, subtracting one from that value and then multiplying by 100, i.e. $(100(e^{\beta} - 1)\%$ (Long 1997). An example of this is $(100(e^{0.55} - 1)\% = 73.33\%$; the result is interpreted as an increase in dispersal distance of 77.33% relative to the variable used as a reference.

We only estimated dispersal angles for geese recovered outside of the 10-minute block of banding. Estimates for mean dispersal angles from each BCR were compared to each other using 95 percent confidence intervals for the difference in two means test (Zar 1996). Wind roses (Kovach 1994) were created for each BCR to visually compare dispersal directions.

Angular Data

We analyzed angular data created by the ArcView script for each BCR with program Oriana for Windows (Kovach 1994) to estimate mean dispersal directions and associated circular statistics. We used only dispersal angles of geese that were recovered outside of the 10-minute block of banding because BBL banding and recovery locations were only recorded to the nearest 10-minute block. These dispersal angles were compared to each other using 95% confidence intervals for the difference in 2 means test (Zar 1996) among BCRs and wind roses were created to compare angular patterns.

Results

Dispersal distances were determined for 5,278 band recoveries of known-age giant Canada geese from six BCRs in four states (Table 1). Of the eight models assessed, only one was strongly supported by the data (Table 2). The highest-ranking model was relatively complex, implying that many factors affected dispersal distances of giant Canada geese. The other seven models received little support (ΔAIC > 25, Table 2).

Explanatory Variables

Recovery year.—Influence of recovery year (RYR) was annually variable. All but five of the parameter estimates for RYR indicated a decrease in dispersal

Table 1. Mean (standard error) dispersal distances (km) moved by giant Canada geese from their respective Bird Conservation Regions in the central United States based on band recovery data 1985/1986 to 2000.

Bird conservation region	*N* band recoveries	Mean dispersal distance (km) (SE)	95% CI
Appalachian Mountains	502	82.4 (8.95)	64.8–99.9
Central Mixed-grass Prairie	350	49.2 (6.28)	36.8–61.5
Central Hardwoods	1533	86.6 (5.28)	76.2–96.9
Eastern Tallgrass Prairie	2519	94.6 (4.32)	86.1–103.0
Mississippi Alluvial Valley	220	26.3 (8.16)	10.3–42.2
Oaks and Prairies	154	61.3 (14.35)	33.1–89.4

Table 2. Model selection for the effects of recovery year, number of years banded post-initial plant, bird conservation region, gender, and age on dispersal distance moved by giant Canada geese in the central United States, 1985/1986–2000.

Model[a]	Model structure	*K* Parameters	Log likelihood	ΔAIC[b]	AIC weight
1	DD=RYR+BPP+REGION +SEX+RYR*REGION	187	2154127.27	0	0.99
2	DD= RYR+BPP+REGION +SEX+AGE	72	2153999.73	25.07	<0.01
3	DD=RYR+BPP+REGION	69	2153993.40	31.14	<0.01
4	DD=RYR+BPP+REGION+AGE+BPP*REGION	188	2154111.35	33.83	<0.01
5	DD=RYR+BPP+REGION+BPP*REGION	186	2154104.56	43.42	<0.01
6	DD=RYR+BPP+REGION+AGE+ BPP*REGION+RYR*REGION	299	2154206.01	66.5	<0.01
7	DD=RYR+BPP	64	2153956.90	94.74	<0.01
8	DD=RYR+BPP+REGION+AGE+SEX*AGE+ BPP*REGION+RYR*REGION	301	2153274.56	1933.42	<0.01

a. DD = Dispersal Distance, RYR = Recovery Year, SEX = Sex of Goose, BPP = Number of Years Banded Post-Initial Plant, AGE = Age of Goose, REGION = Bird Conservation Region banded in.

b. Minimum AIC = –4307880.53.

distance when compared to RYR 32. In examining the 95% confidence intervals for each parameter estimate, only six had a biologically significant effect on dispersal distances. These included RYR 13 with a 72.15% (95% C.I.= –90.8%, –16.0%) decrease in dispersal distance, RYR 14 with a 83.51% (95% C.I.= –94.7%, –48.2%) decrease in dispersal distance, RYR 15 with a 71.06% (95% C.I.= –88.3%, –28.3%) decrease in dispersal distance, RYR 17 with a 70.79% (95% C.I.= –89.2%, –20.7%) decrease in dispersal distance, RYR 18 with a 68.59% (95% C.I.= –88.6%, –13.2%) decrease in dispersal distance, and RYR 25 with a 52.60% (95% C.I.= -76.9%, –2.6%) decrease in dispersal distance.

Banded post-initial plant.—Considerable variability existed in percent changes in dispersal distance caused by the BPP variable. Although all parameter estimates

Table 3. Mean dispersal azimuth, number of observations, and 95% confidence intervals for giant Canada geese by the Bird Conservation Regions in the Central United States, 1985/86–2000.

BCR	*N* observations	Mean dispersal angle (SE)	95% CI Lower limit	95% CI Upper limit
Appalachian Mountains	327	347° (6.10)	325°	9°
Central Hardwoods	1156	297° (4.43)	291°	304°
Central Mixed-grass Prairie	243	346° (7.79)	320°	12°
Eastern Tallgrass Prairie	1143	81° (3.52)	69°	94°
Mississippi Alluvial Valley	71	182° (6.16)	154°	210°
Oaks and Prairies	112	288° (6.56)	255°	321°

reflected an increase in dispersal distance after being planted, the associated 95% confidence intervals were variable and we deemed the biological effects of these parameters inconclusive.

Region.—Only geese from the CMP showed a biologically important change in dispersal distance when compared with geese from the CH BCR. Dispersal distances of geese from the CMP BCR were 54.0% (95% C.I. = –93.5%, –54.0%) less than geese from the CH BCR.

Gender.—Because the 95% confidence interval was evenly distributed around 0, the estimate of Gender parameter in the best model indicated dispersal distance did not differ between sexes.

*Recovery Year*Region.*—The set of Recovery Year*Region interactions produced 146 parameter estimates. Based on examining the 95% confidence intervals, only three of these parameter estimates had a biologically important effect on dispersal distances. These parameters included RYR 2 in the ETP with a 99.94% difference in dispersal distance (95% C.I.= –100.0%, -99.0%), RYR 7 in the ETP with a difference in dispersal distance of 86.55% (95% C.I.= –97.1%, –36.6%), and RYR 16 in the MAV with a 97.05% difference in dispersal distance (95% C.I. = –99.8%, –56.4%).

After plotting mean dispersal distances and examining 95% confidence intervals for each region by BPP, the recoveries analyzed followed no consistent dispersal pattern. Dispersal distances were variable among geese and over time.

Dispersal Direction

Among geese that were recovered outside of the 10 minute block in which they were banded (*N*=3,052), sample sizes varied considerably among BCRs (Table 3). Sample sizes varied among BCRs from 71 in the MAV to 1,156 in the CH. Due to small sample sizes for some BCRs, these results may be tenuous. Dispersal directions varied for each of the six BCRs (Table 3). In comparing mean dispersal angles among BCRs, we determined that 5 of the 15 pairs of BCRs had similar dispersal angles. These BCRs were: the AM and the CMP (95% C.I. difference of means = 344.50° – 17.19°), the AM and the OP (95% C.I. difference of means = 338.28 ° –

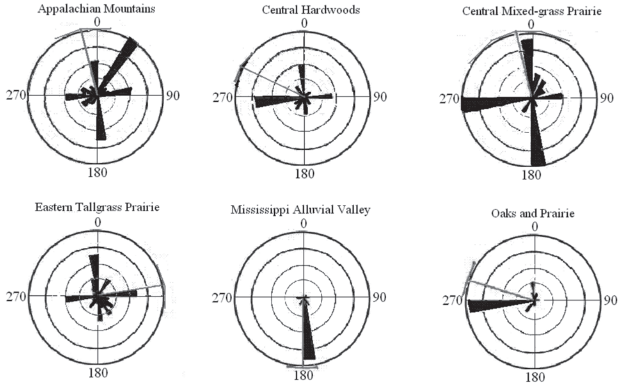

Figure 2. Wind roses indicating distribution of dispersal directions for giant Canada geese from the Appalachian Mountain, Central Hardwoods, Central Mixed-grass Prairie, Eastern Tallgrass Prairie, Mississippi Alluvial Valley, and Oaks and Prairie Bird Conservation Regions. Mean dispersal directions are shown by an arrow.

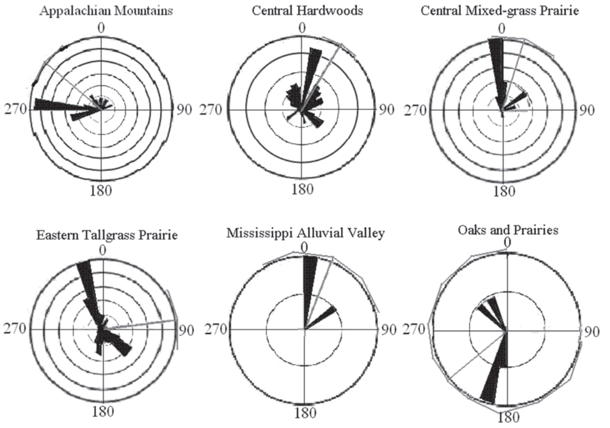

Figure 3. Wind roses indicating the distribution of dispersal directions of giant Canada geese dispersing >270 km from the Appalachian Mountain, Central Hardwoods, Central Mixed-grass Prairie, Eastern Tallgrass Prairie, Mississippi Alluvial Valley, and Oaks and Prairie Bird Conservation Regions. Mean dispersal directions are shown by an arrow.

140.30°), the CH and the CMP (95% C.I. difference of means = 281.18° – 176.42°), the CH and the OP (95% C.I. difference of means = 291.34° – 87.86°), and the CMP and the OP (95% C.I. difference of means = 334.60° – 142.20°). Although mean dispersal angles of these BCRs were similar, the wind roses for the angular patterns of dispersal were variable (Fig. 2). Mean dispersal angles and wind roses varied among the remaining BCRs.

Because most dispersal distances analyzed were within the 10-minute degree block of banding, we created wind roses using dispersal angles of geese whose dispersal distances were in the highest quartile of dispersal distances to determine if geese dispersing long distances were returning to locations where goose stocks were originally obtained. The wind roses for long-dispersing geese from each BCR showed no large-scale movement in the direction of the locations where goose stocks were obtained (Fig. 3).

Discussion

Because our analyses were based on band recovery data, it is important to consider possible effects of band reporting rates on our results. Although the Bird Banding Lab has established a toll-free number for reporting band recoveries which has increased reporting rates considerably, much of our data were collected before the initiation of this program in 1995. Before 1995, reporting rates varied considerably on a regional basis. These regional reporting rates did not vary in a smooth latitudinal or longitudinal gradient, making it impossible to estimate reporting rates based on region of recovery. Reporting rates varied without regard to location and ranged from 0.29–0.46 (SE = 0.02; Nichols et al. 1991). This variation could have introduced biases in our data. It is possible that birds recovered in a specific BCR were reported with greater frequency than in others, causing longer or shorter mean dispersal distances to be represented in the data. Reporting rates have also been shown to vary between males and females, and juvenile and adult birds of other waterfowl species (Reinecke et al. 1992, Nichols et al. 1995). We do not believe that this affected our analysis due to the lack of sexual dimorphism and difficulty in determining the age of giant Canada geese by hunters.

Our results suggested that dispersal distance of giant Canada geese was influenced by several factors that did not vary consistently among BCRs. Only the CMP exhibited an appreciable difference in goose dispersal distance compared to the other BCRs. However, the CMP still had a mean dispersal distance of <50 km (95% C.I.= 36.89 – 61.51). We originally anticipated that geese would disperse over large distances, but we found that most birds did not travel far during dispersal. Our results indicated that 75% of dispersal distances were < 48 km and all BCRs analyzed had mean and 95% confidence intervals for the dispersal distances of <104 km. Thus, most movements were within the BCR of original banding. Greater dispersal distances were anticipated in the initial years of reintroduction to a BCR because reintroduced adult geese were often wing-clipped before release and, once those geese nested and regained flight, we suspected they would return to their original location. We expected this behavior in the first two years after initial release. After the first two years, we expected to see a decline in dispersal distances, followed by a gradual increase in later years as lack of prime habitat eventually forced longer dispersal distances. Our predictions were not supported by the data.

Neither RYR nor the interaction between RYR and REGION were consistent in explaining dispersal distances. Although all biologically important changes in dispersal distances due to RYR were shorter, the starting year for each comparison was different. Thus, there was no large-scale, temporal effect across all regions simultaneously. Rather, changes in dispersal distances among regions were inconsistent. We found even less consistency in dispersal distances of geese due to the RYR by region interaction. These inconsistencies suggested that changes in dispersal distances in the RYR parameters could have been caused by factors not considered, such as extreme weather or new early hunting seasons.

Because dispersal distances in many waterfowl species are related to gender (Paradis et al. 1998), we anticipated the Gender parameter would explain much of the variation in dispersal distances. Such was not the case. Possibly the strong pair bonds between individual geese negated sex-specific dispersal distances.

We knew that most of the geese obtained for introduction to the BCRs were from the Great Lake region and north central Colorado. Assuming that planted geese were imprinted on those geographic areas, we thought the dominant direction of dispersals would be towards those two general areas. None of the wind roses for dispersing geese demonstrated a consistant movement towards the direction where goose stocks were originally obtained. Geese from different BCRs did not follow similar dispersal patterns. Interestingly, both the MAV and the ETP BCRs dispersal patterns were inconsistent with the other BCRs. This probably resulted from the high proportion of geese recovered within the same 10-minute block of banding in these two regions. The MAV and ETP had 68% and 53% of all recoveries made in the same 10-minute block of banding, respectively. The region with the closest proportion of recoveries made in the 10-minute block of banding was the AM with only 34%. In the case of the MAV, interpreting results was problematic because of small sample size (220 recoveries). However, for the ETP, we believe that few geese left that region because high quality habitat was available there.

Long-range dispersals in wild animals occur regularly but at low frequencies (Grinnell 1922), and the mean dispersal distances from BCRs in our analysis were all shorter than we anticipated (<104 km). Because band recoveries indicated that most geese remained at or near the location of banding, we believe that introduced giant Canada goose populations in one region or state will have little influence on goose populations in other states or regions through emigration, recognizing that our results did not address molt migration consequences. These results imply that population control and other management techniques should be used within the local area of concern because this is where most geese remain. Attempting to control human / goose conflicts by manipulating populations outside of local areas would be ineffective.

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Literature Cited

Ankney, C. D. 1996. An embarrassment of riches: Too many geese. Journal of Wildlife Management 60:217–223.

Burnham K. P. and D. R. Anderson. 1998. Model selection and inference: a practical information theoretic approach. Springer-Verlag, New York, New York.

Commission for Environmental Cooperation. 2000. North American Bird Conservation Initiative: Bird conservation region descriptions. U.S. Fish and Wildlife Service, Arlington, Virginia.

Conover, M. and G. Chasko. 1988. Too much of a good thing? Living Bird Quarterly 1988:8–13.

Converse, K. A. 1985. A study of resident nuisance Canada geese in Connecticut and New York. Ph.D. thesis, University of Massachusetts, Amherst.

ESRI. 1999. Getting to know ArcView GIS. ESRI Press, Redlands, California.

Greenwood, P. J. and P. H. Harvey. 1982. The natal and breeding dispersal of birds. Annual Review of Ecology and Systematics 13:1–21.

_____, _____, and C. M. Perrins. 1979. The role of dispersal in the Great Tit: The causes, consequences and habitability of natal dispersal. Journal of Animal Ecology 48:123–142.

Grinnell, J. 1922. The role of "accidental." The Auk 39:373–380.

Hestbeck, J. B., J. D. Nichols, and R. A. Malecki. 1991. Estimates of movement and site fidelity using mark-resight data of wintering Canada geese. Ecology 72:523–533.

Johnson, B. K., J. W. Kern, M. J. Wisdom, S. L. Findholt, and J. G. Kie. 2000. Resource selection and spatial separation of mule deer and elk during spring. Journal of Wildlife Management 64:685–697.

Kovach, W. L. 1994. Oriana for windows. Kovach Computing Services Inc., Anglesey, Wales, United Kingdom.

Lessells, C. M. 1985. Natal and breeding dispersal of Canada geese. Ibis 127:31–41.

Long, J. S. 1997. Regression models for categorical and limited dependent variables. Sage Publications, Inc., Thousand Oaks, California.

Nelson, H. K. 1963. Restoration of breeding flocks of Canada geese in the north central states. Transactions of the North American Wildlife and Natural Resources Conference 28:133–150.

_____ and R. B. Oetting. 1998. Giant Canada Goose Flocks in the United States. Pages 483–495 *in* D. H. Rusch, M. D. Samuel, D. D. Humburg, and B. D. Sullivan, editors. Biology and Management of Canada Geese. Proceedings of the International Canada Goose Symposium, Milwaukee, Wisconsin.

Nichols, J. D., R. E. Reynolds, R. J. Blohm, R. E. Trost, J. E. Hines, and J. P. Bladen. 1991. Band reporting rates for mallards with reward bands of different dollar values. Journal of Wildlife Management 55:119–126.

_____, _____, _____, _____, _____, and _____. 1995. Geographic variation in band reporting rates for mallards based on reward banding. Journal of Wildlife Management 59:697–708.

Paradis, E., S. R. Baillie, W. J. Sutherland, and R. D. Gregory. 1998. Patterns of natal dispersal in birds. Journal of Animal Ecology 67:518–536.

Part, T. and L. Gustafsson. 1989. Breeding dispersal in the Collared Flycatcher: Possible causes and reproductive consequences. Journal of Animal Ecology 58:305–320.

Reinecke, K. J., C. W. Shaiffer, and D. Delnicki. 1992. Band reporting rates of mallards in the Mississippi Alluvial Valley. Journal of Wildlife Management 56:526–531.

SAS 1996. SAS/STAT software: changes and enhancements, through version 6.11. SAS Institute Inc., Cary, North Carolina.

Spear, L. B., P. Pyle, and N. Nur. 1998. Natal dispersal in the Western gull: Proximal factors and fitness consequences. Journal of Animal Ecology 67:165–179.

Zar, J. H. 1996. Biostatistical Analysis, third edition. Prentice Hall Inc., Upper Saddle River, New Jersey.