SHORT COMMUNICATIONS

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ESTIMATING WINTERING BALD EAGLE DENSITIES IN THE MISSISSIPPI ALLUVIAL VALLEY

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Surveys on the winter distribution of Bald Eagles have been concentrated in the northern USA (Hastings 1988, Mattson 1988), where Bald Eagles are most common. Few density estimates for wintering Bald Eagles exist. In the past, different survey techniques with little standardization have been used. Statistical analyses and error measurements of existing winter survey data usually are not possible. The National Wildlife Federation's "midwinter Bald Eagle survey," the largest operational winter survey, is not systematic. Observers concentrate on areas where large numbers of Bald Eagles winter. We collected Bald Eagle density and distribution data in the Mississippi alluvial valley (MAV) while conducting four regional aerial surveys for Mallards (*Anas platyrhynchos*) during the winters of 1988-89 and 1989-90. Our objectives were to determine if the relatively large sample size and experimental design used in our Mallard surveys would provide accurate population estimates and additional distribution data not provided by current Bald Eagle surveys.

STUDY AREA AND METHODS

The MAV is located in the southeastern USA and extends from southeastern Missouri to southern Louisiana and encompasses approximately 1000 km^2. Well-defined loess hills border the valley on the east, but its western boundary is less well defined. Our study area encompassed 891 km^2 of the MAV (Fig. 1). Historically, periodically flooded bottomland hardwood and Cypress (*Taxodium distichum*)-Tupelo (*Nyssa aquatica*) forests dominated the MAV. Currently, about 80% of the forests are cleared (Tiner 1984) and extensive water control projects have altered the hydrology of the MAV.

We divided the MAV into four major strata, primarily on the basis of state boundaries. The four strata were Missouri (including small portions of southern Illinois, western Kentucky, and western Tennessee), Arkansas (including small portions of western Tennessee), Mississippi, and Louisiana. We divided the major strata into 16 substrata based on Mallard density data from operational midwinter waterfowl surveys conducted by the U.S. Fish and Wildlife Service's Office of Migratory Bird Management and cooperating state agencies.

We used the Neyman method (Cochran 1977:98–99) to allocate sampling effort to strata and substrata. Effort was proportional to sample area size and the standard deviation of Mallard density in the sample area. Within each substratum, transects were randomly selected proportional to size and with replacement. The number of transects per substratum ranged from 10–48 with a survey total of 373. We flew east-west transects (8–102 km long) at altitudes of 76 or 152 m in small fixed-wing aircraft at 150 km/hr. We used window and strut markers (Norton-Griffiths 1975) to maintain a 500-m transect width. Transects were 2 parallel, slightly offset, 250-m strips with a small space between them. The space was the area directly beneath the aircraft which was not visible to observers. Each survey team was a pilot with 2 observers. One observer from each crew counted eagles from the right, front seat (co-pilot position), the other from the left, rear seat We used all Bald Eagles seen in a transect to estimate population sizes. Each survey sampled approximately 91 km^2 (9% of the MAV). Population estimates ($\hat{N}$) and standard errors (SE) were calculated using formulas for stratified random sampling (Cochran 1977:254–255). An approximate 90% confidence interval (CI) on $\hat{N}$ was provided by $\hat{N} \pm 1.65$ SE. We conducted Surveys 1–4 during 2–14 December 1988, 9–22 January 1989, 1–13 December 1989, and 9–22 January 1990, respectively. Personnel from the U.S. Fish and Wildlife Service, Arkansas Game and Fish Commission, and Louisiana Department of Wildlife and Fisheries were observers.

We also attempted to predict how reallocation of sample effort would effect variance of estimates. We reduced the sampled area in two strata (Mississippi and Louisiana, where Bald Eagle numbers were low) by 50%. The sample effort removed from Mississippi and Louisiana was then applied equally to Arkansas and Missouri (where numbers were relatively high). We then recalculated estimates of population variance using the variance obtained during this study.

RESULTS

Our estimates of total MAV Bald Eagle populations ranged from 94 (SE = 37) for Survey 3 to 278 (SE = 72)

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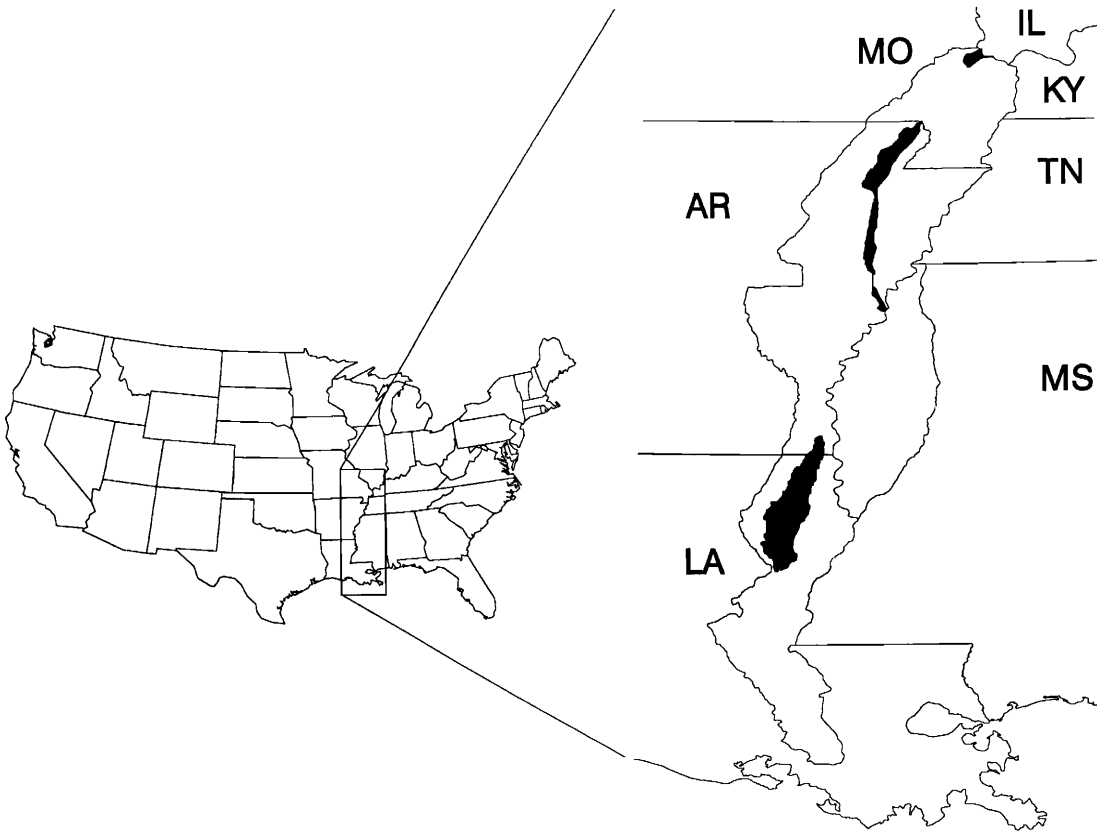

Figure 1. Approximate area and stratum boundaries for Bald Eagle surveys, 1988–1990. Darkened areas represent unsampled uplands.

for Survey 4 (Table 1). Mean CV for the four surveys was 38%. We predict that a reallocation of 50% of the sample effort from Mississippi and Louisiana to Arkansas and Missouri would reduce mean CV to 30%. Counts of the midwinter Bald Eagle survey for the MAV in January 1989 and 1990 were within the 90% CIs of our estimates (Table 1).

We saw only 3 Bald Eagles in Mississippi and 1 in Louisiana. Most Bald Eagles were seen at or near Reelfoot Lake in Tennessee (24) and the lower White and Arkansas Rivers in Arkansas (25). One Bald Eagle perched near an artificial agricultural reservoir while all others were at rivers, lakes, and wildlife refuges.

DISCUSSION

Our results include all observations even though some Bald Eagles may have been breeding during the surveys. The presence of breeding eagles would tend to make our estimates too high. Currently, there is little breeding activity by Bald Eagles in the MAV (Murphy et al. 1984) so this probably did not influence our estimates. Some Bald Eagles may have been overlooked when Mallards, the primary survey subjects, were present (Watson et al. 1969). Visibility bias is common in aerial surveys (Caughley 1974) and our results have not been adjusted to account for this effect.

The majority of the wintering Bald Eagles were in the northern portion of the MAV. This distribution was similar to the data reported in the midwinter Bald Eagle survey (Hastings 1988). Most eagles seen during our surveys were associated with Reelfoot Lake in Tennessee and forested wetlands near the confluences of the Arkansas and White Rivers with the Mississippi River in Arkansas. Our January population estimates were not different from the midwinter Bald Eagle survey. Our estimates had relatively large amounts of error associated with them (mean CV = 38%). Our simple reallocation of sample effort among the four strata could yield reductions in variance for future surveys (mean CV = 30%). Proper management of wintering Bald Eagles may require more accurate inventories (Steenhof 1978). Although our surveys were not specifically designed to estimate Bald Eagle distribution and numbers in the MAV, it provided information that could be useful in designing future surveys. The stratifi-

Table 1. Comparison of two estimates ($\hat{N}$) of wintering Bald Eagle populations in the Mississippi alluvial valley, 1988-90.

Survey Date	Number of Eagles Counted	$\hat{N}$	SE	CV	90% CI	MWBES[1] Count
12/88	17	264	93	35%	111–417	
1/89	19	220	111	50%	37–403	196
12/89	8	94	37	39%	27–149	
1/90	27	278	72	26%	160–396	392

[1] Midwinter Bald Eagle Survey.

cation of the MAV based upon known Bald Eagle densities could be used to allocate sampling effort to provide an efficient, statistically valid survey technique. This would mean increased effort in high-density areas (e.g., Reelfoot Lake and the lower White River) and decreased effort in low-density areas (e.g., Mississippi and Louisiana).

Since our survey results were not different from those of the midwinter Bald Eagle survey, some question exists on the preferred method. The midwinter Bald Eagle survey has been conducted since 1979 and may be less costly to complete, although cost comparisons have not been made. A systematic survey, such as ours, provides measurements of error. Annual midwinter Bald Eagle surveys with periodic systematic surveys to gauge accuracy may be most desirable.

RESUMEN.—Cuatro estudios desde el aire, de ánades silvestres de la especie *Anas platyrhynchos*, realizados con muestras al azar correspondientes a cuatro estratos del valle aluvial de Mississippi, han sido usados para estimar densidades poblacionales de invierno, del Águila Cabeciblanca (*Haliaeetus leucocephalus*). Estos estudios fueron hechos en diciembre de 1988 y 1989, y en enero de 1989 y 1990. Nuestras estimaciones de enero concuerdan con los resultados del estudio de medio invierno que sobre estas águilas ha hecho el National Wildlife Federation (entre 90% CI de N); sin embargo, nuestras estimaciones fueron relativamente imprecisas (media CV = 38%). Si esfuerzo y tiempo han sido puestos en hacer el estudio y cómputo en áreas donde la abundancia de ánades silvestres es sabida que es alta, la precisión podría ser mejor si las inspecciones y cómputo fueran realizadas en áreas donde se supiera que las Á. c. (*Haliaeetus leucocephalus*) son también abundantes. Un estudio con este tipo de diseño experimental podría ser útil a ejecutivos de recursos naturales, al proveer estimaciones, estadísticamente aceptables, de poblaciones invernales de Águila Cabeciblanca.

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