Central Valley Winter Raptor Survey (2007-2010): Winter Raptor Population Estimates

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Estimating populations of birds over large geographic areas is extraordinarily difficult. As a result, there is relatively little information in the published literature beyond estimates for game birds and some species of conservation concern (Igl et al. 1999). In addition, the problems and limitations inherent in sampling populations and extrapolating those data to large areas have been well-documented and thoroughly reviewed (Ralph and Scott 1981, Bildstein 2001, Thompson 2002, Brouwer et al. 2003, Pollack et al. 2009). Even given the difficulty and uncertainty, the importance of such estimates of avian abundance makes the effort to produce them worthwhile.

The most thorough attempt to estimate North American bird populations was conducted through Partners in Flight (Rich et al. 2004) using Breeding Bird Survey (BBS) data. These authors used the average number of birds found on BBS routes during the 1990s as the basis for their estimates. They extrapolated from the area actually surveyed by the BBS routes to the entire North American region and applied adjustments based on estimates of likelihood that all birds of a particular species had been detected by the surveyors.

Although the CV Winter Raptor Survey was not designed to produce data for population extrapolations (likewise for BBS), we estimated bird densities by habitat type and determined the proportion of each habitat type within the entire CV. This allowed us to make estimates of winter populations in the CV based on a set of explicit assumptions. We also used those estimates, in conjunction with Christmas Bird Count (CBC) data, to attempt extrapolations to populations for the lower 48 United States. Using guidelines suggested by Brouwer et al. (2003), we detailed the assumptions, calculations, limitations, and probable biases inherent in our extrapolations.

METHODS

CV Winter Population Estimates

Survey methods are described in the accompanying overview and methods paper (Pandolfino and Smith 2011a). We produced CV population estimates by taking the average density observed in each habitat type, multiplying that density by the total area of that habitat type in the CV (Pandolfino et al. 2011):

[Density in each habitat (birds per ha)] X [Area of each habitat in the CV (ha)] = CV winter population in each habitat],

and then adding the numbers for each habitat type. Key assumptions inherent in these estimates are:

1. All birds of each species present in each habitat block were detected and correctly identified.
2. The densities of birds in the habitat types we surveyed were representative of densities of birds in that habitat throughout the CV.

US Winter Population Estimates

We used the population extrapolations for the CV for each year of our study as described above, in combination with CBC data (National Audubon Society 2010) from the lower 48 states, to estimate the winter populations in the US. Starting with the assumption that the estimates we made for the CV each year were accurate, we derived a CBC Detection Correction Factor which, when multiplied by the total number of each species recorded on all CBC circles that fell within the CV, would produce the same population number we derived from CV Raptor Survey data:

CBC Detection Correction Factor = (CV population estimate for a species fromraptor survey)/(Total number of a species recorded on all CV CBC circles)

In order to extrapolate from CV CBC data to CBC data for the lower 48 states, we accounted for the difference in geographic coverage of CBC circles in the lower 48, compared to the CV. We calculated a Coverage Correction Factor for each year as noted below:

Coverage Correction Factor = (Percent of the CV total area covered by CV CBC circles)/(Percent of the lower 48 states area covered by CBC circles)

We also needed to account for the difference in effort level (number of party hours) of CBC circles in the lower 48 versus the CV. We calculated an Effort Correction Factor for each year as:

Effort Correction Factor = (Average party hours per CV CBC circle)/(Average party hours per lower 48 CBC circles)

The resulting values for these correction factors are shown in Table 1.

Table 1. Annual correction factors for coverage and effort.

	Year 1	Year 2	Year 3
Coverage Correction Factor	1.57	1.56	1.63
Effort Correction Factor	1.37	1.34	1.48

For each of the three years of the CV raptor surveys, we estimated winter population of each species in the lower 48 states as:

(Total number of a species from all lower 48 CBCs) X (CBC Detection Correction Factor for a species) X (Coverage Correction Factor) X (Effort Correction Factor) = Total lower 48 winter population of a species

Key assumptions inherent in these estimates are:

1. CV population estimates from the raptor survey are accurate.
2. The efficiency of detection of a species is equal between CV CBCs and other US CBCs once adjusted for relative effort (party hours).
3. CV CBC circles are sampling habitat types in the same proportions as in the Raptor Surveys.

RESULTS AND DISCUSSION

We estimated the winter population in the CV for eight raptor species for each of the three years of our surveys (Figures 1 and 2). There were no significant year-to-year differences in numbers except for Rough-legged Hawks, which were present in very low numbers in the CV in the third winter of our surveys. Such fluctuations in wintering Rough-legged Hawk numbers are well-documented (Bechard and Swem 2002).

Potential Sources of Bias

Although we designed our surveys as area searches to attempt to count every bird in the habitat blocks, it is certain that some were missed. These open country raptors are generally visible and relatively easy to detect, but birds perched in wooded areas or hidden behind structures or vegetation could not have been detected.

In spite of using experienced observers on every route, there is always some variation from observer to observer in the ability to detect all birds present. We did not employ any methods like double-sampling (Bart and Earnst 2002) or double-observer replicates (Nichols et al. 2000) to address this effect. However, such detection bias is much more of a problem in

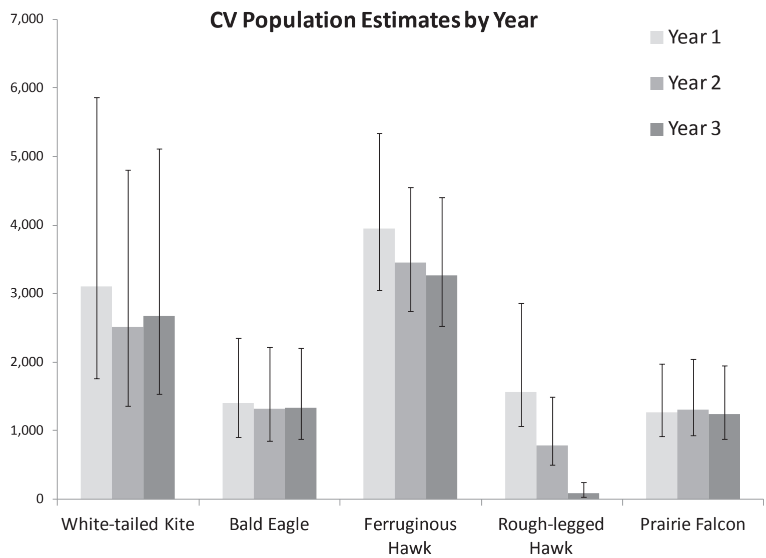

Figure 1. Winter population estimates for the CV for White-tailed Kite, Bald Eagle, Ferruginous and Rough-legged hawks, and Prairie Falcon. Error bars are based on 95% confidence intervals.

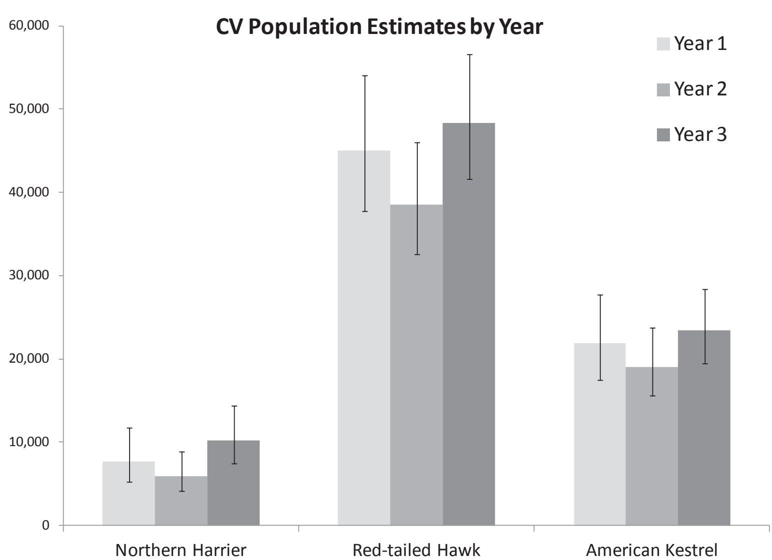

Figure 2. Winter population estimates for the CV for Northern Harrier, Red-tailed Hawk, and American Kestrel. Error bars are based on 95% confidence intervals.

surveys for smaller birds or birds which tend to skulk (Diefenbach et al. 2003). Although some raptors were undetected in our surveys, it is likely that the large majority of the target species were recorded for the following reasons:

1. surveys were designed to be thorough area searches (rather than as time-constrained point counts),
2. areas surveyed were mainly open country, and
3. habits of most of the species surveyed make them relatively visible.

Because our routes were not chosen randomly (Pandolfino et al. 2011), it is likely that the habitats we surveyed may not be representative of the habitats throughout the CV. In choosing routes we tried to incorporate habitats characteristic of the CV, but we exercised an intentional bias for areas with open country to facilitate observation of all raptors and low levels of traffic due to safety concerns. The distribution of our routes displays a bias for the Sacramento and northern San Joaquin valleys over the southern San Joaquin Valley and for open habitats such as grassland and rice over habitats such as oak savannah or orchards.

Our survey routes were all confined to roads, and it is well known that roads can affect raptor use of adjacent habitats, and thereby can introduce bias (Fuller and Mosher 1987). However, the CV is a highly developed area and most of the habitat types we surveyed are criss-crossed by roads. One important exception to this is grassland, as some grasslands in the CV consist of large roadless areas. Of these three sources of bias, the detection bias is negative and would underestimate populations, the route-selection or roadside bias may produce either a positive or a negative effect on estimates.

Our estimates of populations for the lower 48 United States include all the potential biases noted above, and also issues related to the CBC data used for extrapolation. As with our survey routes, CBC circles also were not chosen randomly chosen. We also used a correction factor for the efficiency of CBCs to detect raptors that, while it may apply to the CV, may not apply to other areas of the country due to weather, terrain, and other local factors. We also used party hours to correct for effort and this method of normalizing data across counts is also subject to valid criticism, especially at very low and very high effort levels within a count circle where the effects of added party hours on detection rates are not linear (Sauer and Link 2002).

Population Estimates for the lower 48 United States

Using data from CV and US CBCs combined with our estimates of CV winter raptor populations, we estimated US populations for eight raptors (Figure 3 and 4). Compared to two prior attempts to estimate populations for

Table 2. Comparison of our population estimates to previous estimates.

Species	Winter Estimates Low	Winter Estimates High	Winter (US+Canada) (Johnsgard 1990)	Breeding (US+Canada) (Rich et al. 2004)
White-tailed Kite	15,000	18,000		11,000
Bald Eagle	460,000	570,000		300,000
Northern Harrier	180,000	270,000	111,500	400,000
Red-tailed Hawk	1,400,000	1,700,000	350,000	2,000,000
Ferruginous Hawk	57,000	80,000	5,500	20,000
Rough-legged Hawk	290,000	680,000	49,600	300,000
American Kestrel	700,000	850,000	236,000	4,300,000
Prairie Falcon	30,000	50,000	7,800	30,000

a suite of raptor species across the continent (Table 2), our results align most closely with those of Rich et al. (2004), and are universally much higher than those of Johnsgard (1990). Johnsgard (1990) used CBC data, but it is unclear what methods he used to extrapolate from those data to total populations. His calculations were also based on data from the mid-1980s and populations of many raptors have increased since then (Hoffman and Smith 2003, Bildstein et al. 2008). Rich et al. (2004) used BBS data to estimate North American breeding populations. Their methodology is explained in detail and they include ratings of relative data quality, quantity, variance, and coverage for each species.

The estimates of Rich et al. (2004) are based on breeding season data and cover a different geographic area than used for ours. Therefore, these differences should be considered in comparing the numbers. However, with the exception of estimates for Ferruginous Hawk and American Kestrel, the numbers are close, especially given the high degree of uncertainty inherent in such extrapolations.

White-tailed Kite: Unlike all the other species analyzed here, the White-tailed Kite has a very restricted range and is almost entirely resident year-round within that range. The range of our estimates is above that of Rich et al. (2004). The fact that we used CBC data from across the continent for this localized species may make our estimate less reliable.

Bald Eagle: Population estimation for Bald Eagles are difficult in winter or in the breeding season. The breeding range includes large areas of Canada and Alaska that are not well-covered by BBS routes. In winter, though widespread, large numbers of eagles concentrate along the west coast of British Columbia and southern Alaska. The breeding population estimate of 300,000 (Rich et al. 2004) is below our range. Given that their estimates are based on data from the 1990s and ours on data from 2007-2010,

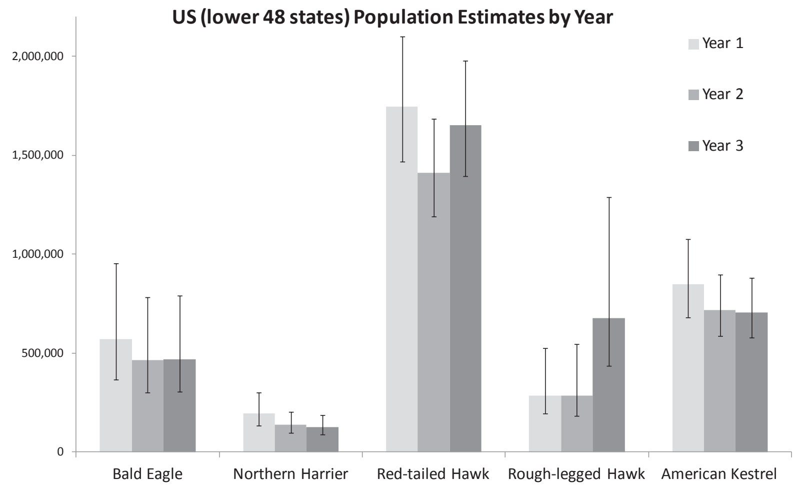

Figure 3. Winter population estimates for the lower 48 United States for Bald Eagle, Northern Harrier, Red-tailed and Rough-legged Hawk, and American Kestrel. Error bars are based on 95% confidence intervals.

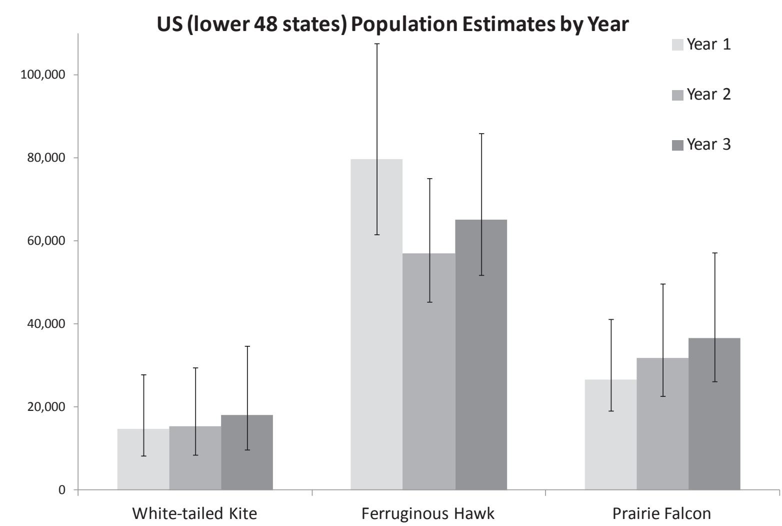

Figure 4. Winter population estimates for the lower 48 United States for White-tailed Kite, Ferruginous Hawk, and Prairie Falcon. Error bars are based on 95% confidence intervals.

the recent rapid increase in Bald Eagle populations (Buehler 2000) could account for some of this discrepancy.

Northern Harrier: Our estimate of Northern Harrier populations ranges up to 270,000, below the 400,000 estimated by Rich et al. (2004). Some of this difference may be explained by the fact that, while the breeding range lies within Canada and the US, some of the population of this species winters from Mexico well into Central America and would not be included in our estimate.

Red-tailed Hawk: As with the harrier above, our slightly lower estimate of the Red-tailed Hawk population could reflect the fact that some of the US breeding population winters in Mexico and Central America.

Ferruginous Hawk: Our estimate of the Ferruginous Hawk population is well above that of Rich et al. (2004). Earlier estimates of this species' population ranged from 6,000 to 14,000 (Bechard and Schmutz 1995), also well below our estimates. We believe our estimate is inflated due to our inclusion of survey routes in grassland areas with unusually high concentrations of this species (Pandolfino and Smith 2011b).

Rough-legged Hawk: The high arctic breeding range of the Rough-legged Hawk makes it very difficult to estimate the breeding population, as acknowledged by the low ratings given by Rich et al. (2004) to the data quality used in their estimates for this species. Since nearly the entire winter range is restricted to the lower 48 United States, this season may provide the best opportunity to assess population size. The estimate from Rich et al. (2004) falls within the lower part of our range. The high upper limit of our estimated range is due to the extrapolations based on the very low number of this species present in the CV in the third year of our surveys. Therefore, a population in the range of 300,000 is probably a good estimate.

American Kestrel: The Rich et al. (2004) estimate of over 4 million American Kestrels is much higher than ours and more than double the earlier estimate of Cade (1982). Some portion of the US/Canada breeding population winters south of the US, but probably not enough to account for the difference in our estimates. Rich et al. (2004) rate the quality of the data used highly, so their estimate may be a good one and we are unable to speculate why our estimate is so much lower than theirs.

Prairie Falcon: Rich et al. (2004) estimated a breeding population of 30,000, right at the lower end of the range from our analyses. Both estimates are well above earlier reports of a wintering population of 13,000 and 10-12,000 breeding birds (unpublished data cited in Steenhof 1998). Given that some portion of the US breeding population winters in Mexico, our estimate should be lower, rather than higher than that of Rich et al. (2004). This discrepancy may be due to the same reason noted for Ferruginous Hawks: our inclusion of routes in areas of grassland that supported unusually high numbers of grassland raptors.

Given the fact that our approach and that of Rich et al. (2004) used different datasets, from a different season, and different geographic areas, we find that the numbers agree remarkably well for most species. Our approach may have some value for making winter population esutimates in other areas and for other species where independent surveys can be used to make population estimates over a geography that includes a number of CBC circles. The approach of sing independent data to develop a detection correction factor for CBCs could allow others to make better population extrapolations from CBC data.

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