DETECTION PROBABILITY OF GYRFALCONS AND OTHER CLIFF-NESTING RAPTORS DURING AERIAL SURVEYS IN ALASKA

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EXTENDED ABSTRACT.—Assessing the status of Gyrfalcons (*Falco rusticolus*) and other cliff-nesting raptors as the Arctic climate changes often requires aerial surveys of their breeding habitats. Because traditional, count-based surveys that do not adjust for differing detection probabilities can provide faulty inference about population status (Link and Sauer 1998, Thompson 2002), it will be important to incorporate measures of detection probability into survey methods whenever possible.

To evaluate the feasibility of this, we conducted repeated aerial surveys for breeding cliff-nesting raptors on the Yukon Delta National Wildlife Refuge (YDNWR) in western Alaska to estimate detection probabilities of Gyrfalcons, Golden Eagles (*Aquila chrysaetos*), Rough-legged Hawks (*Buteo lagopus*), and also Common Ravens (*Corvus corax*). Using the program PRESENCE, we modeled detection histories of each species based on single species occupancy modeling following MacKenzie et al. (2002, 2006). We used different observers during four helicopter replicate surveys in the Kilbuck Mountains and five fixed-wing replicate surveys in the Ingakslugwat Hills (hereafter called Volcanoes) near Bethel, Alaska.

We used the following terms and definitions throughout: *Survey Site:* site of a nest used previously by a raptor and marked with a GPS-obtained latitude and longitude accurate to within 20 m. All GPS locations were obtained in prior years from a helicopter hovering approximately 10–20 m from a nest. The site was considered occupied if a bird or an egg was detected within approximately 500 m of the nest and this area served as our sampling unit. When multiple historical nests were located on a single cliff, we used only

one GPS location to locate the survey site. *Detection probability (p):* the probability of a species being detected at a site given the site is occupied. *Occupancy (ψ):* the probability that the species of interest is present at a site during the survey period. A site was considered occupied if the species was detected there during any of the surveys; confirming breeding status was not necessary for us to consider a site occupied.

Here we show that during helicopter surveys, Gyrfalcons had the highest detection probability estimate ($\hat{p}$; $\hat{p}$=0.79; SE 0.05), followed by Golden Eagles ($\hat{p}$=0.68; SE 0.05), Common Ravens ($\hat{p}$=0.45; SE 0.17), and Rough-legged Hawks ($\hat{p}$=0.10; SE 0.11) (Table 1). Detection probabilities from fixed-wing aircraft in the Volcanoes were similar to those from the helicopter in the Kilbuck Mountains for Gyrfalcons and Golden Eagles, but were higher for Common Ravens ($\hat{p}$=0.85; SE 0.06) and Rough-legged Hawks ($\hat{p}$=0.42; SE 0.07). Fixed-wing aircraft provided detection probability estimates and SEs in the Volcanoes similar to or better than those from helicopter surveys in the Kilbucks and should be considered for future cliff-nesting raptor surveys where safe, low-altitude flight is possible.

Overall, detection probability varied by observer experience and in some cases, by study area/aircraft type. These results demonstrate that estimating and accounting for detection probability during cliff-nesting raptor surveys is possible, though doing so may require additional effort or shifting priorities in survey protocols. *Received 2 March 2011, accepted 9 May 2011.*

Table 1. Detection probability estimates for each species by study area and aircraft type on the Yukon Delta National Wildlife Refuge, Alaska in 2007.

Detectability estimates for experienced and inexperienced observers provided from models assuming detectability varied by observer experience (p(experience)).

Species	Study Area/Aircraft	Model	Detectability ($\hat{p}$)	Experienced Observer Detectability ($\hat{p}$)	Inexperienced Observer Detectability ($\hat{p}$)	Total Number of Sites Species was Detected
Gyrfalcon	Kilbucks - Helicopter	ψ(.) p (.)	0.79 (0.05)[a]	-	-	14
		ψ(.) p (experience)	-	0.87 (0.06)	0.72 (0.08)	14
	Volcanoes - Fixed-wing	ψ(.) p (.)	0.78 (0.07)	-	-	9
		ψ(.) p (experience)	-	0.85 (0.07)	0.64 (0.13)	9
Golden Eagle	Kilbucks - Helicopter	ψ(.) p (.)	0.68 (0.05)	-	-	20
		ψ(.) p (experience)	-	0.75 (0.08)	0.60 (0.09)	20
	Volcanoes - Fixed-wing	ψ(.) p (.)	0.69 (0.10)	-	-	5
		ψ(.) p (experience)	-	0.73 (0.13)	0.62 (0.18)	5
Rough-legged Hawk	Kilbucks - Helicopter	ψ(.) p (.)	0.1 (0.11)	-	-	5
		ψ(.) p (experience)	-	0.15 (0.16)	0.08 (0.10)	5
	Volcanoes - Fixed-wing	ψ(.) p (.)	0.42 (0.07)	-	-	20
		ψ(.) p (experience)	-	0.53 (0.12)	0.40 (0.08)	20
Common Raven	Kilbucks - Helicopter	ψ(.) p (.)	0.45 (0.17)	-	-	3
		ψ(.) p (experience)	-	0.45 (0.21)	0.45 (0.22)	3
	Volcanoes - Fixed-wing	ψ(.) p (.)	0.85 (0.06)	-	-	8
		ψ(.) p (experience)	-	0.90 (0.09)	0.83 (0.08)	8

[a]SE in parentheses corrected by multiplying model-based SE's by square root of c-hat for each model set.

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