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Perch site selection by reintroduced peregrine falcons *Falco peregrinus*

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As part of a program to recover the peregrine falcon *Falco peregrinus* in the southeastern U.S. we recorded perching behaviour with the objective of characterizing perches used in the reintroduction area. We used a site-attribute design and logistic regression to compare characteristics between used and non-used perches. Peregrines used pines *Pinus* spp. exclusively, while pines comprised 78% of available trees. Perches were larger than non-used trees (diameter at breast height in cm (in $\bar{x} \pm SD$); 29.2 ± 15.7 and 23.9 ± 10.3), in more advanced stages of decay (2.5 ± 1.5 and 1.5 ± 1.1 (index)), and usually dominant in crown class (1.5 ± 0.6 and 1.7 ± 0.5 (index)). Perches were always on cliff plateaus and tended to be situated in sites with a less even canopy (0.5 ± 0.3 and 0.7 ± 0.2 (index)) and fewer deciduous stems (1.8 ± 3.4 and 2.3 ± 2.3 (stem density)) than non-used trees. These attributes depict selection of perches that provide unobstructed flight paths, good visibility, and a capacity to detect and respond rapidly to stimuli.

Key words: behaviour, *Falco peregrinus*, perch selection, post-fledging, wildlife reintroduction

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Perches are important components of raptor habitat because they play a role in population processes such as individual spacing, predation and survival. For territory establishment, courtship activities, defence, prey access and predator avoidance, raptors rely on selecting perches that confer a general capacity to detect and respond to stimuli (Sonerud 1992, Lima 1994). These functions are not mutually exclusive as many species such as large eagles, vultures and osprey *Pandion haliaetus* will place nesting materials on conspicuous perches, then use these sites for display, defence and hunting (Newton 1979). Conservation of rare or endangered species that are susceptible to raptor predation, such as sage-grouse *Centrocercus urophasianus* (Boyko et al. 2004) or black-footed ferrets *Mustela nigripes* (M.R. Dzialak, pers. obs.), would benefit from increased understanding of the role perches play in interspecific interaction (Wolff et al. 1999). Also, an understanding of perching behaviour has enabled managers to respond effectively to human-caused mortality in raptors such as electrocution at utility structures (Janss & Ferrer 1999).

The peregrine falcon *Falco peregrinus* is known for long distance movement and aerial pursuit. Yet, the peregrine has been reported to spend about 90% of its time perching (*sensu* Newton 1979, Jenkins 1987). Little information on perching behaviour in peregrines is available (Dobler 1993), and quantitative assessments of perch selection do not appear in the published literature. For visually oriented diurnal predators like peregrines, perches may be important in the development of prey recognition and pursuit techniques, and in social interaction. These considerations are of particular relevance for reintroduced peregrines because young individuals approaching fledging age (40-45 days old) are used nearly exclusively in recovery efforts, and the post-fledging period is critical in the development of survival and social skills (Sherrod 1983). Data on perch use by post-fledging peregrines may benefit population recovery efforts by advancing our understanding of important habitat features of areas near the eyrie or release site at which fledgling peregrines concentrate activity before dispersing (i.e. post-fledging area), and by providing information for managers seeking to balance recovery and human recreational use of cliff habitat. As part of an effort to assist recovery of the peregrine in the southeastern United States, we examined perch selection by peregrines reintroduced in Kentucky. Our objective was to determine the characteristics

of perch sites used by fledgling peregrines at cliff habitat in this reintroduction area.

Material and methods

We hacked 22 peregrines during 2001-2002 at two hacking stations 1.5 km apart in Daniel Boone National Forest, Kentucky. Hacking is a release method in which young raptors are housed in a shelter in the release area, provided with food, and then released at an age that corresponds to their ability to fledge and sustain flight (Sherrod et al. 1982). In 2001, we hacked 12 at one station, and in 2002 we hacked 10 at the second station. The site has massive sandstone outcrops and cliffs typically 60 m in height that form broad plateaus within a rugged matrix of mixed mesophytic and oak-pine forest. Each peregrine was fitted with a tarsal-mounted RI-2CM transmitter (Holohil Systems, Ltd., Ontario, Canada) and given unique identification markings on the dorsal humeral region using non-toxic paint to facilitate behavioural research (Dzialak et al. 2006). Dzialak et al. (2005a,b) provided details on release site selection, habitat and post-release monitoring. We observed peregrines during 18 June - 14 August from a distance of 200-400 m using binoculars and a 20 × 60 m spotting scope (Fujinon®, Wayne, New Jersey, USA; Nelson 1973). Observation was conducted from a single location at each site; these locations were selected to maximize survey capacity. Observation began immediately following fledging and ended with dispersal. Sessions were 10-hour blocks with start and end times staggered to encompass daylight hours (06:30-21:00). Each fledgling was observed in 1-hour blocks. When a fledgling moved beyond survey range for ≥ 15 minutes, a different fledgling was selected for observation. We recorded perch use ≥ 4 days/week during the post-fledging period. We defined a perch as having been used if a peregrine remained on the perch for ≥ 30 seconds after alighting. Using a geographic information system (ArcView®, ESRI, Redlands, California, USA) and Kentucky Gap Analysis Program data (Mid-American Remote Sensing Center 2001), we delineated and quantified the area within the observer viewshed (i.e. the total area in view from the observation point; Camp et al. 1997) at each hacking station. Viewshed areas were 100 km² and 56 km², respectively. We restricted evaluation of perch use and availability to within respective viewsheds to reduce

Table 1. Mean, standard deviation and 95% confidence intervals for characteristics of used (N = 52) and non-used (N = 34) peregrine falcon perching sites in Daniel Boone National Forest, Kentucky, USA, during June-August 2001 and 2002.

Variable	Used			Non-used		
	Mean	SD	95% CI	Mean	SD	95% CI
Diameter at breast height (in cm)	29.2	15.7	25.0-33.4	23.9	10.3	20.6-27.2
Height (in m)	12.1	6.3	10.4-13.8	12.0	5.2	10.3-13.7
Crown class ^a (index)	1.5	0.6	1.3 - 1.7	1.7	0.5	1.5 - 1.9
Snag class ^b (index)	2.5	1.5	2.1 - 2.9	1.5	1.1	1.2 - 1.8
Live deciduous stem density	1.8	3.4	0.9 - 2.7	2.3	2.3	1.5 - 3.1
Snag stem density	1.2	1.2	0.9 - 1.5	1.2	1.2	0.8 - 1.6
Live conifer stem density	6.3	5.7	4.8 - 7.8	7.0	5.1	5.3 - 8.7
Crown evenness index ^c	0.58	0.32	0.49-0.67	0.70	0.21	0.63-0.77

^a Index values for crown class were designated as 1 = dominant and 2 = co-dominant. Dominance refers to trees with crowns extending above the general level of the canopy and receiving full light from above and partly from the side; co-dominance refers to trees whose crowns form the general level of the canopy and receive full light from above but comparatively little light from the sides (Barnes et al. 1998).

^b Index values for snag class are stages of decay with higher numbers corresponding with greater stages of decay (Thomas et al. 1979).

^c Arcsine transformed values for crown evenness index (CEI) proportions displayed. CEI was a measure of the evenness of the canopy as described by 'J' where crown evenness varies from 0 to 1. Complete co-dominance was designated as 1. 'J' approaching 0 indicated a highly uneven or broken canopy in which only dominant trees (i.e. isolated canopies) occurred in the 0.04-ha plot (Zar 1996).

the likelihood of incorrectly identifying non-used trees.

We used a site-attribute design in which a used perch was paired for analysis with a perch that was available but not observed to be used during the study (Flesch 2003). In no instance was a peregrine observed to perch in trees on lower slopes or below the tree canopy, so we limited examination of availability to trees that were dominant or co-dominant in crown class (Barnes et al. 1998), on upper slope positions or cliff plateaus, and that were similar to the associated used tree in terms of distance to the nearest cliff plateau. To select an available non-used tree, we searched in a random direction from each used tree along the nearest cliff plateau until we encountered a dominant or co-dominant tree that was ≥ 20 m from the associated used tree. We delineated 0.04-ha plots around each used and non-used tree to evaluate habitat characteristics that, based on our experience with peregrine reintroduction, we suspected to be important in perch selection. For each tree we recorded species, diameter at breast height (DBH; in cm), height (HT; in m), crown class (CRNCL, including dominant and co-dominant stems; Barnes et al. 1998), and snag class (SNGCL, including stages 1-6 with 1 = live trees, 2 = declining, 3 = dead, 4 = loose bark, 5 = clean and 6 = downed logs; Thomas et al. 1979). Plot variables included live conifer stem density (CSTD, number of coniferous dominant or co-dominant stems), live deciduous stem density (DSTD, number of deciduous dominant or co-dominant stems), snag stem density (SSTD, number of dominant or co-dominant stems in > snag

class 3), and a crown evenness index (CEI; Table 1). These data were collected after all peregrines dispersed from the study area (Dzialak et al. 2005b).

We used logistic regression to compare habitat characteristics between used and non-used perch sites. We constructed a candidate list of 13 models to evaluate variation in the binary response (used vs non-used) following model building strategies outlined in Burnham & Anderson (1998) and Hosmer & Lemeshow (2000). We evaluated interactions by adding interaction variables individually to the main effects model. If interaction terms resulted in increased estimated standard errors and minimal change in point estimates, we considered them not significant (Hosmer & Lemeshow 2000). We used Akaike's Information Criterion corrected for bias (AIC_c) to determine maximum model parsimony, and we considered the model with the lowest AIC_c value to be the best. We calculated ΔAIC_c values and Akaike weights to evaluate the relative plausibility of models and to quantify the weight of evidence in favour of a given model (Burnham & Anderson 1998). Results are presented as mean \pm SD.

Results

We logged 362 total hours of observation. Although three peregrines died before dispersing, perching was recorded in all 22 individuals. We sampled 52 used trees and 34 non-used trees. Many of the observed perch trees were located on shelves that protruded from the cliff face and supported

few or no additional trees to be sampled as associated non-used trees, thus accounting for the fewer number of non-used trees compared to used trees. This biological constraint posed a statistical problem because it is desirable to evaluate an equal or larger number of non-used sites in site-attribute designs (Manly et al. 2002). To address this we conducted a separate analysis in which we randomly selected 34 used trees for comparison with 34 non-used trees; however, we do not report this analysis because results were consistent with the initial analysis and a reduced sample size is not desirable.

Peregrines used pines *Pinus* spp. (*P. rigida*: N = 27; *P. virginiana*: N = 13; *P. strobus*: N = 5; unknown *Pinus* sp.: N = 4; and *P. echinata*: N = 3) exclusively, while pines comprised 78% of the available trees. Dominant trees comprised 55.8% of used perches, whereas dominant trees comprised 32.4% of available trees. Used trees were characterized by greater DBH, and more advanced stages of decay (SNGCL; see Table 1). Used trees tended to be situated in sites with a less even canopy (CEI). The models $\hat{g}(\text{use}) = -1.77 + 0.18(\text{DBH}) + 0.63(\text{SNGCL}) - 0.31(\text{HT})$, and $\hat{g}(\text{use}) = -1.77 + 0.18(\text{DBH}) + 0.71(\text{SNGCL}) - 0.29(\text{HT}) - 0.13(\text{DSTD})$ best fit the data on perch use. These models had AIC_c values of 96.4 and 96.5, and Akaike weights of 0.484 and 0.460, respectively. The other 11 models had AIC_c values of ≥ 102.3 and Akaike weights of ≤ 0.020 .

Discussion

Perch trees used by fledgling peregrines in Kentucky, while not always tall, were large in DBH, in advanced stages of decay, usually dominant in crown class, and were always coniferous. They also tended to be situated in sites with uneven canopies, few deciduous trees, and were always located on cliff plateaus. These attributes likely provide unobstructed flight paths and good visibility, and may represent selection by fledgling peregrines for effective detection of conspecifics, predators or prey (i.e. 'detection effect'; Lima 1994). Vigilance and the general capacity to respond rapidly to stimuli are important for visually oriented predators such as diurnal raptors (Andersson 1981, Bohall & Collopy 1984, Chandler et al. 1995). Tree height can be a predictor of perch use by raptors, particularly in level terrain (Stalmaster & Newman 1979). But considering the topographic complexity and prevalence of cliff plateaus in Daniel Boone National Forest,

perching in tall trees apparently conferred little additional advantage in terms of detection effect over using shorter, stable trees that were in favourable cliff plateau locations. It might seem counterintuitive that greater DBH was not always associated with taller trees but in this habitat larger DBH trees in favourable locations were often stunted in terms of height because of harsh growing conditions or wind damage. Used trees also seemed to confer a degree of protection as they were often at a stage of decay between declining and dead which provided a combination of exposed branches and some needle cover. While our study provides the first quantitative assessment of perch selection in peregrines, our results support a general acknowledgement of the role and importance of perches in raptors and other birds (Sonerud 1992, Krams 2001). Fledgling American kestrels *Falco sparverius* used a variety of perches along secondary roads that provided unobstructed views of their main prey, and they hunted less frequently in habitats that lacked suitable perches (Varland et al. 1993). Fledgling ferruginous hawks *Buteo regalis* perched more often in recently cut hayfields as opposed to unharvested fields where vegetation was more dense (Konrad & Gilmer 1986).

Information from our study might be useful for managers in forested regions who seek to balance raptor recovery and increasing demands for recreational use of cliffs. Rock climbing, rappelling, hiking and camping on cliff plateaus occur throughout public lands in the southeastern U.S. and other forested regions (Matthes et al. 2003). An understanding of what types of perches peregrines prefer in forested cliff habitat could better enable managers to address particular recreational activities such as trail establishment or firewood collection that may alter the structure of post-fledgling area habitat. Perch use data might be useful in development of monitoring strategies for this recently delisted species (U.S. Fish and Wildlife Service 2003), in prioritizing future release areas, or enhancing hack sites by installing artificial perches. Despite the peregrine's remarkable habitat plasticity and the diversity of potential perching substrata throughout its distribution, the adaptive significance of perch selection behaviour likely remains relatively consistent among habitats and between hacked and wild-produced individuals (Sherrod 1983). Additional studies on perch selection by peregrines in portions of their distribution where habitats may be vastly different, such as tundra or desert, will be valuable

in developing a more complete understanding of locally important post-fledging area habitat features.

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