Productivity of Reintroduced Peregrine Falcons in Western North Carolina

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Abstract: Observers monitored a reintroduced peregrine falcon population in western North Carolina from 1987 to 1992. Five of 9 occupied territories produced 19 fledgling peregrines during the study. Productivity for the period was 0.59 young fledged per territory-holding pair per year when using the full data set and 0.79 young fledged per territory-holding pair per year when we dropped marginal territories and 1 adult-subadult pair from the data set. Both estimates of productivity were below that thought necessary for a self-sustaining population. Biologists should improve their monitoring of the region's peregrine falcon population to gain age-specific natality and mortality data.

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Peregrine falcons (*Falco peregrinus anatum*) inhabited the southern Appalachian region of eastern North America before 1960 (Berger et al. 1969). North Carolina's recorded nests were in its western region (Spofford 1942). Various observers reported peregrines in 10 North Carolina locations (Brewster 1836, Ganier 1934, Pearson et al. 1942); but discovered nests with young at only 2 (M. Edwards pers. commun.). Peregrines almost certainly bred at more than these locations in western North Carolina (WNC). We observed, for example, released peregrines successfully reproduce at 2 cliffs not previously reported in the literature as peregrine sites.

Peregrines apparently disappeared from their North Carolina aeries simultaneous to their loss in the late 1950s from other parts of eastern North America. The last active peregrine nest in the state was observed in 1957 (Berger et al. 1969), though peregrines may have persisted unnoticed for several more years. Berger et al. (1969) unsuccessfully searched 5 North Carolina sites for breeding peregrines in 1964.

Scant information exists about the breeding behavior of the southern Appalachian's original peregrines. Some of the best information resulted from observations in the Great Smoky Mountains National Park (Stupka 1963). At the time, Stupka regarded peregrines as resident in the park, noting that the species occurred throughout the year there. Ganier (1931, 1934) observed eggs and young in the park and indicated peregrines began incubating eggs as early as the first week in March.

Reintroduction of captive bred peregrines to eastern North America began in 1974 (U.S. Fish and Wildl. Serv. 1991). A number of southeastern states made releases, starting with North Carolina and Tennessee in 1984. Six states released 349 peregrines in the southern Appalachians between 1984 and 1992. These birds, for the most part, were offspring of The Peregrine Fund (Cornell) breeding flock and therefore represented several subspecies (U.S. Fish and Wildl. Serv. 1991). Releases of captive bred peregrines in the southern Appalachians continue, albeit at a slower pace than in earlier years of the project.

The release of peregrines in an unoccupied region offered an opportunity to study the behavior of a recovering population. In 1987, peregrine falcons made the first breeding attempt observed in the region in decades (Henry 1987). The North Carolina Wildlife Resources Commission (NCWRC) started a survey the same year that relied on volunteer observers to locate nesting pairs. Primary goals of the survey were to document the recovery of the state's peregrine population and to protect peregrine falcon nests from disturbance. The monitoring effort grew as the number of breeding pairs increased. Recently, about 50 volunteers and employees of the NCWRC, U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS) and U.S. National Park Service (USNPS) participated in peregrine nest surveys in North Carolina.

We thank the many volunteers, seasonal employees, and agency personnel who made this study possible. We give special thanks to Gary Henry of the USFWS and Marty Gilroy for their pivotal role in peregrine falcon restoration in the region. We thank G. Henry and H. Mueller for helpful reviews of this paper. Much of the funding for peregrine restoration in North Carolina came from donations to the Nongame and Endangered Wildlife Fund of the NCWRC. The USFS and USFWS also provided significant funding for this work.

Methods

The area examined during the study was the southern Appalachian region of North Carolina and associated foothills to the east. Elevations range from 180 m in the southeastern section of the study area to 2,037 m at Mount Mitchell. Numerous river gorges cut through mountainous areas, particularly through the Blue Ridge escarpment. Granitic plutons are another important feature of the region, being most numerous in its southern portions. Average annual rainfall varies from 108 cm in eastern to 212 cm in southern parts of the area (Natl. Climatic Data Ctr. 1990). Mean temperatures in February (when peregrines initiate breeding activity) vary from –1° C on the highest peaks to 6° C in southeastern parts of the region. People live throughout the area in small towns and on farms. Small- and mediumsized cities occur in the eastern parts of the study area and in the French Broad river valley. Predominant land uses are farming, forestry, light industry, and urban. Hardwood forests cover most mountainous areas. The USFS and USNPS manage important areas in the region as Pisgah and Nantahala National Forests, the Blue Ridge Parkway, and the Great Smoky Mountains National Park.

We conducted the peregrine nest survey in a 4-stage process each year. First, volunteers searched for peregrines in suitable habitat during the courtship phase of the breeding season. Second, biologists followed up positive reports to verify territories and determine nesting outcomes. Third, we used a helicopter to look for nest cliffs and peregrines in difficult terrain. The fourth step in the survey involved climbing to accessible aeries to verify nesting and get unhatched eggs and prey remains.

An objective of the first step of the survey, locating occupied territories, was to observe each survey site on 2 different days for at least 4 hours each day. Project personnel selected survey sites based on peregrine sightings during the breeding season and length, height, and prominence of cliffs. The NCWRC conducted workshops for volunteers each winter. Participants learned to identify peregrines and recognize characteristic breeding behaviors. Volunteer observers began fieldwork 1 April during the period 1987–1990; thereafter, they began 1 March. Personnel used binoculars during the search phase of the survey. We counted as checked sites only those sites that ground observers visited on 2 days for total observation times of 8 or more hours. Reported observation hours represented time spent watching sites and did not include travel time to sites.

Biologists following up on positive reports attempted to make at least 1 visit to each territory each week, observing pair behavior to determine breeding status. Nest monitors always used spotting scopes and binoculars. We did not climb to every nest each year and instead relied on adult behavior to reveal egg laying or hatching in several cases. Biologists estimated dates of incubation by aging chicks based on their growth and the behavior of adults and chicks, then backdating to estimate start of incubation. We did not determine the start of incubation for all pairs that laid eggs. Project personnel attempted to observe nests until the young fledged when 40–45 days old; however, we counted young as successfully fledged once they attained the age of 35 days if there were no subsequent observations.

Biologists used 2 different helicopters during the study, a Huey H model and a Hughes 500. We timed aerial surveys when most pairs would have had 2- to 3-week-old young that were more visible from the air than older eyases. Aerial surveys helped to locate new survey sites. We did not conduct an aerial survey in 1987.

Results

Project personnel checked an average of 13 sites for occupancy by peregrines each year (Table 1). Observers spent an average of 156 hours searching for occupied territories each year, detecting peregrines at territories, on average, within 7.5 hours of starting observations (range 1.5–22.9 hours).

Table 1. Survey effort for nesting peregrine falcons in western North Carolina, 1987–1992.

Year	*N* sites checked	Effort locating territories (hours)	Effort monitoring occupied territories (hours)
1987	11	207	101
1988	11	154	366
1989	14	168	420
1990	12	137	660
1991	13	132	277
1992	15	139	438
Total	76	937	2,262

Nine different territories occupied by pairs received 2,262 hours of observation. Peregrines made 19 nesting attempts in 5 of the 9 territories (Table 2). These pairs fledged 19 eyases, or 2.11 young per successful nest (Table 3). Productivity was defined as fledged young per territory-holding pair and averaged 0.59 during the study. Productivity reached its highest value in 1990, 1.25, and its lowest value in 1991, 0.17. We suspected infertile clutches, predation of eggs and chicks, disease, and the death of small young during bad weather as causes of nest failures.

Biologists estimated dates of incubation for 16 of 19 clutches laid during the 6-year study. Peregrine falcons started breeding earlier in the season during later years of the study (Table 4). Peregrines nesting from 1990 to 1992 began incubating 5 of 9 (56%) clutches during the last half of March. The earliest incubation start occurred in 1992 during the first week of March.

Discussion

Other recovering peregrine falcon populations had higher reproductive success than the population studied in WNC. Ratcliffe (1980) gave estimates of productivity in several regions of Great Britain that ranged from 0.92 to 1.47 for the period 1976 to 1979. Newton and Mearns (1988) observed a recovering peregrine population in south Scotland with an average productivity of 1.10. Productivity varied from 0.60

Table 2. Peregrine population level and breeding performance in western North Carolina, 1987–1992.

Years	Pairs occupying territories	Pairs laying eggs	Pairs hatching eggs	Pairs rearing young
1987	1	1	1	0
1988	5	3	3	1
1989	7	3	2	1
1990	8	5	4	4
1991	6	3	2	1
1992	5	4	3	2
Total	32	19	15	9

Table 3. Fledged brood size and productivity of peregrine falcons in western North Carolina, 1987–1992.

Year	Brood fledged	Brood size 1	2	3	4	5	Mean brood Size	Young per Occupied territory
1987	0						0.00	0.00
1988	1	1					1.00	0.20
1989	1		1				2.00	0.29
1990	4		2	2			2.50	1.25
1991	1	1					1.00	0.17
1992	2		1	1			2.50	1.00
Total	9	2	4	3	0	0	2.11	0.59

to 1.45 during that study. Reintroduced peregrines in New England produced on average 1.24 fledged young per territory-holding pair during the period 1989 to 1992 (Gilroy 1989, Gilroy and Cade 1990, Cade and Telford 1991, Cade 1992). There are several possible explanations for the low estimate of productivity in WNC.

The small number of nests studied reduces the robustness of the productivity estimate. Observer error may also bias productivity estimates. Failing to detect successful pairs or undercounting young fledged could bias estimates of productivity downward. Failing to detect the laying of eggs could bias estimates of pairs producing eggs downward. Failing to detect unsuccessful pairs could bias estimates of productivity upward. Some inexperienced volunteers helping with the search phase of the survey increased the probability of sample error. For example, a volunteer missed an adult peregrine in 1992 at a cliff observed throughout the study. An aerial survey revealed that at least 1 peregrine occupied the territory that year; however, it was too late to determine whether a pair occupied the site or a nesting attempt had occurred.

Table 4. Approximate start of incubation by peregrine falcons in western North Carolina, 1987–1992.

Period incubation started	1987	1988	1989	1990	1991	1992	Total
1–7 Mar						1	1
8–14 Mar							
15–21 Mar				2		1	3
22–28 Mar				1		1	2
29 Mar–4 Apr							
5–11 Apr			1				1
12–18 Apr		1			1		2
19–25 Apr	1		1				2
26 Apr–2 May		1		1		1	3
3–9 May							
10–16 May							
17–23 May		1					1
24–30 May			1				1

Many pairs probably consisted of young individuals making their first breeding attempts during the study. The reintroduction project began in the southern Appalachians in 1984, 3 years before our survey started. No peregrine nests were discovered in North Carolina from 1958–1986 (Lee and Boynton 1990). Observations at 2 of the 5 productive aeries found during this study began before occupancy by peregrines. These were large, prominent cliffs attractive to peregrines and likely to be occupied first by a recovering population (Ratcliffe 1980). Observations at another productive aerie began while occupied by a 2-year-old or older bird and a 1-year-old bird (Ad-Sub pair). Project personnel observed 8 Ad-Sub pairs during the study. None fledged young, though they may have laid eggs. Peregrines less than 2 years old rarely breed successfully; however, they are more likely to do so in a recovering population (Ratcliffe 1980, Newton and Mearns 1988). A trend toward earlier dates of egg laying was another indication that pairs consisted of individuals just beginning to breed during the study (Table 4). Observations of captive peregrines show that breeding behavior appears earlier each season for the first 3 years of breeding (Wrege 1977). We believe that we observed the first nesting attempts in almost 30 years at 4 of the 5 sites where breeding occurred during the study.

Ratcliffe (1980), citing examples of one-time or irregular occupancy of some cliffs, suggested that marginal habitat may not fully stimulate breeding activity in peregrines. Of the 32 instances of territory occupancy during the study, 7 (22%) occurred at 4 sites where no breeding attempt ever occurred. Ad-Sub pairs occurred in 5 of these 7 cases. We had released captive bred young at 3 of these 4 sites in years preceding their occupancy by pairs.

We made another estimate of productivity by excluding from the data set the 7 instances of territory occupancy at sites where no breeding ever occurred and 1 instance of initial occupancy of a productive territory by an Ad-Sub pair. This analysis gave a productivity of 0.79 (19 young fledged in 24 pair-years). Both estimates of productivity from this study were less than that thought necessary for a self-sustaining population (Enderson 1969).

Many of the area's largest cliffs offer few protected ledges on rounded, granite domes. Territories with poor nest sites may influence the productivity of peregrines in WNC. At least 1 brood died during a heavy rain that lasted several days. Newton and Mearns (1988) presented data showing that productivity declined in years with heavy rains around the time of hatching. One territory observed in this study fledged no eyases in 2 years that peregrines incubated eggs on exposed ledges. Immediately after abandoning eggs incubated in 1989, a pair began courtship displays, including scraping, in a recently built raven (*Corvus corax*) nest. The raven nest offered good protection from the elements, and the aerie fledged 5 young in the 3 years since the move. Conversely, peregrines occupying another territory with the largest observed cliff fledged young at least 4 of 5 years that pairs occupied the territory. Production averaged 1.00 young fledged per year. The large nest cliff offered several protected ledges, and pairs changed nest ledges every year, in contrast to pairs on other cliffs with more limited choices.

Poor food resources could have reduced peregrine productivity. Thiollay

(1988) discussed several indicators of a peregrine population limited by food including unusually active hunting by both adults, few surplus prey items in nests or caches, small clutches, and starved young. Our study did not produce data that permit comparison of these indicators with similar data from more productive populations. In later years of the study, WNC peregrines apparently timed their breeding to be feeding young as migrant birds returned. We recovered migratory prey remains from nests where young hatched, for example, red phalarope (*Phalaropus fulicarius*), solitary sandpiper (*Tringa solitaria*), northern pintail (*Anas acuta*), and green-winged teal (*Anas crecca*) (B.A. Sabo pers. commun.). None of these species breed or winter in WNC.

We do not know if contaminants affected the productivity of peregrines in WNC during this study. Peregrines in WNC probably ingest contaminants carried by their migratory prey. Judging from prey remains at nests where young fledged, WNC peregrines depend heavily on resident birds, particularly rock dove (*Columba livia*), mourning dove (*Zanaida macroura*), common flicker (*Colaptes auratus*), and blue jay (*Cyanocitta cristata*) (B.A. Sabo pers. commun.). The youthfulness of the breeding population argues against high contaminant levels, which increase as individual peregrines age. Nonetheless, we have not ruled out contaminants contributing to low peregrine productivity in WNC. We observed several instances of unexplained loss of well-developed embryos or small young.

Human disturbance may have had an impact on peregrine productivity during this study. Rock climbing and hang gliding were 2 human activities potentially disturbing peregrines. The USFS and 1 private landowner closed climbing routes at 4 of 5 productive aeries. The fifth productive territory occurred in a remote area not frequented by humans. One aerie was a popular tourist attraction with over 100,000 visitors each year. A well-traveled trail passed 75 m below the nest ledge. Although climbers did not use the nest area during the breeding season, peregrines avoided observable perches when the park was crowded. The site strongly attracted pairs despite the disturbance, but produced fledged young only once in 4 years.

The number of captive-bred peregrine falcons released in the southern Appalachian region has dropped in recent years. Biologists are counting on natural reproduction to keep the recovery going. This work reports on the breeding success of only a portion of the region's peregrine population. The authors hope that this paper will stimulate additional efforts to monitor peregrine recovery.

The reintroduced peregrine population in WNC may not produce enough young to offset expected adult mortality. However, we have no age-specific information on mortality rates and thus cannot truly assess population trend. Trapping, banding, and identifying breeding peregrines would give insight into movements between territories, adult mortality rates, and age of first breeding. More frequent and detailed observations of nesting pairs would give better counts of young fledged, better information on adequacy of the prey base, and reveal causes of nest failures more often. This type of work is important. Biologists should have an understanding of peregrine productivity and mortality rates when assessing the need for additional releases of captive-bred young.

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