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HUNTING RANGE AND STRATEGIES IN A TUNDRA BREEDING PEREGRINE AND GYRFALCON OBSERVED FROM A HELICOPTER

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ABSTRACT.—Between 6–15 June 1974 an adult male Peregrine Falcon (*Falco peregrinus*) from a breeding site on Alaska's North Slope was followed by helicopter and mapped during 21 hunting sorties. His hunting range was about 319 km² and the greatest straight line distance from the eyrie where he stooped at prey was 14.6 km. All parts of the hunting range were not used equally. An area with sedge-grass marshes and many small lakes was hunted most frequently with 51% of the prey capture attempts occurring there. A second area of similar but drier habitat was used secondly with 36% of prey capture attempts occurring there. Three different hunting methods were used: 1) low, "ground-effect" flight, 2) high direct/maneuvering flight, and 3) soaring. One flight of long duration and one of short duration from start to finish are described. Seventeen hunts timed from leaving to returning to the eyrie averaged 57 min. The shortest hunting sortie followed by helicopter was 22 min; when not followed, the shortest sortie was 23 min. From 2–24 stoops were required during a hunting foray before a kill was made.

Between 27 June and 4 July 1978 near the Dempster Highway, Yukon Territory, Canada, a nesting female Gyrfalcon (*F. rusticolus*) was followed by helicopter (on 9 flights) for a total of 4 hr 1 min and a male (on 5 flights) for 3 hr 10 min. The female hunted and patrolled within 3.2 km of the eyrie. The male went up to 24 km from the eyrie while hunting. On 1 sortie he "patrolled" a three-quarter circle, traveling high approximately mid-way between his eyrie and those of four neighboring pairs. Hunting methods are described and included soaring, ridge-sailing, and "forest slalom."

We also discussed cautions and advantages of using the helicopter to study home ranges, habitat use and behavior far from the nest.

Area y estrategias de caza de un Halcón Peregrino y Gerifaltes de la tundra observadas desde un helicóptero

EXTRACTO.—Entre el 6 y el 15 de junio de 1974, seguimos en helicóptero a un ejemplar macho adulto de Halcón Peregrino (*Falco peregrinus*) desde su nido en la vertiente norte de Alaska, y describimos su recorrido durante 21 excursiones de caza. Su área de acción cubrió 319 kms². La mayor distancia entre su nido y el punto en que se lanzó en picada para atrapar a la presa alcanzó 14.6 kms. El halcón no usó indistintamente todas las secciones del área, sino que mostró preferencia por un área pantanosa y lacustre. Un 51% de sus lances ocurrieron en el área mencionada. La segunda preferencia resultó ser un área con un hábitat similar, aunque más seco, escenario de un 36% de los lances. El halcón utilizó tres métodos diferentes de caza: 1) vuelo rasante; 2) vuelo, maniobras y suspensión en altura; y 3) planeo de altura. Se describen dos vuelos completos, uno de larga y uno de corta duración. El tiempo de duración de 17 excursiones, desde la salida hasta la llegada, promedió los 57 minutos. Las salidas que seguimos con el helicóptero duraron un mínimo de 22 minutos; las salidas que hizo solo, duraron un mínimo de 23 minutos. Durante las excursiones, el halcón se lanzó en picada entre 2 y 24 veces hasta matar una presa.

Entre el 27 de junio y el 4 de julio de 1978, en las proximidades de la carretera Dempster (Territorio de Yukón) seguimos en helicóptero a una hembra de Gerifalte (*F. rusticolus*) que estaba incubando. La seguimos en 9 vuelos por un total de 4 horas 1 minuto, y a un macho lo seguimos en 5 vuelos por

3 horas 10 minutos. La hembra cazó y patrulló en un radio de 3.2 kms. desde el nido. El macho se alejó, en sus cacerías, hasta 24 kms. del nido. En una excursión realizó un "patrullaje de altura" recorriendo tres cuartas partes de un círculo entre su propio nido y los de 4 vecinos. Se incluyen y se describen tres métodos de caza: planeo de altura, aprovechamiento de corriente de aire ascendente, y vuelo zigzagueante entre los árboles ('slalom').

También se comentan las ventajas y desventajas de usar un helicóptero para estudiar los territorios, el uso de hábitat y el comportamiento de los halcones cuando están lejos del nido.

[Traducción de Hugo N. Olaiz]

There are few published data on hunting ranges of the Peregrine Falcon (*Falco peregrinus*), other than some informative radio tracking studies such as those of Enderson and Kirven (1983), and Mearns (1985). For the Gyrfalcon (*Falco rusticolus*) there are no comparable published data. Much of the information on hunting techniques used by wild falcons comes from observations on the outcome of specific stoops fortuitously observed from the ground (e.g., Rudebeck 1951, Campbell 1975, and Dekker 1987) or from observation of nesting falcons that hunted within sight of nesting cliffs (e.g., Monneret 1973, Bird and Aubry 1982). Because our study sites were selected on the basis of eyrie location relative to intensity of human activities (peregrine) and relative to neighboring eyries (Gyrfalcons) and because it was necessary to know the travels and space use by these wide-ranging falcons, the logistics and problems of using radiotelemetry or ground-based observations precluded those methods. This paper reports on the first successful attempts to study hunting behavior and use of home range of two raptors by following them in a helicopter at close quarters from the birds' leaving their eyrie's to their return.

We recognize that the single pair of both species watched may not be representative of their respective species in tundra habitat. We have tried not to draw too many general conclusions from our observations. Because emotion regarding raptors frequently runs high, a good deal of prudence and common sense must be used when studying them (cf. Fyfe and Olendorff 1976). Although helicopters are routinely used to locate raptor eyries, use of helicopters near eyries is still controversial, especially around rarer species. Our studies provide further information on the responses of 2 raptor species to "non-threatening" helicopters nearby.

The peregrine study (by C.M.W.) was accomplished during the construction of the Alaska oil pipeline on Alaska's North Slope. The study was designed by the U.S. Fish and Wildlife Service and oil company personnel to determine effects of oil development on hunting ranges of the peregrine. The

Gyrfalcon study (by R.W.N.) sought information on hunting methods and ranges relative to neighboring eyries, while gathering population, reproductive, and behavioral data for a subsequent larger study by N. Barichello. White was at first skeptical that a helicopter could be used to follow hunting peregrine but the techniques that evolved proved to be perhaps the most suitable available for this type of study at the time. White's success with peregrines stimulated Nelson to attempt similar observations on Gyrfalcons when that opportunity arose.

STUDY AREA AND METHODS

In this paper a hunt, foray or sortie is defined as a flight in which prey capture appeared to be the main objective. A hunting foray may include any number of stoops or capture attempts of prey. A stoop is any dive during a hunting foray that appears to be directed toward a prey item. A chase is the following, in direct flapping flight, of a prey item with apparent intent to capture.

Peregrine Falcons. Peregrine observations were made on the Sagavanirktok River on Alaska's North Slope from 6-15 June 1974, variously between 0600-2300 H, at one eyrie ca. 3.2 km from an Alaskan pipeline construction camp of about 200 persons. A Bell 206B Jet Ranger helicopter was used to follow the falcon. Originally the helicopter was parked below the eyrie and some 180 m distant. The male falcon, doing all the hunting for the female and recently hatched young, was watched with binoculars from the waiting helicopter until he left the cliff to hunt. The helicopter was then started. Because of a warm-up time for the aircraft, the falcon usually was out of sight and unlocatable by the time we were airborne. We then tried waiting on top of the cliff and some 180 m away hoping to be able to keep track of him as he flew away. This was also unsuccessful.

Upon arrival at the cliff on 7 June after a refueling stop, we intercepted the falcon as he left to hunt. It became evident that once both helicopter and falcon were in the air it was relatively easy to follow him at a distance of 150 m as long as he was silhouetted above the horizon. At that distance, however, he was lost to view as he made his second stoop. In general, once he was lost to vision and if his direction of flight was unknown, he was impossible to relocate except by chance. Because of this problem we adjusted our distance from the airborne falcon until it became clear that he could be followed from as close as 45 m.

While waiting below the eyrie we timed the male's rest intervals between hunting sorties, which were about 1.5

hr. By waiting for this time period and then flying slowly past the roosting male, we found we could flush him into the air, veer away to let him start a hunting trip, and then close the distance and follow him through the entire hunt.

It requires practice and skill on the part of the helicopter pilot to "stoop" along with the falcon, keep it in view and at the same time not put the helicopter into the ground; we were successful in following the stoop from start to finish and the hunt from start to finish in most cases.

The size of the home range was determined by plotting movements of the male on a 1:63 360 scale (contour interval 15 m) U.S. Geological Survey map. Stoops he executed were marked on the map. Drawing lines around the hunting range is at best approximate, and we chose to use the boundary lines of the 1 mi² (2.5 km²) sections or half sections diagonally on the map. Locations of the dots indicate the nature and extent of the hunting range. Events were timed with the helicopter clock and notes were made as events occurred. Air speeds given were those registered on the helicopter air speed indicator.

Gyrfalcons. One pair, caring for well-feathered nestlings and then just-flying fledglings, was studied about 10 km from the Dempster Highway, Yukon Territory, Canada. A Bell 206A Jet Ranger helicopter was used. Observations were made between 0900–1800 H, on 6 d from 27 June to 4 July 1978. Helicopter-sharing and logistics precluded observations (a) early in the day, (b) for long durations during any one day, and (c) earlier in the nestling phase. We followed the falcons for just over 7 hr but spent 29.6 hr on the ground observing the nest and environs, awaiting the movement of the adult female off the cliff or the arrival back of either adult. There was no predictability to the timing of the hunts of these falcons. Presence of the male usually was fleeting. He quickly delivered prey to the female or nestlings and immediately left the vicinity of the eyrie. Sometimes we waited up to 5 hr before an adult became visible and available for "shadowing." We were aware of White's success with waiting 1.5 hr before "bumping" the male peregrine into flight, and then following on a hunt. This procedure did not work with Gyrfalcons. The male usually did not perch near the cliff nor begin his hunts from there, and the female, if "bumped," usually simply flew to another perch.

When we arrived near the nest cliff we flew slowly along a ridge running west from the cliff, attempting to find a falcon "ridge sailing," whereupon we followed the bird; or after finding one perched on a prominent rock. If no bird was located, we parked the helicopter on a "bench" slightly below the nest elevation and about 300 m in front of the cliff, to await an opportunity to follow a bird. After some early frustrations at losing sight of adult birds while the helicopter warmed up, we used every opportunity to follow the female as she flew and soared in the general vicinity of the nest cliff. Several times this allowed us to find the male when the female broke off soaring and flew 1 km or more from the nest cliff to receive an aerial food transfer of prey from the male.

Twice, while flying steeply upward toward a high-soaring Gyrfalcons, the helicopter stimulated a stoop from the falcon directly toward the aircraft. Once the falcon pulled out only 10–15 m over the rotors. The other time the helicopter turned aside and fled and the falcon's actions

went unrecorded. Flying the helicopter upward 200–300 m from the falcon, and then slowly approaching it horizontally, caused neither attack nor avoidance.

Usually we followed 30–50 m behind with the falcon at the 1000–1030 H position. If we were directly behind, the falcon often glanced back over its wing, indicating some concern. A position slightly below the falcon allowed for easier viewing of the bird above the horizon. When the bird soared, we often followed it on the opposite side of the circle or hovered just outside its soaring circle. Flight routes of the falcons were plotted on a 1:250 000 National Topographic Series map (150 m contours) and detailed notes made during the flights.

RESULTS AND DISCUSSION

Peregrine Hunting Range: Size. The hunting range was approximately 319.8 km² based on 19 hr 20 min that the male was followed (Fig. 1). The greatest straight line distance from the eyrie where a stoop was made was 14.6 km to the SE. Actual size of the hunting or home range has not been determined for other pairs of tundra inhabiting peregrines, so far as we are aware. Even in relatively uniform tundra habitat, size of the hunting range may vary considerably from individual to individual as shown for the Prairie Falcon (*F. mexicanus*; U.S. Dept. Interior 1979) in a relatively homogeneous sagebrush habitat.

Information on home range size of peregrines elsewhere suggests similar extreme distances traveled from the eyrie and some have ranges a fraction of the size of the Alaskan male. A male and female in California were radio-tracked to about 8 km from their eyrie while a female in Colorado was tracked as far as 19 km from her eyrie (Enderson and Kirven 1983). Of two telemetered females in Scotland followed late in the breeding season, one ranged as far as 18 km from her eyrie, and the two females had maximum hunting ranges of 23 km² and 117 km², respectively (Mearns 1985). Also, in Scotland, Weir (1978, not using telemetry) found no evidence of prey being taken more than 6 km from an eyrie. In that study about 60%, by weight, of the food was grouse (*Lagopus* sp.). In Utah, peregrines have traveled 19–24 km from the eyrie to favored feeding localities (White 1963, Porter and White 1973).

Peregrine Hunting Range: Use. Different regions and habitats around the eyrie were hunted with different intensity. This was probably related in some fashion to prey density and vulnerability (see also Schoener 1971). Wet tussock-heath tundra areas with numerous lakes and sedge-grass marshes in the quarter of the hunting range SE of the eyrie received

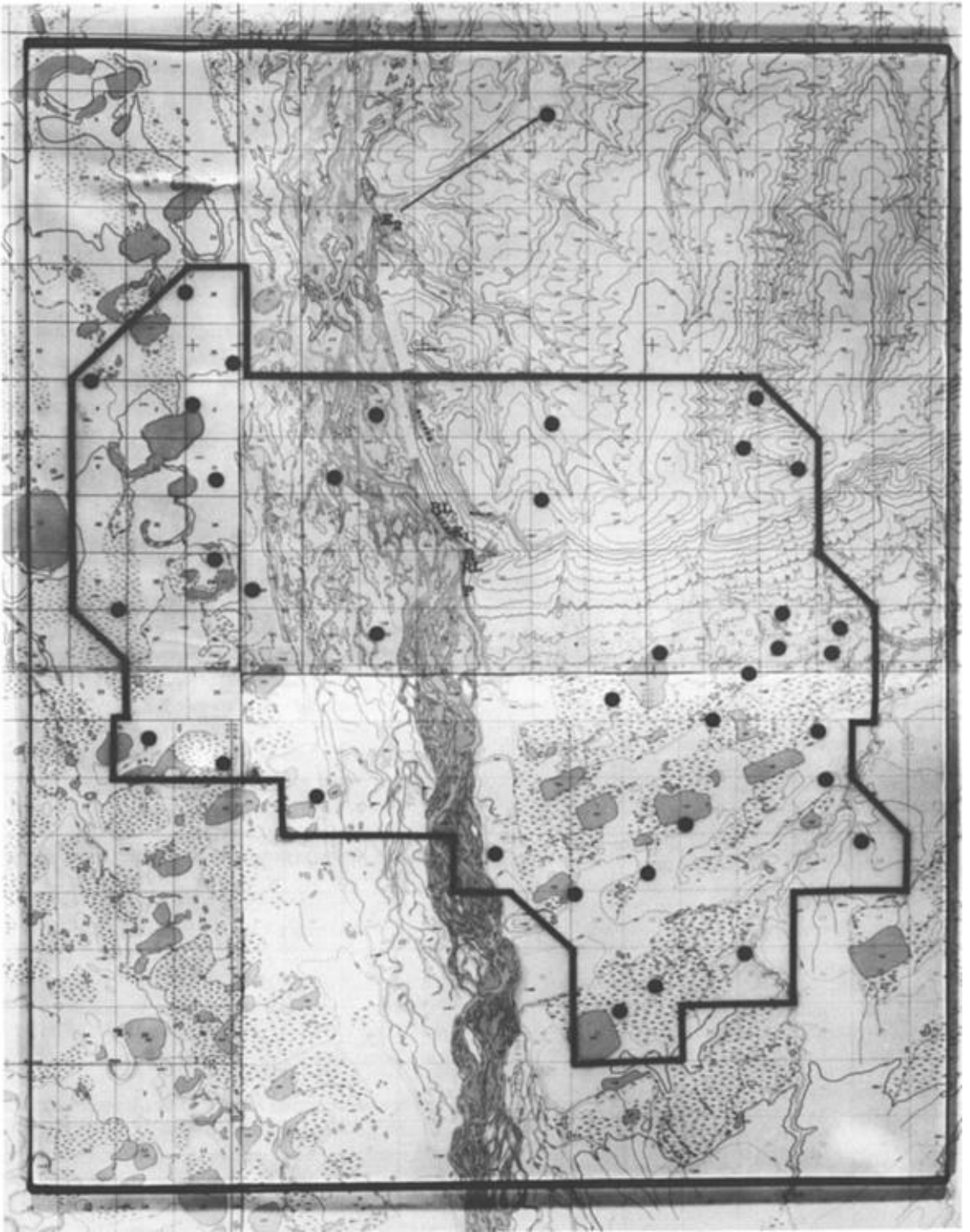




Figure 2. View from near eyrie 2 (see E2, Fig. 1) on 12 June showing the river valley in the midground and wet tussock-heath tundra with numerous lakes in the background.

greatest use (Fig. 2). Fifty-one percent (counting those where we started to follow him but then subsequently lost him) of the hunting forays occurred over this area. Likewise, the greatest amount of time was spent by the male in that area and he went farthest from the eyrie in that direction. West across the river an area of similar habitat but much drier and better drained received the next greatest use. About 36% of the hunting sorties occurred there.

The least used areas were the river corridor and the quarter of the hunting range E, overland from the eyrie. That overland habitat was an elevated region of extremely dry tussock-heath tundra with several willow fringed streams draining S into the wet tundra. Only 13% of prey capture attempts occurred there and most were along a stream rather than over the tussock-tundra itself, although the falcon did crisscross the tundra.

←

Figure 1. Approximate hunting range (within black lines, see text for discussion) of a breeding male Peregrine Falcon in tundra environment. Top of figure is north. Squares on map = 1 mi². Dots represent locations of stoops or chases after prey, selected to avoid clutter and to indicate nature and area of hunting range. E2 outside the hunting range is a second peregrine eyrie and shows one location where the female from that eyrie was followed and stooped at prey. Within the hunting range from top to bottom are a cluster of raptor nests; RL = Rough-legged Hawk (*Buteo lagopus*) nest, E1 = peregrine eyrie from where male was followed, R = Common Raven (*Corvus corax*), RL = a second Rough-legged Hawk, and P = territory held by a lone female peregrine.

Although experience elsewhere on the North Slope indicated that riparian habitat along the rivers received considerable hunting pressure, this was not the case on the Sagavanirktok River. On the Colville River, for example, about 17% of 433 bird-prey items (12 of 41 prey species) consisted of willow-inhabiting passerines typical of riparian habitat (White and Cade 1971). Unlike the Colville, willows along the Sagavanirktok River were generally small and less dense and appeared to support considerably fewer birds. Only three stoops were seen over the main river.

Gyr Falcon: Hunting Range: Size. We flew with the female on nine occasions, totalling 4 hr 1 min, with the longest single flight lasting 63 min and consisting of much high soaring. Six attacks at prey were observed, and one Arctic Ground Squirrel (*Spermophilus parryi*) was captured. When at a perch, soaring at 600 m, or drifting on the wind up and down the high ridges extending away from the eyrie, she appeared to be hunting. Once she attacked an intruding immature Golden Eagle (*Aquila chrysaetos*). Her activities were all confined to within 3.2 km of the eyrie, possibly because of her reluctance to leave with nesting and non-nesting eagles nearby.

We followed the male on five occasions, totalling 3 hr 9.5 min, with the two longest flights lasting 67 and 67.5 min before he was lost to view. One flight was short, to a commanding ridge-top perch, and as we landed nearby, he disappeared off the far side of the rock. One flight went rather directly high and SW over a large tundra plain, another went high and S about 9 km, then W for 8 km to near the same location on the tundra plain. On both flights, by following at too great a distance, we lost him as he suddenly dived steeply and went below the horizon, once at about 600 m and once at about 900 m above ground level. The fourth flight went high and N for 10 km to a mountain range where he hunted the ridge tops and near the peaks at over 1525 m; at one point he was 24 km from the eyrie. We lost him as he crossed over a mountain ridge and disappeared down into a huge tundra-clad bowl. The fifth flight was long, appeared to not involve hunting until the final minutes, again in the tundra plain about 9 km SW of the eyrie; it is described below.

Other studies have shown that Gyrfalcons range widely to obtain food, especially in years when ptarmigan (*Lagopus* sp.) numbers are low (White and Cade 1971). On Alaska's North Slope they appear

to go in excess of 16 km from the eyrie and Kistchinskii (1958) determined that on the Kola Peninsula Gyrfalcons may travel approximately 19 km from the nest to hunt.

Gyr Falcon Hunting Range: Patrolling. On one flight the male flew high N toward the mountains, passing 8 km E of a neighboring occupied eyrie, then 7.5 km E of another eyrie. At that point he had curved NE and eventually arrived over a bank of low cloud which blanketed the mountain range. He then flew E for about 5 km over the edge of the mountains and cloud until turning S when 6.5 km W of another eyrie. He flapped and glided almost directly south for about 14 km, turning SW when 4.5 km from yet another eyrie. After flying about 10 km SW over the tundra plain, he wandered 5 km NW and began a series of low level hunts. After about 10 km of low-level hunting he landed during a rain shower, and eventually we lost him there, in the general vicinity of where we had lost him on the two stooping flights. The first part of this flight gave every appearance of being a boundary patrol of the line midway between his eyrie and that of four neighboring Gyrfalcon pairs to the WNW, NW, NE, and ESE. (No active eyrie was found in the mountain range to the N of this eyrie.) This flight path described a slightly flattened circle and enclosed almost 200 km². His total observed travels in just over 3 hr of our flight time encompassed about 280 km².

Peregrine Hunting Sorties: Methods. The predominant mode of hunting by peregrines has generally been portrayed as a steep angle stoop from a "waiting-on" position at prey that is already on the wing. Watching peregrines hunt in an array of habitats (tundra, montane, taiga, tropical forest, marine and urban) suggests that certain modes of hunting are used more in one habitat than in another and that several types are used with considerable frequency. Some of the techniques used by the peregrine were similar to those briefly described for Gyrfalcons (White and Weeden 1966, Bengston 1971).

Three distinct hunting strategies were observed in this study: 1) low, maneuvering "ground-effect" flight, 2) high, direct/maneuvering flight, and 3) soaring "waiting-on" flight. These types were used in combination and most frequently the latter two were used alternately. However, soaring was used almost exclusively in the case of one hunting sortie once the male was over the preferred hunting area.

The low, ground-effect flight consisted of continuous, rapid wing beats while traveling on average

60–80 kmph (air speed) about 12–25 cm above the ground. In direct (unladen) flight to hunting areas the male averaged about 55 kmph which is nearly 20% faster than normal cruising air speeds (\bar{x} 44 kmph) of migrating peregrines (Cochran and Aplegate 1986). On several occasions during the low ground-effect flights the tips of the wings seemed to actually touch the tops of tussock mounds or the water over which the falcon flew. On one occasion (flight started at 1809 H) he continued this strategy over a zig-zagging course covering about 7 km during which time three passerines flushed in front of him. He unsuccessfully grabbed at each of them. He achieved at least 112 kmph on three occasions. Finally at 1830 H a male Willow Ptarmigan (*L. lagopus*) flushed from the dwarf willows along a stream the falcon began to follow. The falcon was traveling so quickly that he had to make a rather wide arc before he could start chasing the ptarmigan, which had by that time gained about 60 m on the falcon. The falcon took a direct course at the ptarmigan until it was evident that the ptarmigan was turning to fly downhill at which time the falcon took a diagonal course to intercept it. The falcon reached the ptarmigan after about 215 m. Just as he was about to grab the ptarmigan from behind (both birds being about 2 m above the tundra) the latter rose vertically into the air and the falcon passed under him, after which the ptarmigan dropped straight to the ground (a typical ptarmigan evasive tactic to avoid Gyrfalcons as described by White and Weeden 1966). The peregrine made 2 shallow stoops at the ptarmigan on the ground. An immature Golden Eagle that was summering in the immediate area and perhaps had been sitting on the tundra, suddenly flew in at the ptarmigan. The falcon immediately began to soar (1834 H) and reached 80 m where he remained until 1836 H when he stooped at a prey item on the ground, missed, and began the low flight again. At 1840 H he was momentarily lost to view and as we sat the helicopter down we saw him rise above the horizon (perhaps 5 m in the air) in the fashion of a falcon that had missed its prey after a stoop, and he then resumed the low-to-the-ground flight. We were unable to relocate him. He returned to the eyrie with prey at 1936 H.

During the time we were able to follow him he covered about 12–16 km of circuitous flying. He spent at least 22 min of the time traveling less than 30 cm off the ground at about 72 kmph, occasionally exceeding 112 kmph, with a continuous wing beat.

The manner in which he followed the contour of the ground at those speeds was similar to behavior we have seen in peregrines following the contours of the ocean's swells as they hunt small alcid and storm-petrels (*Oceanodroma* sp.; cf. Sherrod 1988 for a discussion). Apparently by flying so low, falcons in both environments are gaining the advantage of reduced drag produced by the so-called "ground-effect" described by pilots as lift produced by compression of air below the wing when within one-half the wing span of the ground (cf. Jenkins 1974, Welch 1987) and thereby obtain higher speeds from the same energy expenditure. Such rapid, low-level flight also must be important in approaching and surprising potential prey.

The course of two high, direct/maneuvering hunting sorties, one of long and one of short duration, are given in Tables 1 and 2. One of the more salient features of these sorties was the "all business" attitude of the male when hunting, similar to the high intensity hunting of Treleven (1980). Immediately after a stoop he climbed directly back to a high position and began searching for another prey item. Note in Table 1 how consistently and quickly he rose to near 150 m after each capture attempt. A consistent height was also regained after each stoop by the peregrines monitored by Alerstam (1987). Even when the falcon struck a potential prey but did not kill it he promptly began hunting again.

The peregrine did not use the cliff as a perch from which to launch directly at prey nor did he make kills near the cliff. Hunting from a cliff perch was seen in the tundras of Greenland (W. Burnham, pers. comm., Harris and Clement 1975) to catch Lapland Longspur (*Calcarius lapponicus*) and Wheatear (*Oenanthe oenanthe*), in the Yukon taiga to chase passerines and shorebirds, and in the marine setting to catch small seabirds (R.W.N., pers. obser.). This method has also been observed in western montane regions (C.M.W., pers. obser.). We likewise did not observe peregrines chase prey high into the air where they are finally caught and killed (Campbell 1975, Cade 1982, Clunie 1976). Both methods, however, probably are used on occasion in the tundra.

More prey items were killed on the ground or grabbed while only a few meters in the air than those "struck" in the air. Careful observations from other regions are similar. Monneret (1973) watched about 400 attacks by a breeding peregrine in mountainous country in France and found that the falcon

Table 1. A long hunting sortie of male peregrine employing both soaring and high flight on Alaska's North Slope, followed on 12 July 1974.

TIME	EVENT	COMMENTS
1125	Started hunt	Left cliff going to SE at 90 m and 56 kmph (helicopter air speed), climbing to 240 m, steady wing beat until arriving over ice-covered lake about 12.8 km SE of eyrie.
1134	Arrive at lake	Continuous, steady wing beat.
1136	Stoop	Missed intended prey, climbed immediately again to 90 m, continuous steady wing beat.
1137	Stoop	Hit sandpiper (<i>Calidris</i> sp.) on ground but could not hold it, chased sandpiper up to about 90 m where he began soaring for first time trying to get above the sandpiper eventually going to 120 m.
1141	Steady wing beat	Altered wing beating with soaring for 2 min, reaching 130 m.
1142	Soaring	Alternated wing beating with soaring maintaining about 130 m.
1143	Stoop	Low across lake, striking water surface twice in attempt at a Red-necked Phalarope.
1145	Climbing	Climbed immediately back up to 150 m with steady wing beat.
1146	Soaring	—
1147	Stoop	Began stoop at 200 m, leveled off horizontal by ca. 10 cm above ground while 180 m from prey and exceeded 160 kmph (air speed) along ground, missed prey, climbed immediately back up to 110 m.
1148	Flight	Began alternating soaring and steady wing beating.
1148.5	Stoop	Hit an American Golden Plover and dragged plover a few feet across ground but lost hold.
1149	Climbing	Climbed back to 90 m.
1149.5	Soaring	Soared up to 220 m.
1150	Alternate flying modes	Between 1150 and 1203 H there was alternating of a steady wing beat followed by a glide and then soaring followed by steady wing beat with a repeat of the sequence; reached 226 m.
1203	Stoop	Missed sandpiper (<i>Calidris</i> sp.) on ground on first try, momentum carried him ca. 5 m in the air where he tried twice more at sandpiper as it flew across tundra.
1203.5	Interspecific encounter	Chased by Parasitic Jaeger (<i>Stercorarius parasiticus</i>) briefly but then jaeger began chasing the sandpiper.
1204	Climbing-soaring	Climbed back up to 215 m where he soared for 6 min reaching 330 m; defecated twice.
1210	Stoop	Increased speed to 144 kmph, leveled off about 60 cm above ground while yet 30 m from sandpiper (<i>Calidris</i> sp.); missed.
1210.5	Climbing-soaring	Climbed immediately back up to 120 m again, began to alternate soaring, steady wing beating and gliding, rising to 135 m where he remained for about 7 min.
1217	Stoop	Missed prey, then he continued across tundra at 5-6 m as he grabbed at but missed 2 passerines and 1 sandpiper that flushed from tundra in front of him as he flew past, then climbed.
1222	Stoop	Pulled out after 125 m, leveled off, discontinued stoop and soared.
1229	Stoop	A series of loops and nearly vertical stoops at a passerine but missed.

Table 1. Continued.

TIME	EVENT	COMMENTS
1229.5	Climbing—steady flapping	Climbed back up to 120 m, steady wing beat for about 3 min.
1232	Stoop	Hit prey on ground, continued to fly with prey back toward eyrie.
1245	Arrived at eyrie	Returned to eyrie with a Pectoral Sandpiper after 80 min hunt.

seemed to prefer hunting from a high cliff and “binding” to the prey rather than “waiting on” high in the air and striking the prey. Also, he found that attacks were more often initiated when prey were on the ground or perched than when prey were on the wing (see Monneret 1987). This latter tendency was clearly evident with the peregrines on the North Slope.

Most stoops were executed at about a 60°–45° angle (but see Alerstam 1987) reaching speeds of at least 160 kmph with a leveling off at about 60–150 cm in the air while yet 30 m or so from what proved to be his intended prey. Most frequently we could not discern what he was after until we saw it flush or saw him actually strike at it. Several stoops were started over 1.6 km from the point where he actually struck at the prey. The majority of the stoops were made from an altitude of 215–320 m.

Peregrine Hunting Sorties: Duration and Success. The presence of the helicopter seemed not to

alter the duration or success of the falcon’s hunting effort. The average length of 17 successful hunting sorties for which we have precise times on departure from the eyrie to return was 57 min (on some of these the falcon was lost so we returned directly to the eyrie to await his arrival). When followed in helicopter (N = 10), the shortest time between leaving the eyrie, making a kill and returning to the eyrie was 22 min. When not followed (N = 7) the shortest time was 23 min. The longest time for a sortie when followed was 80 min and 93 min when not followed.

We followed the male falcon on 21 sorties although in 4 cases he was lost in as few as 5 min and in 2 cases he was found again after being lost to view for as much as 5 min. We have a fair degree of confidence that on 13 sorties he averaged about 10 stoops (range 2–24) before making a kill. The 2 stoops were directed at a single prey item and the 24 involved attacks at nine different prey items. Dur-

Table 2. A short hunting sortie of a male peregrine as followed on 12 July 1974.

TIME	EVENT	COMMENTS
1642	Started	Left eyrie going back overland over dry tussock hunt tundra.
1644	Steady flapping	Turned south in direction of lakes.
1647	Stoop	Start stoop at 125 m, missed, climbed back to 122 m.
1647.5	Soaring	—
1648	Stoop	Grabbed sandpiper (<i>Calidris</i> sp.) about 3 m above the ground where he nearly stalled out in the air but regained flight (about 10.4 km SE of eyrie) and headed in the direction of the eyrie but a bit south of it.
1649	Flying	Reached 60–90 m in a steady course flying 44–50 kmph until he reached edge of river bluff at which time he was only 9 m above bluff; dropped low along edge of cliff flying straight to eyrie but 1.6 km north along the bluff.
1705	Exchange	Food exchange in air, female flew off to eat and male went to nest; from leaving cliff to kill 6 min elapsed. From departure to return to cliff 23 min elapsed.

ing the course of a hunt involving 14 stoops, two sandpipers were grabbed but released or escaped. This male was not as efficient as that described by Cade (1982; New Jersey marsh) or L. Hays (pers. comm.; Zion Natl. Park) where frequently prey was caught on the first attempt within a few minutes after the falcon left his perch. In more recent years, two different males along the Colville River, Alaska, have been seen to make a kill on the first stoop of a hunt (C.M.W., pers. obser.).

The prey items that were either killed and identified or identified from the helicopter after a stoop was made were: Willow Ptarmigan, Semipalmated Sandpiper (*Calidris pusilla*), Lesser Golden Plover (*Pluvialis dominica*), Pectoral Sandpiper (*Calidris melanotos*), Red-necked Phalarope (*Phalaropus lobatus*), Lapland Longspur, Savannah Sparrow (*Parserculus sandwichensis*), and American Tree Sparrow (*Spizella arborea*).

Gyrfalcon Hunting Sorties: Methods. Gyrfalcons hunted (a) from perches, and while (b) in a harrier-like flight, (c) ridge-sailing, (d) ridge-hopping, (e) swerving among trees in forest (forest slalom), and (f) traveling high with soaring. Both sexes hunted from commanding perches on rocks on high ridges or hills from which a downhill attack could be initiated. We saw no attacks from the immediate vicinity of the eyrie cliff. Several times the female hunted for many minutes almost like a harrier, flapping and sailing slowly along an erratic path 2–20 m over the tundra and fine gravel ridges, apparently in search of ground squirrels.

Ridge-sailing, on days with sufficient wind, was used especially by the female. With few wing beats she sailed at 3–8 m along and back over the windward side of a long, high ridge. Once she suddenly landed on a patch of dirt and caught a ground squirrel. She sailed a short distance farther along the ridge, then swung back along the ridge and dived to the eyrie with the freshly caught prey.

In the mountains the male traveled close to some low peaks and crossed high over intervening valleys. Several times he crossed very low over ridges (ridge-hopping) and suddenly had below him expanses of tundra in which unsuspecting prey might be spotted.

Especially the male used a forest-slalom hunting method in which, from various heights, he made a rapid, shallow swoop ending with a twisting race for 50 m or much more between the middles and tops of the scattered spruce trees on the slopes of draws in the tundra plain. It was not clear whether

he was attempting to ambush prey already sighted or whether he expected unseen or seen prey to flush in front of him as he suddenly approached.

The male used a very strong flapping pattern when climbing in a straight line or circling up quickly, and when traveling high (airspeed 48–56 kmph). Presumably he was hunting most of the time when he was traveling to an area where he was seen to hunt. When about to initiate an attack he might flap with a more leisurely beat, glide and flap, soar, or continue the strong flapping pattern—we had no warning that a serious attack was to begin. He twice started steep dives from great heights, but the rest of those two hunts went unseen. The female often soared high, especially over the edge of the tundra plain. Sometimes she was followed on a long, very shallow stoop from soaring, ending with a rapid glide just above the vegetation for 50 m or more before pulling out of unsuccessful attacks.

Gyrfalcon Hunting Sorties: Problems in Following. It was extremely easy to lose sight of the falcon. If we lagged too far behind, the falcon could disappear against dark talus or vegetation, and if the falcon stooped it became invisible when it passed below the horizon. Once the falcon crossed a mountain ridge, and we were unable to relocate him when we reached the ridge just seconds later. Not once did it appear that the falcon was attempting to lose the helicopter; this would have been relatively easy for the falcon to do, especially when flying at a considerable height.

If we had flown with the Gyrfalcons early in the nestling phase, before the female had seriously resumed hunting, we probably would have had more opportunities to follow the male on hunts because he was much more conspicuous near the cliff at that time.

Observed Responses to Helicopters. We have accumulated nearly 1700 hr (as of 1990) of combined time in helicopters observing or searching for raptors. From such flights we believe that peregrines are particularly tolerant of helicopters even when not on nests (see White and Sherrod 1973, D.H. Ellis, pers. comm.). Gyrfalcons appear to be less tolerant. It is possible that the falcons we observed for this study became habituated to the helicopters quickly as a result of our early and unsuccessful attempts to follow. Once we mastered the techniques, the birds were not visibly intimidated by the rather slow and unthreatening flight characteristics of our flying patterns. Although it is possible that many of

these birds will readily tolerate a helicopter traveling with them, it must be noted that much of the philosophy and methodology which brought us these results are not detailed here; the potential threat of the helicopter-shadowing technique to the lives of the raptors and their broods, and to the lives of the human observers, may be high and must not be taken lightly.

Several times we passed relatively slowly within 20 m over or beside peregrines in both Jet Rangers and Alouette helicopters. On those occasions the falcons' response was to turn their heads and watch us pass. On one occasion in the Aleutian Islands, as we were landing the helicopter at an archeological site near the beach, we noted an immature female peregrine about 6 months old flying along the beach ridge toward us. She landed on a mound at the archeological site (20 m away) just as we were settling the helicopter to the ground. She watched the helicopter as the main rotor stopped turning, and she did not fly until being frightened as one of us stepped into full view from the aircraft. Similarly, the peregrines we observed on the North Slope were unusually tolerant of the helicopter as long as a human was not in view outside of it. Although we have never witnessed a peregrine attack a helicopter, R.W. Fyfe (pers. comm.) observed this on the Mackenzie River, Canada. In the same general area J. Campbell, Jr. (pers. comm.) reported a peregrine attack upon a fixed-wing aircraft.

Gyrfalcons seem somewhat less predictable, perhaps more aggressive. Both sexes calmly soared within 12–15 m of our hovering helicopter (Fig. 3). However, Gyrfalcon on the North Slope and in this study flew rapidly from helicopters traveling at high speeds, while the aircraft is still several hundred m distant (Platt 1977, J.B. Platt, pers. comm. and pers. obser.). In some situations, Gyrfalcons vigorously attacked fixed-wing aircraft (D. Roseneau, pers. comm.). As noted above, Gyrfalcons have attacked a helicopter climbing toward them, and D. Mossop (pers. comm.), while surveying nests during inclement weather, had a number of Gyrfalcons attack a mostly white helicopter. The normal response of the study peregrine to the helicopter is demonstrated by the following account. On 8 June at 1050 H the male relieved the female at her brooding duties, and she flew to a nearby gully to perch. At 1130 H she took flight and began to soar as though she might be going to hunt. She was in a thermal and slowly started to rise, eventually going from 156 m to about 190 m

as she drifted south along the cliff line. We remained about 24 m from her. We maintained the front of the helicopter facing the falcon in an effort to keep it in sight forcing us to continually turn in a rather tight circle as though soaring. At 1135 she was immediately above the area occupied by a lone non-breeding female peregrine. The lone female promptly began to soar and soon reached the same altitude as the helicopter. A few stoops were made by each falcon at the other falcon. Both soared to within about 15 m of the helicopter and neither seemed to be concerned with it until at about that distance. A brief dodging movement was then made by each falcon away from the helicopter and then soaring was resumed. An adult male peregrine suddenly appeared with the other two soaring falcons, and he too began to soar. For about 2 min there were three peregrines and one helicopter all "soaring" within a 60 m area. At 1145 H the male started in a direct flight toward some presumably distant downriver locality (the next eyrie site was about 8.6 km downriver) and both females returned to their respective cliffs.

In a similar manner three of the Rough-legged Hawks nesting near the peregrine eyrie (see Fig. 1) attempted to "soar" with the helicopter. In that instance we had lost sight of the hunting male peregrine to view within a couple of minutes of leaving the eyrie and we were slowly turning the helicopter in tight circles scanning the horizon for him. Suddenly we noted two, and a few minutes later a third Rough-legged Hawk level with the helicopter (ca. 300 m altitude), all trying to soar. There was no rising thermal in spite of the "soaring" helicopter and the hawks slowly sank only to flap again to gain altitude opposite the helicopter. They were all within 30 m of the helicopter. We do not know how long they would have maintained this behavior, as we left to return to the falcon eyrie to await the arrival of the male. We have not followed in helicopter Prairie Falcons, Golden Eagles, Bald Eagles (*Haliaeetus leucocephalus*), or Osprey (*Pandion haliaetus*). Individuals of the latter three species have attacked helicopters and Golden Eagles and Ospreys have hit the aircraft and killed themselves (R.W.N., unpubl.).

Several times while the male peregrine was in a hunting soar he drifted to within about 18 m of the helicopter before he appeared to notice it. He usually made a quick turn and flew some 3–5 m further from the helicopter where he resumed hunting, looking at the ground again.



Figure 3. A female Gyrfalcon, being "shadowed" by a helicopter, calmly soared toward and then past within 12–15 m in front of the helicopter. The 2 m antenna on the helicopter's nose shows because the helicopter's slow forward motion was being stopped.

On 11 July the helicopter hovered about 14 m away from the cliff while the female completed an entire sequence of feeding young and then settled to brood without showing apparent distress from the presence of the helicopter. (See White and Sherrod 1973, for a photo from this feeding sequence and further discussion.)

Value of Helicopter Following. Most early studies on home ranges of raptors employed the technique of mapping locations where individual birds were seen on several days and then drawing minimum polygons that encompass all sightings (e.g., Craighead and Craighead 1956). Many later studies used radio telemetry (e.g., Cochran et al. 1965, Forbes and Warner 1974, Enderson and Kirven 1983). For long-distance travelers, such as the falcons we studied, the latter method would have been preferable but has serious logistical constraints. Data using either technique may not, however, correlate directly

with data collected by the method we used and thus comparisons may be difficult.

Data gathered from our studies were unlike two other studies of radio-telemetered nesting peregrines in several aspects. Mearns (1985) in Scotland determined the hunting ranges of two females near the end of the breeding season. An analysis of foods taken also gave some indication of the differential use of the habitat they hunted. Enderson and Kirven (1983) in California studied a male and female and while obtaining good data within 2 km of the eyrie they were uncertain about the extent of use of the main hunting areas. In such radio-telemetry studies the subject bird is out of sight of the investigator on most of the hunting flight and, apart from its approximate location on a map, only the most rudimentary behavioral information were obtained from the radio signal. (Using satellite tracking will of course eliminate the above problems.) While data from our per-

egrine study were obtained over a much shorter time than the above two, a very good indication of the differential use and extent of the hunting range was obtained. The falcon's behavior was continuously observed during hunting flights from start through prey capture and return, and the prey species, locations, and habitats hunted were recorded.

Because both Peregrine Falcons and Gyrfalcons tend to be tolerant of helicopters during certain parts of the breeding season and when they encounter the helicopter under certain conditions, following of these species can produce five kinds of information that are difficult or impossible to obtain through more conventional methods: 1) Hunting techniques, success, and duration, from the start of a hunt to the end can be recorded. 2) The habitats actually hunted and certain sites that are used for hunting more than other areas are identifiable. 3) Precise routes and elevations of hunting falcons can be determined. 4) Prey species actually attacked and different techniques used in various situations or with certain species can be observed. 5) Behaviors previously unrecognized in wide-ranging falcons may be detected.

Although the rental of a helicopter may be very expensive, in situations where the logistics are acceptable and the birds will tolerate the aircraft this technique is very competitive with other methods. In a relatively short time it can produce large amounts of detailed, unusual information about the travels, habitat use, and behavior of extremely mobile birds.

As a postscript, the young peregrines from the eyrie studied were depredated about 3 wk after the study ended (L.W. Sowl, pers. comm.) but either that pair or another used the same eyrie the following year.

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