An Inventory and Protection Plan for Ferruginous Hawk (*Buteo regalis*) Nests on The Navajo Nation

(REDACTED FOR DISTRIBUTION July 7, 2006)

David G. Mikesic, Zoologist
Navajo Natural Heritage Program
Navajo Nation Department of Fish & Wildlife
P. O. Box 1480
Window Rock, Arizona 86515

1 June 2005

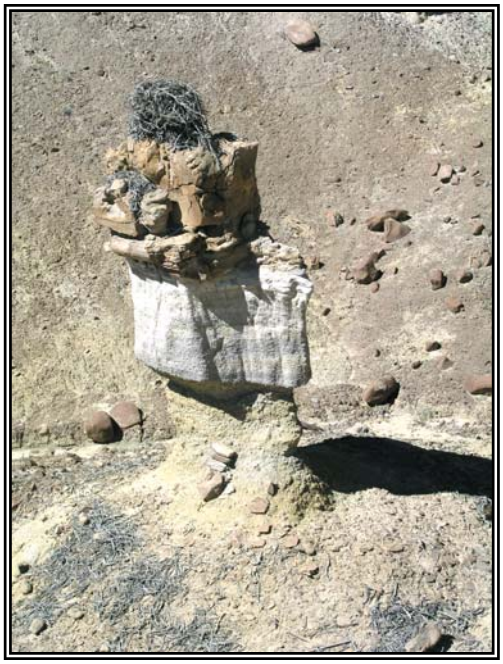


TABLE OF CONTENTS

ABSTRACT

The Ferruginous Hawk (*Buteo regalis*) is a year-round resident to the Navajo Nation, nesting primarily within the grasslands and desert badlands in northwestern New Mexico. This hawk is very sensitive to human disturbance, and is suspected of range-wide declines in population in the last several decades, partly due to human intrusions to nesting habitat. The species is Navajo-tribally listed as 'threatened' on the Navajo Endangered Species List, and listed on numerous sensitive species lists elsewhere. The Navajo Nation Department of Fish and Wildlife (Dept.) has undertaken this project to: find and record all nesting occurrences of the Ferruginous Hawk on Navajo lands in New Mexico, and provide long-term protection to all nesting sites on the Nation.

Approximately 2,787 km^2 (1,076 mi^2) of Navajo Nation lands in northwestern New Mexico was identified as potential nesting habitat for the Ferruginous Hawk. Initial surveys for nests were conducted by rotary-wing aircraft in late August 2004. The pilot and one observer spent 43 flight hours completing survey of 2,442 km^2 (943 mi^2) of suitable habitat, which was 88% of the total area of potential nesting habitat. The remaining 12% of potential habitat was surveyed by fixed-wing aircraft in May 2005.

A total of X Ferruginous Hawk nests were located in 2004, and an additional X nests were located in 2005. Of the total nests, 54.4% nests were newly discovered by these surveys, while 45.6% were known by the Dept. prior to this work. Most nests (64.8%) were found on sandstone and/or clay pillars, around 10% were found on each of three other substrates of ground (10.7%), small butte (10.7%), and cliff (11.5%), while only 3.2% were on large butte structures. Nearly all nests (93.6%) were found on lands managed by the Navajo Nation. All

nests were within a 500-m (1,640-ft) range of elevations from approximately 1,567 m (5,140 ft) to 2,066 m (6,780 ft) above sea level.

Nests were separated into potential territories using home-range estimates from the literature. Sixty percent of these territories were newly discovered during this work, while 40% were previously known. Nest-quality determinations revealed that 58% of all potential territories had at least one nest in good or excellent condition, while 42% of the territories contained only old or dilapidated nests. Although 42% of potential territories appear abandoned by nesting hawks, this may not necessarily indicate a decline in the breeding population, but rather be a result of the hawks' nomadic nature in selecting nest sites. Regardless of whether we are observing a decline in breeding or just the dynamic use of a landscape for nesting, broad nest protective measures seem necessary to ensure long-term survival of this hawk's nesting population on the Navajo Nation.

INTRODUCTION

The Ferruginous Hawk (*Buteo regalis*) is the largest North American hawk, with adults of the typical light-morph distinguished by a white or gray tail, nearly-white underparts, and dark-reddish legs (Bechard and Schmutz 1995). They also exhibit a rust-colored shoulder patch, gray back and feathered tarsi (Glinski 1998). The species nests within open-country habitats of grasslands, shrubsteppes, and desertlands throughout much of the western North America. The breeding range extends through three Canadian provinces from southeastern Alberta to extreme southwestern Manitoba, and includes 17 western states from the Dakotas to northern New Mexico and Arizona, then northwest through Nevada to eastern Oregon and southeastern Washington. Within this range outline, the species is absent from much of northeastern Idaho, western Montana, northeastern Wyoming, southeastern Utah, and central Colorado. Winter range primarily includes grasslands and shrublands from northern California through southern parts of Nevada and Utah to central Oklahoma, then south through eastern Texas to central Mexico (Bechard and Schmutz 1995). The Navajo Nation, which covers 30,883 km^2 (24,347 mi^2) in Arizona, Utah, and New Mexico, occupies part of the southern edge of this species' breeding range, and is near the northern portion of the its wintering range.

The Ferruginous Hawk primarily occupies the eastern portion of the Navajo Nation, nesting within the desert grasslands and badlands in northwestern New Mexico. The Navajo Nation occupies approximately 17,094 km^2 (6,600 mi^2) in New Mexico, with much of the eastern-most portion being divided between various land owners ("check-boarded"), including the Navajo Nation, Bureau of Land Management, National Park Service, state of New Mexico, and private landowners. A large expanse of suitable nesting habitat is present here, especially in the desert badlands, in the form of rounded hilltops, rock and clay spires, small and large buttes,

and short cliffs. The northern portion of this area is excellent wintering habitat due to the presence of a large irrigation (Navajo Irrigation Industry Products) and farming operation (Navajo Agriculture Products Industry) on Navajo Nation lands south of the San Juan River between Farmington and Shiprock. The presence of these two operations provides a dependable source of prey throughout the year, and especially during the winter months, when prey may be scarce elsewhere. Also, BHP Billiton, BHP Navajo Coal Company leases 87 km^2 (34 mi^2) within this part of the Navajo Nation for surface-mining of coal, and has a number of nesting Ferruginous Hawks each year on its lease land plus an additional 1.6-km (1 mi) buffer.

In addition to the hawks nesting in New Mexico, a small number of nesting pairs have been known to occupy parts of the Navajo Nation within Arizona. Each of these pair have used low-elevation grasslands, but habitat characteristics at the nesting sites are rather unique from one other. Nesting habitats in Arizona included: small patches of desert badlands within expansive grasslands, short rocky outcroppings and large buttes within grasslands, and patches of junipers.

Ferruginous hawks use a variety of substrates for nest placement within their preferred habitats of grasslands, shrub steppes, and desert-lands. Analyses of over 2,000 nest sites throughout the hawk's range have found that most nests are placed in trees and shrubs (49%), followed by cliffs (21%), utility structures (12%), and ground outcrops (10%) (Olendorff 1993). Within the Great Plains where natural elevated structures are scarce, ground nests are commonly placed on slopes, knolls, and ridge crests (Palmer 1988). Nearly half of the nests in Colorado and North Dakota were found in human-made settings (Olendorff and Stoddard 1974, Gaines 1985). Electrical transmission towers and artificial nest platforms, specifically constructed for the hawk, are being used more commonly for nesting. Within northwestern New Mexico, Ramakka and Woyewodzic (1993) found 86% of 72 nests situated on tops of clay

or rock pinnacles, 6% on cliffs, 4% on the ground, and only 3% in trees. Prior to this work, over half of the nests known on the Navajo Nation were placed on narrow-vertical rock and/or clay pillars, while hilltops, short-height cliffs, and small and large sandstone buttes were used much less frequently. A few pairs of hawks each have been known to nest in junipers trees and on wooden transmission towers. Despite the substrate, the placement of nearly all Ferruginous Hawk nests is such that shade from the sun is limited, and usually non-existent. Thus nearly all nests are open to the sky, and provide the nesting birds with a commanding view of their surroundings.

Few researchers have studied this hawk's territoriality and home range behaviors. It is clear that nesting adults actively defend a territory against conspecifics with aggressive interactions and displays (Schmutz et al. 1980); however, the size of the area defended is unknown. In compiling data from 11 study areas in the United States, Olendorff (1993) found that nearest-conspecific-neighbor distance ranged from 0.8 to 7.2 km (0.5-4.5 mi). Home range size of this hawk is also under-studied. In Utah, an average home range size of 5.9 km^2 (2.3 mi^2) was estimated by Smith and Murphy (1973) and Wakeley (1978) for 14 individuals; while McAnnis (1990) calculated an average home range of 7.6 km^2 (2.9 mi^2-range of 4.8-14.1 km^2) for 7 breeding males in Idaho. Olendorff (1993) summarized all home range sizes found in the scientific literature (including those above) and estimated an average home range size of 7.0 km^2 for 69 individuals or pairs of hawks.

Many threats to individuals and successful nesting have been identified throughout the species' range; these include predation; shooting and trapping, especially on wintering grounds; contamination by pesticides and other toxins; collisions with powerline wires; human developments at nest and roost sites, including petroleum well, powerline, road, and home development; and degradation of breeding / wintering habitat and prey populations (Bechard

and Schmutz 1995). Ferruginous Hawks are especially sensitive to human disturbance (and most prone to nest desertion) during incubation (Hall et al. 1988). In fact, human disturbance and habitat alteration are considered to be two factors most responsible for decline of hawks throughout their range (Jasikoff 1982). It was due to their sensitivity, that Weston and Ellis (1968) believed that these hawks rarely nested near well-traveled roads or extensive agricultural lands. White and Thurow (1985) found abandonment of one-third of the Ferruginous Hawk nesting sites that were subjected to experimental disturbance, even though the disturbance was brief. Andersen et al (1988) found that movements of raptors were influenced by military training activities in southeastern Colorado; one of two Ferruginous Hawks, and the Swainson's Hawk left the area during training; while three Red-tailed Hawk and one Golden Eagle remained.

Threats found by Ramakka and Woyewodzic (1993) on public lands adjacent to the Navajo Nation included homestead development on Navajo lands and recreational use of the badlands. Ramakka (1988) found that the main impacts from mineral extraction were human disturbance and habitat destruction. Human disturbance began during exploration for minerals (e.g. drilling, blasting, heavy truck operation), and increased when mine or well development began (e.g. additional blasting and drilling, road building, 24-hour gas-drilling rigs, new powerline development). Other effects of these operations included destruction or alteration of nesting habitat, nest and roost sites, primary feeding areas, riparian habitats; also, reductions in prey populations, and introductions of pollutants to the environment were noticed. On the Navajo Nation, many of these same threats are present, including predation, shooting, poaching of young from nests, accidental poisoning, powerline strikes and electrocution, degradation of prey populations (breeding habitat quality) by drought and livestock grazing, and human disturbance and developments near nest sites (including homes and infrastructure to support

them, oil and natural gas wells, powerline and road development, and to a small extent, outdoor recreation (all-terrain vehicle use).

Ferruginous Hawk populations have exhibited causes for concern on federal and local levels during the past 25 years. Populations were considered to be declining in numbers in the 1980s within the core breeding range, but was most noticeable from the edges of the range (especially in Canada). The species was first designated as 'threatened' in Canada in 1980, then later listed as 'vulnerable' in 1995. In the United States, it was petitioned for listing under the Endangered Species Act in 1991 (Ure et al. 1991), but was rejected for listing (U.S. Fish and Wildl. Serv. 1992). It was listed as a Category 2 Candidate by the U.S. Fish and Wildlife Service while that category existed; then it was reclassified as a Federal Species of Concern in 1996. Of the Four Corner states, it is a Species of Concern in Utah, Arizona (Wildlife of Special Concern), Colorado (State Special Concern), and in New Mexico it is a U.S. Forest Service and Bureau of Land Management (BLM) Species of Concern. Now with more attention placed on monitoring their populations, many appeared to be stable into the 1990s (including AZ, CO, ID, KS, MT, NB, Dakotas, TX, WA, and Sasakatchewan; however declines have been confirmed in northern Utah and eastern NV (Olendorff 1993).

The Navajo Nation continues to list the hawk as a Group 3 species on its lands since inception of the Navajo Endangered Species List on 14 February 1991. A Group-3 endangered species is "a species or subspecies whose prospects of survival or recruitment are likely to be in jeopardy in the foreseeable future on the Navajo Nation." Given its status on the NESL, Navajo Nation Code (17 NNC § 507) makes it "unlawful for any person to take, possess, transport, export, process, sell or offer for sale or ship" the hawk. Under this Code, "take," means "the hunting, capturing, killing in any manner or the attempt to hunt, capture or kill in any manner…" Habitat protection, per se, is not afforded under the NNC.

Currently, NatureServe (a non-profit conservation organization, along with its network of Natural Heritage programs are the leading source for information about rare and endangered species and threatened ecosystems) ranks the North American population of Ferruginous Hawks as 'apparently secure.' But they also reported that the species is "widespread and relatively common in the appropriate habitat; reports of local declines, continued loss of habitat, sensitivity to disturbance in a prairie species, and relatively low numbers show this species should be carefully watched and regularly re-evaluated." A recent analysis of the Natural Heritage programs in Canada and the western United States that recognize the species as breeding in their state, revealed that only one state (South Dakota) ranked the species as 'apparently secure.' Six states ranked the breeding occurrence as 'vulnerable'; another six states ranked the species as 'imperiled', one (Oklahoma) listed it as 'critically imperiled', and two states had a listing of between 'imperiled' and 'vulnerable'. Each of the four Canadian providences in which the species breeds has different ranks from 'critically imperiled' to 'apparently secure'. Within the Four-Corner states, the hawk is ranked as 'imperiled' (Arizona and New Mexico), 'vulnerable' (Colorado), or a cross of these two ranks (Utah and Navajo Nation).

To maintain healthy raptor populations, Hall et al (1988) recommended resource managers to: 1) enhance nesting habitat, 2) maximize prey populations, and 3) protect known nesting areas. Ramakka (1988) suggested avoidance strategies for mineral exploration and extraction, that included temporary restrictions of activity to non-critical times of the year; no removal of large trees; use of buffer zones around nests and roosts; and selective road closures. Many managers have established buffer zones around nests to control human disturbances to nesting birds (see Suter and Joness (1981) for details). Fisher (1978) recommended no surface disturbance, year-round, within 0.8 km (0.5 mi) of nests, and a 1.6-km (1-mi) seasonal buffer from 1 March to 15 July, to protect the hawk from geothermal drilling. One survey respondent

to Suter and Joness (1981), R. P. Howard, recommended a 0.8-km (0.5-mi) buffer for all grassland raptors from all types of disturbances. The U.S. Fish and Wildlife Service (1999) recommended a 0.8-km (0.5-mi) buffer for nests during 1 March to 1 August in Utah. White et al (1979) recommended a 1.6 km (1 mi) buffer to minimize deleterious impacts from construction activities, and a 0.8 km (0.5 mi) buffer from normal human activities. Harmata (1991) recommended a 1 km (0.6 mi) buffer from resource development and road construction for maximum protection of these hawks. Olendorff (1993) recommended a 0.8 km (0.5 mi) buffer for prolonged activity within line-of-sight of nests. Suter and Joness (1981) recommended buffers to prevent nest abandonment of 0.5 km (0.3 mi) for low-human disturbance, and 1.0 km (0.6 mi) for construction and noisy activities.

The goals of this study were to: 1) locate and identify all suitable nesting habitat of the Ferruginous Hawk on the Navajo Nation in New Mexico; 2) survey all nesting habitat with rotary-wing aircraft to locate and catalogue all Ferruginous Hawk nests; 3) map all Ferruginous Hawk nests in ArcView and encircle them with appropriate-sized non-development buffers; and 4) implement management guidelines to protect all Ferruginous Hawk nests on the Navajo Nation from human disturbance.

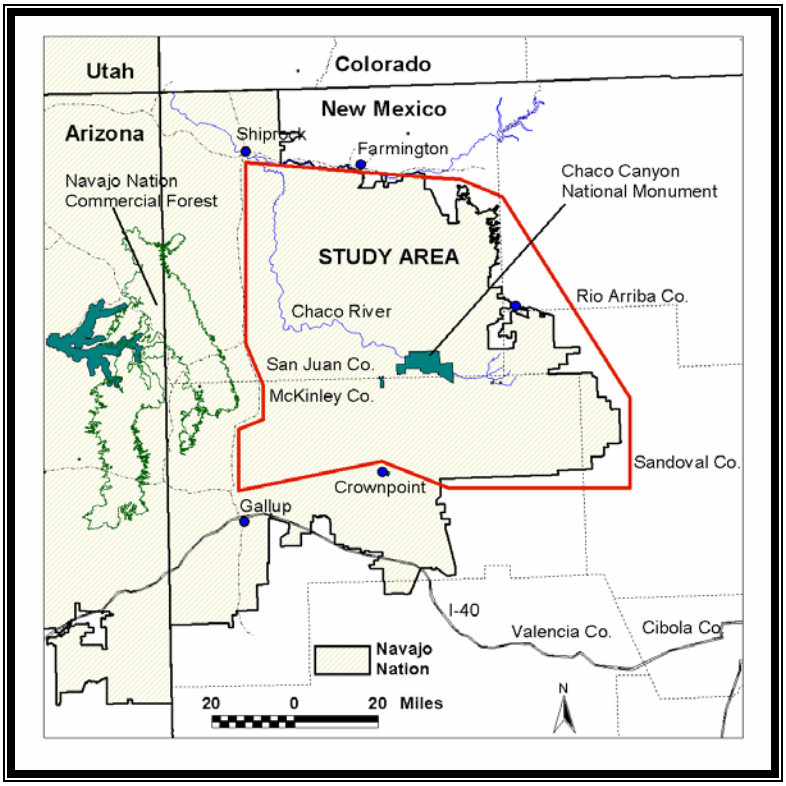
METHODS

The eastern portion of the Navajo Nation within northwestern New Mexico has been known as the stronghold of the Ferruginous Hawk for the Navajo Nation since initiation of nest inventories and monitoring in 1986. Thus, all lands within this region were considered as part of the study area and included in this inventory (Figure 1). The non-perennial Chaco River

bisects this landscape, and its tributaries form the majority of the suitable nesting habitat for the hawk. This river drains an area approximately 64 km by 129 km (40 x 80 mi) in size, including the east slope of the Chuska Mountains, and empties into the San Juan River near Shiprock, NM. The study area is generally bounded by US Hwy 491 and the Chuska Mountains to the west, the San Juan River to the north, US Hwy 44 to the east, and the sandstone-uplift running from Gallup to Crownpoint, NM to the south. Although this landscape was shaped by years of water drainage, today the surface water exists only in a limited number of springs, seeps, stock-ponds and deep-tapped wells, as well as intermittent flow within the tributaries of the Chaco River. The study area is composed of Plains and Great Basin Grassland incised by highly-erosional drainages with Great Basin Desertscrub (Brown 1982). It is within these drainages that most Ferruginous Hawks have found ideal nesting habitat in the form of sandstone ridges, pillars, small buttes, and rounded hills associated with desert-badlands.

To ensure complete coverage of all available habitat within the study area, we examined all 1:24,000-scale topographic maps of the area for topographic relief. Specifically, we searched for the unique 'signatures' of badlands, buttes, and ridgelines. These areas were outlined as polygons on BLM-edition topographic maps of scale 1:100,000 showing surface management status. Polygons were drawn to include the suitable nesting habitat on Navajolands and generally excluded those lands managed by other agencies or private individuals. These polygons represented the total amount of potential habitat to survey. Because of the checker-boarded nature of much of the lands in the southeastern and northeastern portions of the study area, lands managed by others were occasionally included and surveyed. We purposely excluded the BHP Billiton Navajo Mine lease-land, plus the 1.6-km (1 mi) buffer surrounding the mine (total area excluded was 228 km^2 (89 mi^2)), from the study area because the Dept. actively assists in yearly monitoring of Ferruginous Hawks on these lands.

Figure 1. Map of Ferruginous Hawk study area (red outline) on the Navajo Nation within northwestern New Mexico



Polygons were digitally drawn to a mapping software package, MapSource®, that was compatible with the handheld Garmin® Global Position System (GPS) units available during the aerial survey. Topographic maps, along with the digital polygons, were downloaded to the Garmin® handheld GPS unit prior to aerial survey to provide reference lines to insure that each polygon, and all parts of each polygon, were surveyed. Also, the 'track' function of the GPS unit was used to monitor completed versus un-surveyed areas; the GPS unit would store a 'track' of the flight path that could be used as a reference for survey completion during flight.

Ferruginous Hawk nests were inventoried by aerial surveys of habitat polygons conducted by rotary-wing aircraft during 23-27 August 2004, and by fixed-wing aircraft on 19 May 2005. The 2004 surveys were conducted after the hawk breeding season because we were concerned that the survey techniques may cause excessive disturbance during this crucial stage in their lifecycle. In 2004, we contracted AeroWest Helicopter Inc., Albuquerque, New Mexico, which provided a Bell Jet Ranger helicopter and well-qualified pilot. Rotary-wing surveys were conducted with one Dept. biologist at heights generally 6-30 m (20-100 ft) above the terrain. We flew at speeds slow enough to see all nesting substrates within each polygons, usually this was just above hovering speed. Because not all habitat polygons were surveyed in 2004, we contracted Gallup Flying Service (Gallup, New Mexico) in 2005, which provided a Cessna 206 and well-qualified pilot. We completed surveys on all remaining habitat polygons with 8 hr of flight, which was conducted generally 50 m (164 ft) above ground level. This survey was completed during the breeding season since there was little chance of disturbing a nesting hawk with fixed-wing aircraft.

When a nest was located during rotary-wing surveys, the pilot would hover nearby, while the observer collected data. After at least 2 digital photographs were taken of the nest, data were collected on the size and condition of the nest, and type of nesting substrate. Lastly the pilot would momentarily hover at 3-15 m (10-50 ft) over the nest while a GPS location (reported precision of at least 15 m) was recorded. During the 2005-fixed-wing surveys, an accurate GPS location was collected by flying over the nest; however, these locations have a greater degree of inaccuracy than those collected in 2004. Also no nest photos were collected during the 2005 surveys.

Nests were categorized as sizes of small, medium or large, based on the observer's previous experience with Ferruginous Hawk nest sizes. Nest condition was then ranked as one

of four categories, including excellent, good, old, or dilapidated. 'Excellent' nests were structurally intact, with vertical sides and a bowl present, and likely used within the last few years by the hawks. 'Good' nests were also intact, sometimes with a bowl present, but showing signs of weathering and several years on non-usage. Nests ranked as 'old' were flattened to near-substrate level, but still maintained a nest shape, while 'dilapidated' nests were degraded to the point of being barely-recognizable as a nest. Dilapidated nests were identified by the presence of a 'sufficient number of sticks on suitable nesting substrate' that the observer recognized with little doubt that it composed a Ferruginous Hawk nest at one time. Nesting substrates were recorded as the following: 'ground,' if the nest was on the top or the side of large or small rounded hill, usually composed of sandy-clay soil; 'small butte' usually was a sandstone structure with a flat top that was less than 9.3 m^2 (100 ft^2); 'large butte' was a sandstone structure with a top surface of more than 9.3 m^2; 'pillar' was a narrow, vertical projection at least 3 m (10 ft) in height, composed of sandstone and/or clay; and 'short cliff' when the nest was placed on part of a continuous rock or sand-clay wall (see Appendix A for examples of categories).

After completion of the survey, all digital photographs and GPS-nest-location and flight-track data were downloaded to a computer. A database (Appendix D) was created and populated with the following information: nest number (sequential numbering); photograph number(s); GPS location in UTM (NAD27) coordinates, elevation, and general location; nest size, condition, and substrate type; survey polygon number, name of 1,100,000 map on which the nest appears, and landowner; whether the nest was known prior to this survey; and whether the nest had evidence of recent use.

With ArcView software, nests were projected to display their spatial arrangement across the landscape. A circular buffer with a radius of 1.5 km (0.93 mi) was placed around each nest;

this represented the average home-range size of Ferruginous Hawks at 7.0 km^2 (Olendorff 1993). The home-range estimate reported by Olendorff (1993) was used because it was a compilation of all home ranges reported in the literature. All nests that had overlapping home-range buffers were considered part of the same 'potential territory.' Here we use the term 'potential territory' to mean "a nest, or group of nests within the same home range, that represents a location that may be used by one pair of Ferruginous Hawks for nesting."

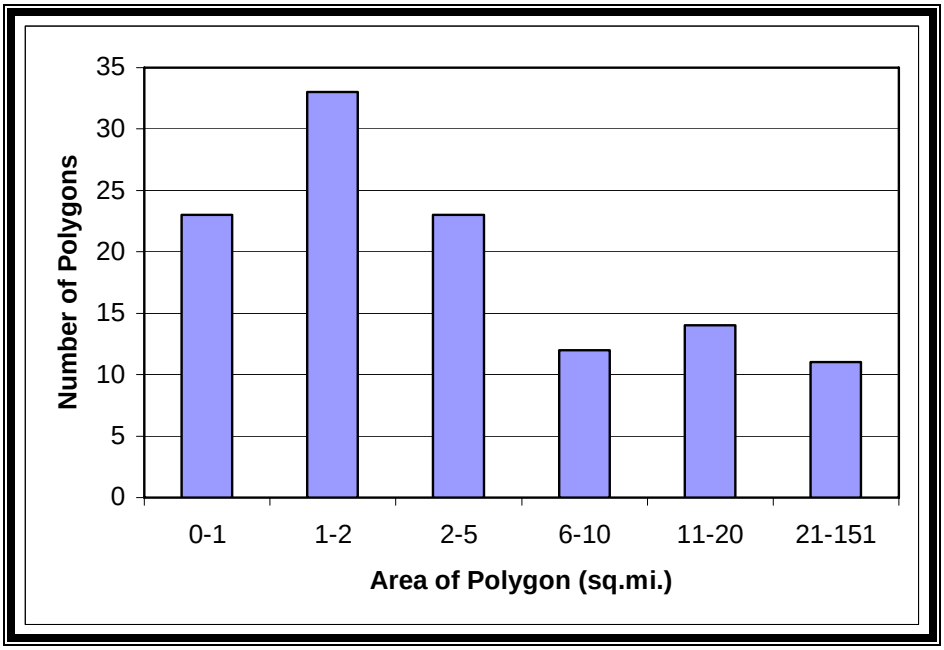
RESULTS

Pre-survey analyses of habitat revealed a total of 2,787 km^2 (1,076 mi^2) of suitable nesting habitat for the Ferruginous Hawk on Navajo lands in northwestern New Mexico. A total of 120 polygons (Appendix D) were drawn on 5 adjoining BLM-edition topographic maps to encompass areas of potential habitat. Habitat polygons ranged in size from 0.5 km^2 (0.2 mi^2) to 392 km^2 (151 mi^2); Figure 2 shows the distribution of polygon sizes.

We spend a total of 43 flight-hours (Budget - Appendix B) surveying these habitat polygons with rotary-wing aircraft during the week of 23-27 August 2004. A total of 83.5 habitat polygons, encompassing 2,442 km^2 (943 mi^2), were completely surveyed (Figure 3). This area composed approximately 87.6% of the total area of suitable nesting habitat. A portion of one day's survey was mapped with the actual points automatically recorded by the handheld GPS (Figure 4), and provided here to show the degree of coverage by the rotary-wing aircraft. To complete the inventory of nests, the remaining 36.5 habitat polygons were surveyed with fixed-wing aircraft on 19 May 2005. A total of 344 km^2 (133 mi^2) of suitable habitat were examined during a 7.75-hours flight. Most of this survey was recorded automatically by the

handheld GPS (Figure 5), and is also provided to show degree of coverage of the potential habitat polygons.

Figure 2. Distribution of sizes (area in square miles) of potential habitat polygons (note that 'Area of Polygon' size categories are progressively larger).



A total of X nests were located during the 2004 and 2005 aerial surveys. Of the total, 54.4% were newly found by these surveys, while 45.6% were known by the Dept. prior to this work. Forty-eight percent of the nests were determined to be in good or excellent condition, while 52.0% were old or dilapidated. In examining nesting substrates, 64.8% were found on sandstone and/or clay pillars (Table 1), near 10% were found on each of three other substrates of ground (10.7%), cliff (11.5%), and small butte (10.7%), while only 3.2% were on large butte structures. Of the total, nearly all nests (93.6%) were found on lands managed by the Navajo Nation. The remaining nests were on lands managed by the BLM, lands under Federal Protection Withdrawal, lands managed by the State of New Mexico, and private lands.

Of the nests newly-discovered by this survey, 26.5% were determined to be in 'excellent' condition (Table 1), but most (63.2%) were 'old' or 'dilapidated' nests.

Table 1. Summary of size, condition, and substrate for all nests located and analyzed in this inventory; and those newly-discovered during aerial surveys.

All Nests

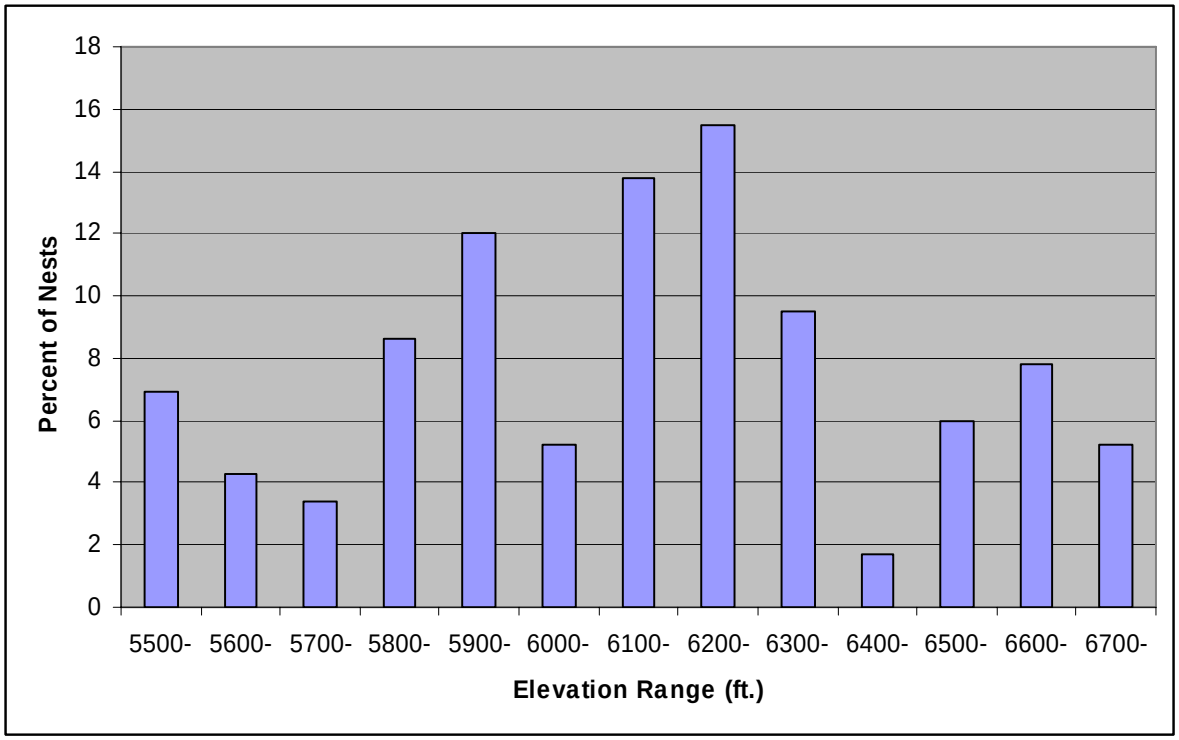
Size	(%)	Condition	(%)	Substrate	(%)
Large	60.8	Old	40.8	Pillar	64.8
Medium	29.6	Excellent	30.4	Ground	10.4
Small	09.6	Good	17.6	Small Butte	10.4
		Dilapidated	11.2	Cliff	11.2
				Large Butte	03.2

Newly-discovered Nests

Size	(%)	Condition	(%)	Substrate	(%)
Large	58.8	Old	54.4	Pillar	57.4
Medium	32.4	Excellent	26.5	Ground	13.2
Small	8.8	Good	10.3	Cliff	14.7
		Dilapidated	8.8	Small Butte	10.3
				Large Butte	4.4

All nests were found within a 500-m (1,640 ft) range of elevations from approximately 1,567 m (5,140 ft) to 2,066 m (6,780 ft) above sea level (Figure 6). Remember that elevation data were collected by the GPS unit in the helicopter hovering from 3 to 15 m (10-50 ft) above the nest; therefore, these data should be regarded as close approximations of the actual nest elevation.

Figure. 6. Elevation distribution of Ferruginous Hawk nests on the Navajo Nation in northwestern New Mexico



All nests were segregated into potential Ferruginous Hawk territories after applying the home-range buffer of 7.0 km^2 to each nest. Forty percent of potential territories were previously known to the Dept., while 60.0% were newly discovered during this inventory. Potential nesting territories contained from one to six nests each, with nearly half (46.7%) having only one nest (Table 2). Nest-quality determinations revealed that 58.3% of all potential territories had at least one good or excellent nest present (indicating that the territory is readily usable by a nesting pair), while 41.7% of the territories contained only old or dilapidated nests. Interestingly, 76.0% of these 'old' territories had only one nest.

Table 2. Number of nests per potential Ferruginous Hawk territory after nests were grouped using an average home range size of 7.0 km² (Olendorff 1993), and number of nests per potential territories based on nest quality.

No. of Nests in Territory	Percent of Territories	Percent of Territories with: only old/dilapidated nests Prev.Known	only old/dilapidated nests New.Found	≥ 1 good/excellent nest Prev.Known	≥ 1 good/excellent nest New.Found
1	46.6				
2	20.0				
3	20.0				
4	6.7				
5	5.0				
6	1.7				
% Total:	**100**	**8.3**	**33.3**	**31.7**	**26.7**

Figure 3. Potential Ferruginous Hawk nesting habitat (habitat-polygons) on the Navajo Nation in New Mexico that were surveyed by rotary-wing aircraft in 2004 and by fixed-wing aircraft in 2005.

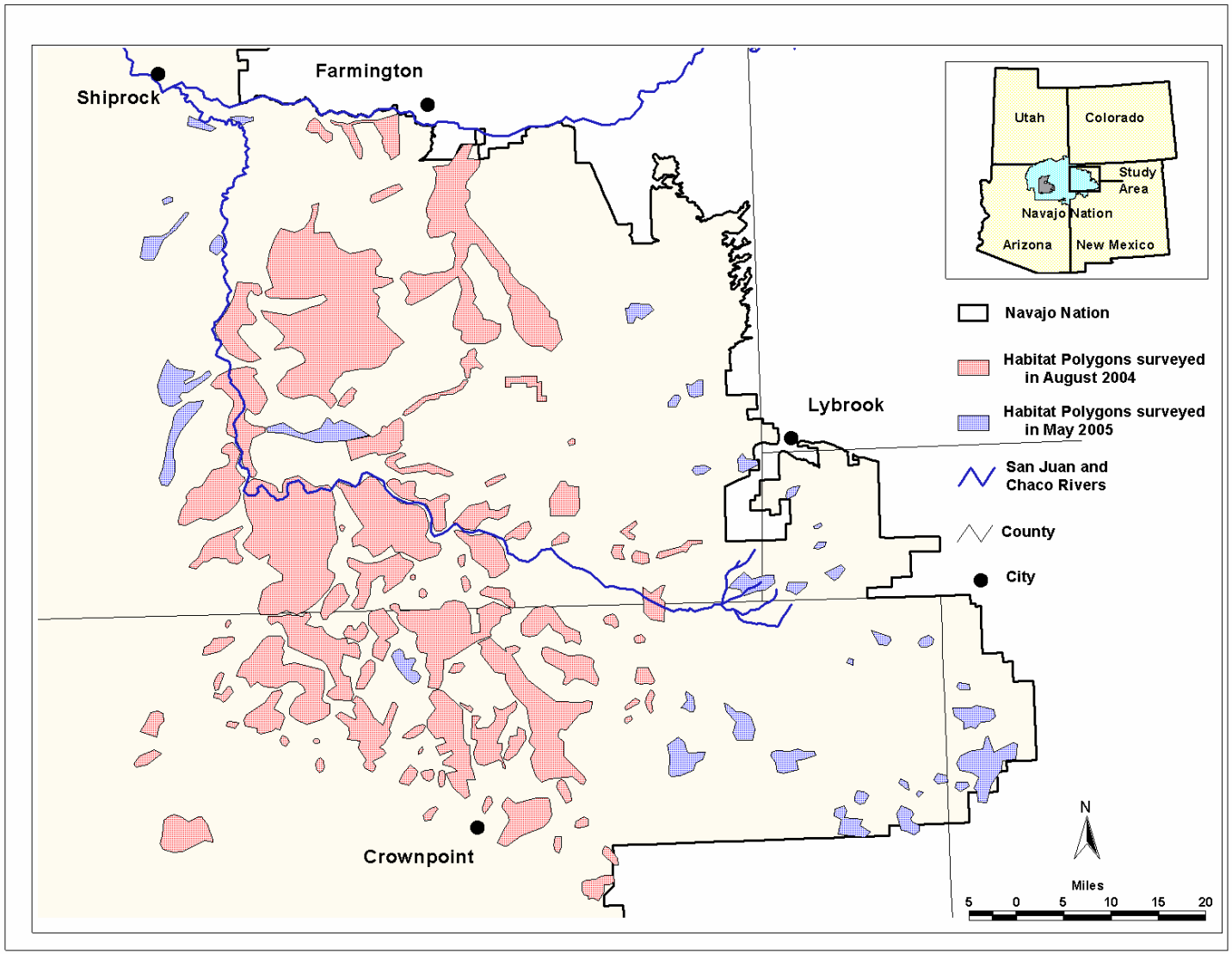


Figure 4. Actual flight path recorded with a handheld GPS during several hours of survey in rotary-wing aircraft during 2004.

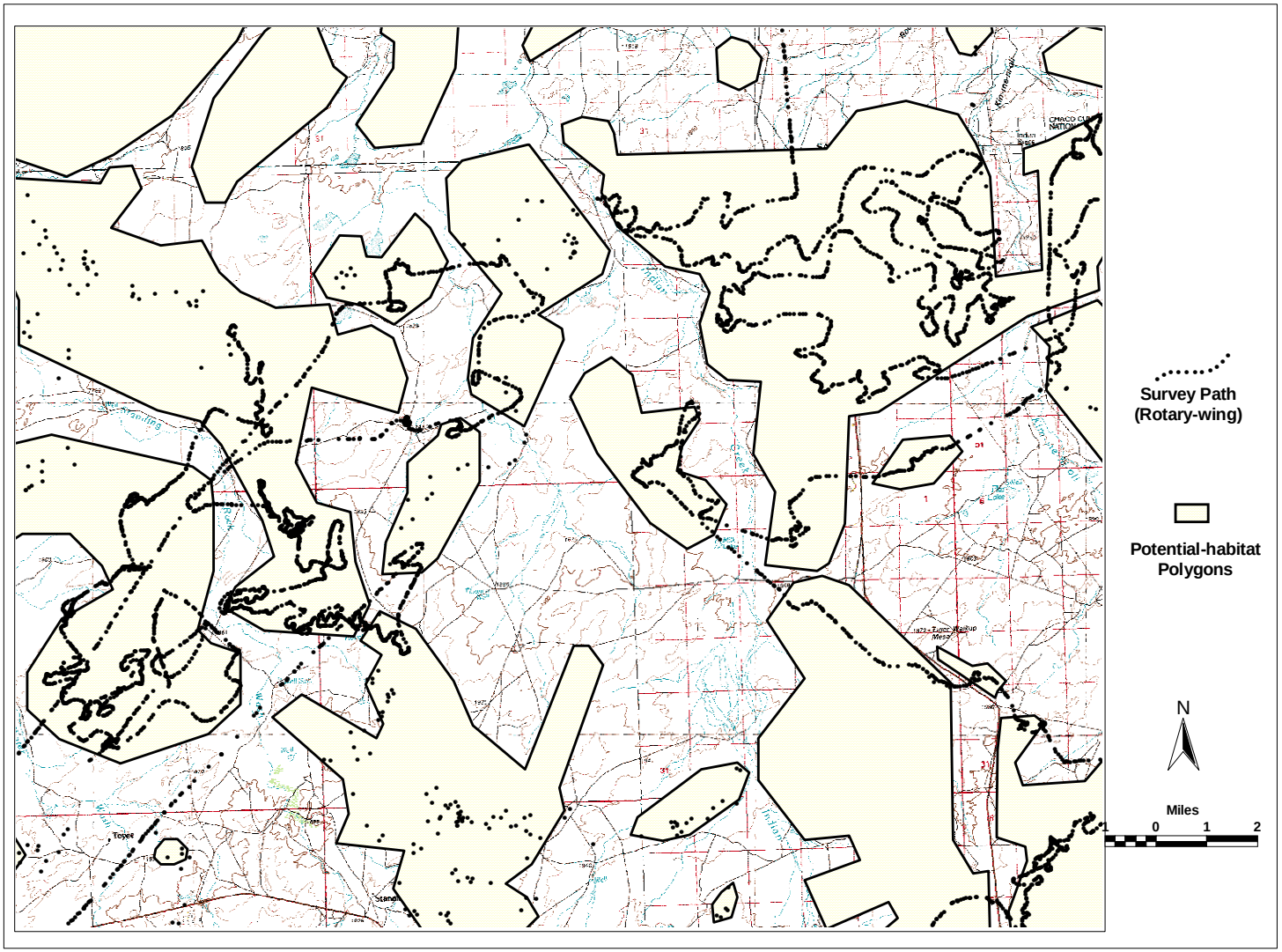
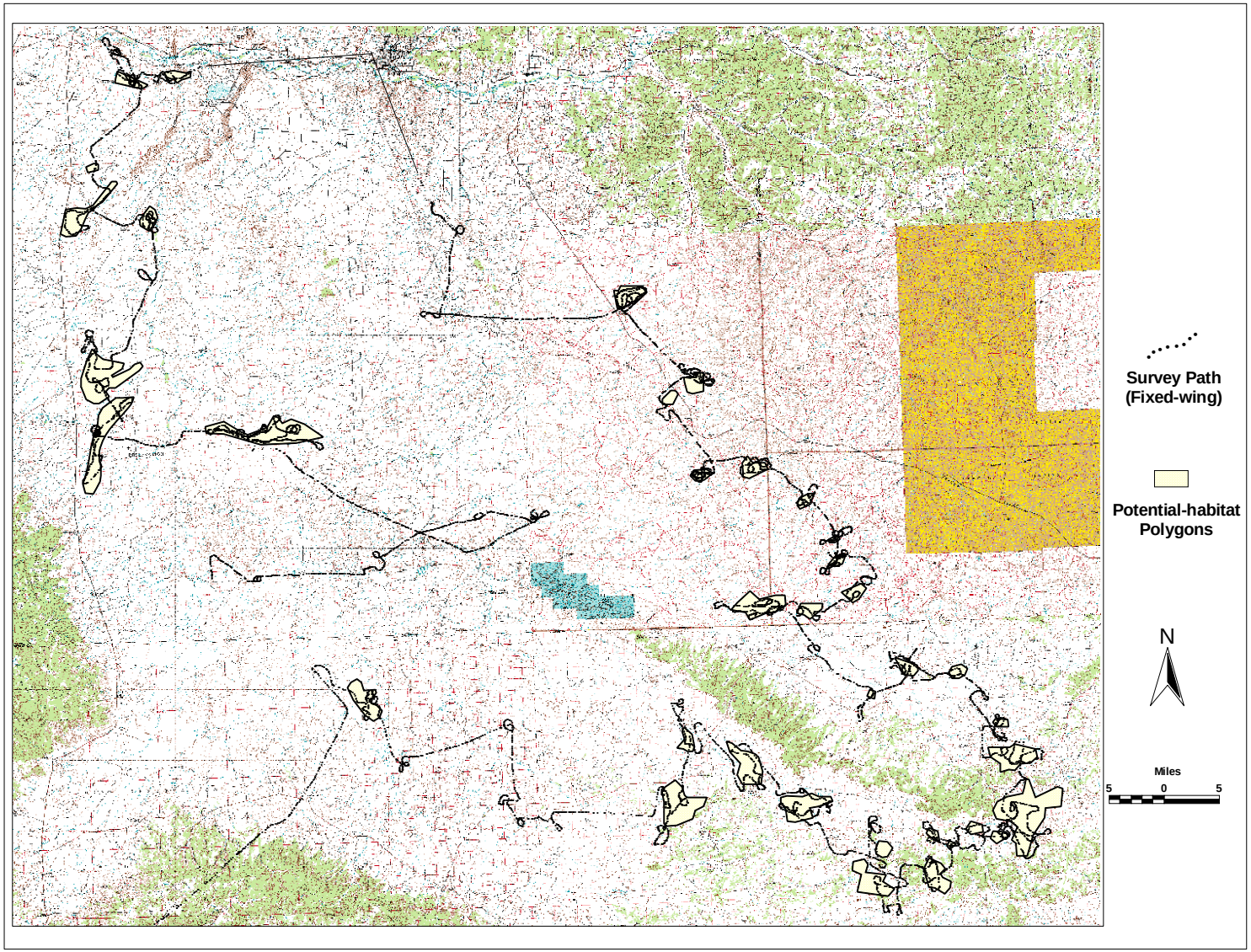


Figure 5. Actual flight path recorded with a handheld GPS during 7.75 hours of survey in fixed-wing aircraft in 2005.



DISCUSSION

This project was successful in accomplishing the first goal of identifying all potential nesting habitat for the Ferruginous Hawk within the study area. The large number of previously-unknown nests found during these surveys (54.4% of the total) confirms that we surveyed appropriate habitats. Also, there were several small patches of badlands habitat that were identified on topographic maps that were previously unknown to us. One example was habitat-polygon number 93, which was a 3.6-km^2 (1.4-mi^2) patch of suitable badlands surrounded by a large expanse of grassland. Although no nests were located in this polygon, it may have gone unnoticed if other survey techniques (e.g. aerial transects) were used. One of the smallest habitat-polygons surveyed was number 32, which was only a quarter-section (0.65 km^2; 0.25 mi^2) of Navajo lands surrounded by BLM lands. Survey of this small polygon revealed a previously-unknown nest atop the one hill within Navajo lands. This large ground-nest would have likely been unknown to us for many years without proper habitat delineation associated with these aerial surveys. Also, only a small percentage (perhaps < 3%) of the area within habitat polygons was declared non-suitable during surveys.

We were also successful in completing surveys within all habitat polygons during 2004 and 2005. Most of this effort was completed in 2004 with rotary-wing aircraft (87.6%), which provided a more thorough survey of potential habitat. We did prioritize surveys in 2004 to ensure that the most suitable habitat-polygons were covered with rotary-wing aircraft. High priority was given to habitat-polygons that encompassed the largest patches of badlands habitat. Priority was also given to habitat polygons within contiguous Navajo Nation-managed lands (i.e. not checker-boarded with other land managers), which is where the Dept. can institute the best protective measures. We used two flight schemes to ensure complete coverage within

habitat-polygons. We flew transects separated by a few hundred meters when in large polygons with contiguous badlands, and flew in 'zig-zag' sweeps through polygons with scattered nesting substrates (Figure 4). Using the 'track' feature of the GPS was very successful in ensuring complete coverage of each polygon, without overlapping survey effort.

Ramakka and Woyewodzic (1993) found 86% of 72 nests in northwestern New Mexico situated on top of pinnacles, but only 3% in trees (presumably junipers or pinon pines). Our inventory revealed that most nests (64.8%) in this study area were also on pillars; however, no tree-nests were discovered. A small number of nests should be in trees if Ramakka and Woyewodzic's (1993) findings are applicable here. Understanding that topographic maps often do not accurately demark areas of juniper woodlands, we did not plan surveys (draw habitat-polygons) that included this habitat type. Trees were examined during surveys when they were encountered within polygons, and in transit between polygons; however, no nests were found within them. Juniper stands and lone junipers, were not common within most of the western polygons, but were more common further east in the study area. Unfortunately, we did not have sufficient survey time to fully examine this potential nesting substrate. Considering previous work with the hawk here, the large amount of high-quality badland habitat, and Ramakka and Woyewodzic's (1993) low percentage of tree nests, we suspect that the Navajo Nation has few tree-nesting Ferruginous Hawks within the study area.

Nests were found well-distributed throughout a wide range of elevations, with only a slight peak between 1,768 m and 1,890 m (5,800 and 6,200 ft). The elevation range in which nests were found was nearly identical that of the study area; thus, it appears that Ferruginous Hawks are selecting nest sites independent of elevation. Because the hawks have fairly specific nest-substrate requirements, we expect them to opportunistically use suitable nesting substrates and habitats, irregardless of elevation.

We divided all nests into distinct potential territories based on home range data reported by others. Although using data from scientific literature is not a perfect substitute to direct field observations, this method seemed to provide fairly accurate results. Based on previous Ferruginous Hawk monitoring here, the home range estimate of 7.0 km^2 divided territories rather accurately. This estimate separated the X nests into X potential territories; however, nearly half (46.7%) of these contained only one nest. A cursory spatial analysis of these single-nest territories revealed that most of them (perhaps 80-90%) were well-separated from its nearest neighboring territory.

Other researchers have reported that Ferruginous Hawks are generally erratic breeders and for unknown reasons, shift nesting territories. It would be expected that nesting territories in the relative xeric and changing habitats of the Southwest may be less regularly occupied than habitats in the core of their range (Hall et al 1988). Also, Woffinden and Murphy (1989) stated that breeding pairs of Ferruginous Hawks exhibit a nomadic nature when nesting. Several results of this inventory support the notion of erratic breeding and territory shifting here. We found that nearly half (41.6%) of the potential territories contained only old and dilapidated nests; and most of these (80%) were newly found by this work. Also, nearly half of the potential territories (46.7%) contained only one nest; and over half (58.3%) of the newly-found territories were composed of only one nest. It appears that these hawks are adept at searching-out areas of suitable habitat and using them for nesting for one or several years. Then, in response to fluctuations in prey cycles (Craighead and Craighead 1969), human disturbances at nest sites (Andersen et al 1988, Hall et al. 1988, White and Thurow 1985), or other factors, the hawks move to other areas more suitable for nesting in subsequent years. And, even though it is impossible to know when these old and lone nests were active, it is unlikely that all were used in the same year. Thus we do not suspect that a large decline in the breeding population has

resulted in this high percentage of single-nest and abandoned territories, but rather it reflects the dynamic nature in which Ferruginous Hawks use their nesting areas.

Old nests and territories that have been vacant for years may be re-used by Ferruginous Hawks. In 2004 one nest, that had been removed from its pillar by an act of vandalism prior to 1999, was rebuilt and used to successfully fledge young. Since this territory had no evidence of use by hawks between 1999 and 2004, this nest re-building and territory re-occupation further exhibit the dynamic use of nesting habitat by Ferruginous Hawks. Perhaps, more importantly, this exhibits the need for any nest-site protection plan to not exclude old, and apparently abandoned, nests and territories.

We must realize that although we doubled our number of known nests, and number of potential territories with this survey, this does not exactly translate into a doubling of our known hawk nesting population. Throughout this discussion, we refer to 'potential territories' as groupings of nests, based on home-range estimates, that likely attract Ferruginous Hawks for nesting because of the presence of intact nests, or their previous relationship to the site. This does not imply that in any given year, that all of these territories will be used by Ferruginous Hawks. Of the potential territories, 58.3% contained at least one nest ranked as 'good' or 'excellent' in condition. These nests were likely used within the recent past (perhaps 1 to 10 years) and presumably, represent the most likely nests to be selected by Ferruginous Hawks in the near future. Therefore, we caution that even though our number of nests and territories have doubled as a result of these surveys, the number of territories with adults and/or active nests each year may not dramatically increase during future monitoring efforts.

In summary, the Navajo Nation Department of Fish and Wildlife now has a 'snapshot' of nearly all existing Ferruginous Hawk nests within their lands in New Mexico. We have more than doubled our number of known nests, and increased our number of potential territories to

examine each year for reproductive success measures. Future surveys for nests and reproductive-success monitoring by the Dept., and by managers of lands adjacent to the Navajo Nation, should be maintained as a priority to further understand this population's stability.

ACKNOWLEDGEMENTS

We are grateful to the U.S. Fish and Wildlife Service for creation of the Tribal Land Incentive Grant program, and selection of this project for funding, without which this work could not have been completed. We are thankful to AeroWest Helicopter, Inc., and their pilot, Andy Boecker, for his excellent piloting skills; Andy quickly learned the proper habitats to survey and developed an eye for finding Ferruginous Hawk nests. Lee Rhodes of Gallup Flying Service also did a tremendous job of helping us complete the remaining polygons in 2005. Former employees of the Navajo Nation Dept. of Fish and Wildlife, John Nystedt and Kathleen McCoy, were instrumental in researching and establishing buffer-zone distances for Ferruginous Hawks.

GENERAL RECOMMENDATIONS

1. Further examine patches of junipers, and lone junipers, encountered during aerial surveys for the presence of Ferruginous Hawk nests; treat all nests found with procedures identical to those followed here.

2. Continue annual surveys of all potential territories that contain at least one good or excellent quality nest and monitor breeding success of occupied territories; monitor less regularly (perhaps every five years) territories with only old or dilapidated nests.

3. As land-use data in G.I.S.-format become available, further analyses should compare the distribution of Ferruginous Hawk nests with past and present human-developments, and other factors affecting their nest-site selection.

MANAGEMENT GUIDELINES

Human land-use practices can have a variety of types of impacts to nesting Ferruginous Hawks and their habitats, including:

1. Direct, Indirect, and Cumulative Impacts to nesting success and adult survival;
2. Direct, Indirect, Cumulative Impacts to nesting and foraging habitat and prey densities.

The purpose of these Management Guidelines is to conserve breeding Ferruginous Hawks on the Navajo Nation by protecting their nests from human activities that may cause temporary or permanent disturbance. Conservation of nesting Ferruginous Hawks is important to the Navajo Nation because it is:

1. A species of cultural importance to the Navajo People;
2. An important part of the ecosystem as a predator on small mammals;
3. A native breeding species of the Navajo Nation, but occurs in low numbers as to be considered 'threatened' on the Navajo Endangered Species List (Group 3);
4. Of concern to other land managers throughout much of its range, and therefore listed on numerous 'Species of Concern' lists for the western U.S. and Canada;
5. A species that was once considered for Federal listing under the Endangered Species Act, and may be petitioned for listing again in the near future.

Protection of both occupied and unoccupied nests is important because:

1. Not all adult raptor pairs breed every year;
2. Not all nesting territories are used for breeding each year;
3. Each intact nest within a nesting territory may be used in any given year;
4. Nesting territories may be reoccupied, and nests may be re-built and used, even if left unattended for a number of years.

These Management Guidelines are designed to:

1. Avoid disturbance to occupied nests during the breeding season;
2. Avoid or minimize impacts to known or potential nesting habitats, especially in consideration of nesting substrate quality and quantity;
3. Avoid or minimize impacts to foraging habitats around occupied nesting habitat; especially in consideration of prey diversity and densities;
4. Minimize impacts over broad areas of the hawk's range on the Navajo Nation;
5. Mitigate for unavoidable losses of nesting sites or habitat quality.

Definitions

'BRIEF ACTIVITIES' are those that occur for up to one (1) hour and involve only personnel and passenger or maintenance vehicles.

Examples include: soil surveys, biological surveys, infrequent maintenance of structures.

'LIGHT ACTIVITIES' are those that occur for up to one (1) day in the same general area (i.e. within 1,000 ft of the previous day's action), and involve up to five (5) vehicles (including up to three (3) construction-type vehicles or equipment), and up to ten (10) personnel.

Examples include: residential utilities (power, water and sewer lines), fence building.

'HEAVY ACTIVITIES' are those that exceed at least one of the criteria for Light Construction, or include permanent structures that involve human activity of up to one (1) visit per week.

Examples include: road construction, oil and gas well construction.

'LOUD ACTIVITIES' are those that exceed the normal base level of construction noise, either for brief or extended periods.

Examples include: blasting, jackhammer, rock crusher.

'PERMANENT STRUCTURES' are above-ground facilities resulting that persist for more than two (2) years in the same location.

'DAILY-USE' involves human activity that occurs daily or more than three (3) days a week.

Examples include: home sites, sheep camps, subdivisions, coal mines, new roads, some road improvements, gas plants, large-scale farming, borrow pits.

'INFREQUENT-USE' involves human activity that occurs three (3) or less days a week.

Examples include: maintenance of oil and gas wells or utilities.

'NEST(S)' is a stick structure verified to, or likely to, have been built by Ferruginous Hawks, based on its characteristics of composition and placement on the substrate.

'OCCUPIED NESTS' are those nests which are repaired, tended, or used for nesting, in the current year by a pair of Ferruginous Hawks. The presence of Ferruginous Hawks (adults, eggs, or young), evidence of nest repair or nest marking, freshly molted feathers, or current years' mute suggest an Occupied Nesting Territory. All nests within an Occupied Nesting Territory are considered as an "Occupied Nest" during pair-bonding and prior to egg-laying. If a nest is selected and eggs are laid, then only this nest will be considered as "occupied," while the others will then be considered 'unoccupied.' An Occupied Nest retains this status from pair bonding, through egg-laying, incubation of eggs, brooding and fledging of young, and post-fledging dependency of the young.

'UNOCCUPIED NESTS' are those nests not selected by Ferruginous Hawks for breeding in the current year. All nests without eggs or nestlings by May 1st of each year shall be considered as Unoccupied Nests. All nests during the non-breeding season (August 1st to February 28th) shall be considered as Unoccupied Nests.

'OCCUPIED NESTING TERRITORY' is a single nest or group of nests with at least one resident adult Ferruginous Hawk during the nesting season.

Navajo Nation Department of Fish and Wildlife's Ferruginous Hawk Management Guidelines for Nest Protection:

1. Protect all nesting Ferruginous Hawks on the Navajo Nation during March 1st to July 31st with the following provisions:
    a. Allow no BRIEF ACTIVITIES within 0.8 km (0.5 mi) of an OCCUPIED NEST.
    b. Allow no LIGHT ACTIVITIES within 1.0 km (5/8 mi) of an OCCUPIED NEST
    c. Allow no HEAVY ACTIVITIES within 1.2 km (3/4 mi) of an OCCUPIED NEST.
    d. Allow no LOUD ACTIVITIES within 1.6 km (1 mi) of an OCCUPIED NEST.

2. Protect all NESTS from human disturbances associated with PERMANENT STRUCTURES on a year-round basis.
    a. Allow no DAILY-USE PERMANENT STRUCTURES within 1.6 km (1 mi) of a known NEST.
    b. Allow no INFREQUENT-USE PERMANENT STRUCTURES within 1.0 km (5/8 mi) of a known NEST.

3. Follow additional measures during project planning if proposed activity is near known Ferruginous Hawk nesting territories or potential habitat to further minimize impacts.
    a. Place new constructions and human disturbances near previously-disturbed areas whenever possible.
    b. Limit the size of construction to smallest area needed to meet project needs.
    c. Reclaim disturbed areas and obliterate roads post-construction.
    d. Consider alternative construction sites and/or methods.

4. Mitigate for unavoidable losses of NESTS or occupied or potential habitat, and for potential disturbances to nesting Ferruginous Hawks with measures approved by the Navajo Nation Department of Fish and Wildlife. Installation of artificial nesting

structures is usually recommended for losses of NESTS or habitat, while monitoring of nesting success for up to five (5) years at the affected NEST(S) is usually recommended for disturbances to nesting Hawks.

5. At the discretion of a qualified biologist of the Navajo Nation Department of Fish and Wildlife, these regulations may be revised or altered as new information becomes available; and deviations (esp. in distances and dates) will be allowed on a case-by-case basis and for warranted circumstances, especially for emergency situations.

6. All Ferruginous Hawks NESTS found in the future will be protected under these Protection Measures following verification and documentation by the Navajo Nation Department of Fish and Wildlife.

7. Very old and dilapidated Ferruginous Hawk NESTS may be deleted from these Protection Measures by a qualified biologist of the Navajo Nation Department of Fish and Wildlife Nest if the NEST appears to no longer represent a suitable breeding location for the hawk. Only NESTS known, or suspected, to be unused for at least ten (10) years, composed of unconsolidated sticks with no vertical cohesiveness may be considered for deletion.

8. All NEST locations are to be considered confidential information of The Navajo Nation Department of Fish and Wildlife, and may be divulged only for protection of the NEST and proper land-use planning.

9. Because of BHP Billiton's commitment to monitor raptor nests each year, Ferruginous Hawk NESTS on active sections of Navajo Mine are excluded from these Protection Measures; however, these Measures apply for NESTS occurring on Mine lease-lands after mining operations and land reclamation are completed.

Literature Cited

Andersen, D. E., O. J. Rongstad and W. R. Mytton. 1988. Home range changes in breeding raptors exposed to increased human activity levels in southeastern Colorado. P. 316 *in* Proceedings of the Southwest Raptor Management Symposium and Workshop (R. L. Glinski et al., eds.). Natl. Widl. Fed., Washington, D. C.

Bechard, M. J., and J. K. Schmutz. 1995. Ferruginous Hawk (*Buteo regalis*). *In* The Birds of North America, No. 172 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologist' Union, Washington, D.C.

Brown, D. E. (ed.) 1982. Biotic communities of the American Southwest – United States and Mexico. University of Arizona. 342 pp.

Craighead, J. J., and Craighead, F. C., Jr. 1969. Hawks, Owls, and Wildlife. Dover Publications, Inc., New York.

Fisher, R. J. 1978. Biological values in the Raft River Valley geothermal resource area. Appendix A in Dept. of Energy Environm. Assessment. Raft River Geothermal Project, Thermal Test Loop, Cassia County, ID. DOE/EA-0008. U.S. Dept. of Energy, Washington, D.C. 121 pp.

Gaines, R. C. 1985. Nest site selection, habitat utilization, and breeding biology of the Ferruginous Hawk in central North Dakota. Master's thesis, N. Dakota State Univ., Fargo.

Glinski, R. L. 1998. Ferruginous Hawk. Pp. 105-108 *in* The Raptors of Arizona (R. L. Glinski, ed.). Univ. Arizona Press, Tuscon.

Hall, R. S., R. L. Glinski, D. H. Ellis, J. M. Ramakka, and D. L. Base. 1988. Ferruginous Hawk. Pp. 111-118 *in* Proceedings of the Southwest Raptor Management Symposium and Workshop (R. L. Glinski et al., eds.). Natl. Widl. Fed., Washington, D. C.

Harmata, A. R. 1991. Impacts of oil and gas development on raptors associated with Kevin Rim, Montana. State Univ. report for U.S. Dept. Interior, Bur. Land. Manage., Great Falls Resource Area, MT. 79pp.

Jasikoff, T. M. 1982. Habitat suitability index models: Ferruginous Hawk. U.S.D.I. Fish and Wildlife Service. FWS/OBS-82/10.10. 18pp.

McAnnis, D. M. 1990. Home range, activity budgets, and habitat use of Ferruginous Hawks (*Buteo regalis*) breeding in southwest Idaho. Master's thesis, Boise State Univ., Boise, ID.

Olendorff, R. R. 1993. Status, biology, and management of Ferruginous Hawks: a review. Raptor Res. and Tech. Asst. Cen., Spec. Rep. U.S. Dept. Interior, Bur. Land Manage., Boise, ID.

Olendorff, R. R., and J. W. Stoddard, Jr. 1974. Potential for management of raptor populations in western grasslands. Pp. 47-88 *in* Management of raptors (F. N. Hamerstrom, Jr., B. E. Harrell, and R. R. Olendorff, eds.). Raptor Res. Rep., No. 2, Raptor Res. Found., Vermillion, SD.

Palmer, R. S. 1988. Ferruginous Hawk. Pp. 135-151 *in* Handbook of North American birds. Vol. 5, pt. 2. Yale Univ. Press, New Haven, CT.

Ramakka, J. M. 1988. Impacats and mitigation of mineral development on raptors in the Southwest. Pp. 335-340 *in* Proceedings of the Southwest Raptor Management Symposium and Workshop (R. L. Glinski et al., eds.). Natl. Widl. Fed., Washington, D. C.

Ramakka, J. M. and R. T. Woyewodzic. 1993. Nesting ecology of ferruginous hawks in northwestern New Mexico. J. Raptor Res. 27: 97-101.

Schmutz, J. K., S. M. Schmutz, and D. A. Boag. 1980. Coexistence of three species of hawks (*Buteo* spp.) in the prairie-parkland ecotone. Can. J. Zool. 58: 1075-1089.

Smith, D. G., and J. R. Murphy. 1978. Breeding ecology of raptors in the eastern Great Basin of Utah. Brigham Young Univ. Sci. Bull. Biol. Ser. 13: 1-76.

Suter, G. W. and J. L. Joness. 1981. Criteria for Golden Eagle, Ferruginous Hawk, and Prairie Falcon nest site protection. Raptor Research 15: 12-18.

Ure, J., P. Briggs, and S. W. Hoffman. 1991. Petition to list as endangered the Ferruginous Hawk (*Buteo regalis*), as provided by the Endangered Species Act of 1973, as amended in 1982. Ferruginous Hawk Project, Salt Lake City, UT.

U.S. Fish and Wildlife Service. 1992. Endangered and threatened wildlife and plants; Notice of finding on petition to list the ferruginous Hawk. Fed. Reg. 57: 37507-37513

U.S. Fish and Wildlife Service, Utah Field Office. 1999. Utah field office guidelines for raptor protection from human and land use disturbances. U.S. Fish and Wildlife Serv., Salt Lake City, UT. 41pp.

Wakely , J. S. 1978. Activity budgets, energy expenditures, and energy intakes of nesting Ferruginous Hawks. Auk 95: 667-676.

Weston, J. B. and D. H. Ellis. 1968. Ground nesting of the Ferruginous Hawk in west central Utah. Great Basin Naturalist 28(2): 111.

White, C. M. and T. L. Thurow. 1985. Reproduction of Ferruginous Hawks exposed to controlled disturbance. Condor 87: 14-22.

White, C. M., T. L. Thurow, and J. F. Sullivan. 1979. Effects of controlled disturbance on Ferruginous Hawks as may occur during geothermal energy development. Geothermal Resources Council, Transactions, Vol. 3: 777-780.

Woffinden, N. D. and J. R. Murphy. 1989. Decline of a Ferruginous Hawk population: a 20-year summary. J. Wildl. Manage. 53: 1127-1132.

Appendix A. Photographs of representative nest and substrate qualities used during this study.

1. Excellent nest on Pillar

2. Good nest on Small Butte

3. Old nest on Short Cliff

4. Dilapidated nest on Ground

Appendix B. Summary of 120 habitat-polygons considered for survey on the Navajo Nation in northwestern New Mexico.

Polygon Number	Area (sq mi)	Survey Aircraft
01	1.85	Fixed-wing
02	1.22	Fixed-wing
03	5.21	Fixed-wing
04	1.94	Fixed-wing
05	0.54	Fixed-wing
06	2.94	Rotary-wing
07	11.45	Rotary-wing
08	2.60	Rotary-wing
09	95.48	Rotary-wing
10	3.47	Fixed-wing
11	2.19	Fixed-wing
12	1.03	Fixed-wing
13	3.89	Rotary-wing
14	3.15	Rotary-wing
15	3.56	Rotary-wing
16	1.88	Rotary-wing
17	151.25	Rotary-wing
18	18.83	Rotary-wing
19	11.62	Fixed-wing
20	10.32	Fixed-wing
21	26.24	Rotary-wing
22a	12.30	Rotary-wing
22b	11.55	Fixed-wing
23	25.87	Rotary-wing
24	9.95	Rotary-wing
25	97.15	Rotary-wing
26	0.23	Rotary-wing
27	46.81	Rotary-wing
28	9.86	Rotary-wing
29	5.57	Rotary-wing
30	1.07	Rotary-wing
31	8.04	Rotary-wing
32	0.34	Rotary-wing
33	8.28	Rotary-wing
34	1.35	Rotary-wing
35	2.87	Rotary-wing
36	12.86	Rotary-wing
37	0.72	Rotary-wing

Polygon Number	Area (sq mi)	Survey Aircraft
38	1.06	Rotary-wing
39	0.62	Rotary-wing
40	0.21	Rotary-wing
41	16.22	Rotary-wing
42	5.26	Rotary-wing
43	0.26	Rotary-wing
44	3.20	Rotary-wing
45	1.00	Rotary-wing
46	1.42	Rotary-wing
47	0.60	Rotary-wing
48	2.35	Rotary-wing
49	14.07	Rotary-wing
50	0.92	Rotary-wing
51	0.24	Rotary-wing
52	0.60	Rotary-wing
53	9.92	Rotary-wing
54	35.52	Rotary-wing
55	28.14	Rotary-wing
56	18.98	Rotary-wing
57	2.89	Rotary-wing
58	3.16	Rotary-wing
59	8.99	Rotary-wing
60	4.86	Fixed-wing
61	1.69	Rotary-wing
62	0.22	Rotary-wing
63	2.20	Rotary-wing
64	1.18	Rotary-wing
65	1.02	Rotary-wing
66	1.14	Rotary-wing
67	42.42	Rotary-wing
68	49.91	Rotary-wing
69	1.08	Rotary-wing
70	3.76	Rotary-wing
71	11.07	Rotary-wing
72	11.23	Rotary-wing
73	3.68	Rotary-wing
74	13.72	Rotary-wing
75	0.42	Rotary-wing
76	26.34	Rotary-wing
77	0.99	Rotary-wing
78	16.24	Rotary-wing
79	2.02	Rotary-wing

Polygon Number	Area (sq mi)	Survey Aircraft
80	1.02	Rotary-wing
81	1.04	Rotary-wing
82	1.52	Rotary-wing
83	4.90	Rotary-wing
84	6.25	Fixed-wing
85	5.80	Fixed-wing
86	8.56	Fixed-wing
87	1.53	Fixed-wing
88	1.31	Rotary-wing
89	0.38	Rotary-wing
90	0.72	Rotary-wing
91	2.56	Rotary-wing
92	0.67	Rotary-wing
93	1.40	Rotary-wing
94	6.05	Rotary-wing
95	2.47	Rotary-wing
96	1.39	Rotary-wing
97	1.35	Rotary-wing
98	1.19	Fixed-wing
99	2.22	Fixed-wing
100	1.07	Fixed-wing
101	0.31	Fixed-wing
102	0.63	Fixed-wing
103	1.65	Fixed-wing
104	1.88	Fixed-wing
105	6.02	Fixed-wing
106	0.30	Fixed-wing
107	1.57	Fixed-wing
108	1.25	Fixed-wing
109	0.73	Fixed-wing
110	6.21	Fixed-wing
111	16.72	Fixed-wing
112	1.02	Fixed-wing
113	1.02	Fixed-wing
114	0.22	Fixed-wing
115	0.62	Fixed-wing
116	3.94	Fixed-wing
117	1.37	Fixed-wing
118	5.53	Fixed-wing
119	3.68	Rotary-wing
120	1.72	Rotary-wing