2007-12-05

A Study of Habitat Variables Associated with Northern Goshawk Nest Site Activity on the Three National Forests in Southern Utah

Keeli Shea Marvel
Brigham Young University - Provo

A STUDY OF HABITAT VARIABLES ASSOCIATED WITH NORTHERN GOSHAWK NEST SITE ACTIVITY ON THE THREE NATIONAL FORESTS IN SOUTHERN UTAH

by

Keeli S. Marvel

A thesis submitted to the faculty of

Brigham Young University

in partial fulfillment of the requirements for the degree of

Master of Science

Department of Plant and Wildlife Sciences

Brigham Young University

December 2007

BRIGHAM YOUNG UNIVERSITY

GRADUATE COMMITTEE APPROVAL

Of a thesis submitted by

Keeli S. Marvel

This thesis has been read by each member of the following graduate committee and by majority vote has been found satisfactory.

_____	_____
Date	Clayton M. White, Chair
_____	_____
Date	Hal L. Black
_____	_____
Date	Val J. Anderson
_____	_____
Date	Ronald L. Rodriguez

BRIGHAM YOUNG UNIVERSITY

As chair of the candidate's graduate committee, I have read the dissertation of Keeli S. Marvel in its final form and have found that (1) its format, citations, and bibliographic style are consistent and acceptable and fulfill university and department style requirements; (2) its illustrative materials including figures, tables, and charts are in place; and (3) the final manuscript is satisfactory to the graduate committee and is ready for submission to the university library.

_____	_____
Date	Clayton M. White Chair, Graduate Committee

Accepted for the Department

_____	_____
Date	Loreen A. Woolstenhulme Graduate Coordinator

Accepted for the College

_____	_____
Date	Rodney J. Brown Dean, College of Life Sciences

ABSTRACT

A STUDY OF HABITAT VARIABLES ASSOCIATED WITH
NORTHERN GOSHAWK NEST SITE ACTIVITY ON THE
THREE NATIONAL FORESTS IN SOUTHERN UTAH

Keeli S. Marvel

Department of Plant and Wildlife Sciences

Master of Science

The Northern Goshawk has been a species of concern since its decline in the early 1990s, which has been attributed in part to loss of critical breeding and wintering habitat. Nest site selection of goshawks has been correlated with certain specific site characteristics including, but not limited to, forest species composition, forest stand size, diameter of nest tree, percent cover, tree height, site slope, and aspect. The goshawk holds the status of a Management Indicator Species (MIS) on all of the six national forests in Utah. This status requires annual monitoring to track goshawk numbers and to address any activities on the forests that may affect nest site activity. Findings from the annual nesting data showed that some territories have been more active than others. We summarized the data from the three national forests in southern Utah in order to understand differences in nesting habitat among the forests. We also analyzed the nesting

habitat variables slope, elevation, and nest tree species statistically to determine if they could be used as predictors of nest activity. We found that slope and elevation were not good predictors while nest tree species was significant in its ability to predict nest activity. We concluded the nesting habitat variables we selected were insufficient in their ability to predict nest activity and other variables such as prey species availability, weather conditions in the spring, and forest cover type might be needed to create a model that more accurately predicts nest activity.

ACKNOWLEDGMENTS

Thanks to Dixie National Forest for the funding and resources used in the study, without which it would not have been possible. Thanks to Barbara Smith and Jeff Jewkes from Manti-La Sal National Forest, and Kreig Rasmussen from Fishlake National Forest and all of the forest service employees that assisted with field work and monitoring data. Thanks to Matthew B. Lee from Dixie National Forest for being my GIS guru. Thanks to Dr. Janene Auger and Cami Fransend for helping me with my nest UTMs, and Gary Ogborn for putting a great map together for me. Thanks to Leslie McFarlane with the Utah Division of Wildlife Resources for keeping me motivated. Also, I thank my fellow graduate students Jenna Jorgensen, Landon Jones, and Rob Bogardus for the camaraderie and homework frustration we shared, and Landon, especially, for helping me out, getting me involved in his own project, and turning me into the bird nerd that I am. I'm grateful for my graduate committee, Clayton M. White, Hal L. Black, Val J. Anderson, and Ronald L. Rodriguez, for the help they gave me. Thanks especially to Clayton M. White and Hal L. Black, who were amazing teachers and instilled in me and many other students a love for ornithology. I know they hope to leave a legacy when they retire, and I believe they will leave very large shoes to fill. Finally, I thank my grandparents, my parents and my husband, Lee, for the support and motivation given me and for always letting me know they are behind me every step of the way

TABLE OF CONTENTS

INTRODUCTION

The Northern Goshawk (*Accipiter gentilis*) is a holarctic species, occurring within its range in North America from boreal and montane forests in Canada and Alaska throughout conifer and deciduous forests in the western U.S. to Mexico and nesting at elevations that range from sea level to alpine (Squires and Reynolds 1997). There are currently three recognized subspecies, the Apache, (*A. g. apache*), the Queen Charlotte, (*A. g. laingi*), and the northern goshawk (*A. g. atricapillus*), the last of which, hereafter referred to as goshawk, is the focus of this study (Squires and Reynolds 1997, Graham et al. 1999).

The goshawk has been a species of concern since it was thought to be in decline in the early 1990s. This suspected decline has been attributed, in part, to loss of critical breeding and wintering habitat due to forest level disturbances such as timber harvesting and insect damage (Graham et al. 1999). In 1992, the USDA Forest Service listed the goshawk as a sensitive species in the Intermountain Region of the Forest Service, which includes all six national forests in Utah (USDA Forest Service 1988, Squires and Reynolds 1997, Graham et al. 1999). The goshawk also has the status of a Management Indicator Species (MIS) on Utah's six national forests (USDA Forest Service 1999). MIS status is a designation developed by the Forest Service in response to the national forest Management Act of 1976, which requires the Forest Service to maintain biological diversity and population viability on national forest system lands. MIS are "…species whose population changes are believed to indicate the effects of land management activities" (USDA Forest Service 1982, Sidle and Suring 1986). Goshawks are MIS on

many national forests throughout their range because as old growth forest nesters they are potentially sensitive to changes in their habitat (Squires and Reynolds 1997).

The concept of MIS was developed, in part, because the Forest Service could not realistically monitor each individual, much less every species, on Forest Service-administered lands. Their solution was to create a selection process whereby they selected and created monitoring programs for a manageable suite of species they felt were representative of the habitats and communities on specific national forests (Sidle and Suring 1986). The Forest Service "…designated the goshawk as a national indicator of mature and old-growth forests," and following that, several national forests made the decision to include it in their Land Management Plans (Sidle and Suring 1986, Patla 1990, Graham et al. 1999). The status as a sensitive and MIS species requires national forests to implement annual monitoring efforts to track goshawk numbers and address any activities on forests that may affect population trend and viability.

A goshawk survey protocol was developed by the Forest Service for the Intermountain Region in 1993 and is the guideline managers in Utah are directed to follow for implementing goshawk survey and monitoring programs (USDA Forest Service 1993). Successful monitoring has in some national forests already produced, and will continue to produce, a consistent and reliable monitoring record of breeding goshawk populations at the national forest level as well as a closer look at goshawk nesting biology and the abiotic and biotic factors involved. Goshawk population monitoring also allows managers to monitor the efficacy of current management practices and their effect on goshawk populations as dictated by sensitive and MIS requirements.

The Forest Service has emphasized the importance of protecting known goshawk breeding sites, in particular, because breeding goshawks exhibit high nest site fidelity (Reynolds and Wight 1978, Detrich and Woodbridge 1994, Wiens et al. 2006). Nest site selection and breeding success of goshawks has been attributed to fulfillment of specific nest site characteristics (Reynolds et al. 1982, Moore and Henny 1983). Forest tree species composition, diameter of nest tree, percent canopy cover, tree height, site slope, and aspect all appear to be important in goshawk selection of suitable nesting habitat.

Goshawk nest sites exhibit specific structural characteristics that vary little between cover types (Graham et al 1999). They nest in mature to old growth coniferous, deciduous, and mixed forests (Moore & Henny 1983, Reynolds 1987, Squires and Reynolds 1997, Graham et al. 1999). Nests are built in trees that are in or near the bottom of drainages with moderately steep side slopes that range up to 40% (Squires and Reynolds 1997, Bosakowski 1999, Graham et al. 1999). Nests are large stick structures located in a primary crotch (in aspen), on large limbs against trunks (in conifers), or occasionally out on large limbs away from trunks (Saunders 1982, Squires and Reynolds 1997, Bosakowski 1999).

Each nest is within a forest stand (the nest site) that is approximately 10-100 ha (25-250 ac) in size (Reynolds et al. 1982, Woodbridge and Detrich 1994, Squires and Reynolds 1997). The home range of a goshawk covers about 2400 ha (6,000 ac). Only a small portion of that, the territory, is actually defended (the definition of a territory). Reynolds and others determined that the minimum territory of a nesting pair of goshawks is just over 200 ha, (500 ac) (Reynolds et al.1992). Both individuals in a nesting pair defend their territory, although the female is the most aggressive and generally exhibits

the majority of defensive behavior. The home range of the goshawk is considered to be the area a nesting pair uses for foraging during the breeding season. Prey base during the breeding season varies according to habitat and availability, and includes medium sized birds such as woodpeckers, jays, and grouse, and small mammals such as squirrels, rabbits, and hares (Squires and Reynolds 1997, Bosakowski 1999, Graham et al. 1999).

When choosing nest trees, goshawks in temperate forests usually choose trees on slopes with north or northeast aspects. A water source such as a small, quiet stream is usually found within the drainage or in adjacent or adjoining drainages. Forest patches with higher canopy cover are preferred, and the nests themselves are generally located just below the living canopy (Hennesey 1978, Reynolds et al. 1992, Squires and Reynolds 1997, Bosakowski 1999, Graham et al. 1999). Because of nest site fidelity, however, some nests remain in continuous use even after forest die-offs cause the canopy to disappear. Dense canopy cover may be an important characteristic of goshawk nest sites for three separate reasons. 1) Canopy cover with intersecting crowns may be necessary habitat for red squirrels (*Tamiasciurus hudsonicus*), an important prey species of the goshawk in Utah (Rodriguez 2007). 2) Dense canopy cover may also provide protection from temperature extremes and severe weather. 3) Canopy may provide cover from goshawks' few known natural predators such as Great Horned Owls (*Bubo virginianus*) and Red-tailed Hawks (*Buteo jamaicensis*) (Squires and Reynolds 1997, Bosakowski 1999). Nest predation may occur by mammals as well, as suggested by observation of claw marks on nest tree trunks, but little is known about mammal predation on goshawk nests (McGowan 1975, Squires and Reynolds 1997, Marvel personal observation 2006).

Preliminary analysis of the annual nesting data from the Dixie, Fishlake, and Manti-La Sal national forests in Utah showed that some territories were active more overall and for more successive years. Based on this observation, we hypothesized that an analysis of goshawk nest activity and nest site habitat characteristics would show that:

> H_a: Certain habitat characteristics are positively correlated with and affect the probability of a nest being active.

Identifying habitat characteristics that are associated with higher goshawk nest activity rates will help managers protect and manage for the enhancement of those characteristics in a more effective manner. Our data summary will also provide updated population demographics for the Dixie, Fishlake, and Manti-La Sal national forests and compare the current status of goshawk populations and their habitat on each.

METHODS

Study Area

The study area comprised three national forests in southern Utah: Dixie, Fishlake, and Manti-La Sal national forests (Fig. 1). Nest site elevations on each of the forests range from 1800 to 3200 m (6,000 to 10,500 ft). Forest cover types range from woodland communities of Pinyon Pine (*Pinus edulis*) and juniper species (*Juniperus spp.*) at the lower elevations, with combinations of Quaking Aspen (*Populus tremuloides*) and mixed conifer in the mid-elevations, to combinations of aspen, Subalpine Fir (*Abies lasiocarpa*), and Engelmann Spruce (*Picea engelmannii*) at the highest elevations. As part of the annual monitoring effort required by sensitive and MIS designations and implemented by each national forest, nest habitat characteristics, location, and yearly activity of nest sites were recorded for national forests in Utah. Suitable goshawk nesting habitat in each national forest boundary was derived geospatially using GIS software. Suitability as

potential nesting habitat was determined by forest cover type and included all forested landscapes excluding woodlands, which are composed of the pinyon/juniper community type only. Forested landscapes included any combination of aspen and various conifer cover types (Rodriguez 2007).

The size of each national forest and the amount of habitat suitable for goshawk nesting on each forest were: Dixie National Forest, approximately 794,941 ha (1,964,341 ac), 264,856 ha (662,140 ac) considered suitable goshawk nesting habitat; Fishlake National Forest, approximately 617,424 ha (1,525,688 ac), 588,557 ha (1,471,392 ac) suitable; and Manti-La Sal National Forest, approximately 571,866 ha (1,413,111 ac), 144,147 ha (360,368 ac) suitable as potential goshawk nesting habitat (Rodriguez 2006).

Monitoring

Our data were assembled from an existing Forest Service database of goshawk monitoring records dating from 1992 to 2006. The USDA Forest Service collected population data on an annual basis from known goshawk nesting territories. Nest sites were located through survey efforts, generally conducted in areas of proposed projects, and from incidental sightings. Monitoring and surveys were conducted according to the protocol described in the Northern Goshawk Survey Protocol for the Intermountain Region (USDA Forest Service 1993).

Monitoring was conducted beginning in May each summer and continued until all juvenile goshawks fledged. Each territory was monitored annually, and if possible, each alternate nest was visited at least once. If goshawks were not immediately evident at the onset of a nest visit, then a goshawk alarm call was played using a tape player and broadcasting megaphone three times in three separate directions 120 degrees apart while

technicians listened for a response (Joy et al. 1993, Kennedy and Stahlecker 1993, Watson et al. 1999). In the absence of a response, technicians initiated a ground search for other signs that might indicate activity. These signs included plucking posts (used by adults to pluck or dismember prey), fecal droppings (whitewash) and freshly killed animal carcasses or parts on, under, and around the nest, and greenery (newly laid nest material such as branches with green needles/leaves) in the nest.

Location and habitat data were collected from each known territory, and ideally, each known nest site annually. A Universal Transverse Mercator (UTM) location of each nest site was recorded using a hand-held GPS unit. Figure 2 is a map of goshawk nest locations included in this study. Habitat data that were recorded included specific nest site characteristics such as cover type, nest tree species, slope, aspect, and activity of each nest or nesting territory. Presence of adult hawks was confirmed through visual sightings of incubating birds, birds flying around the nest, and defensive behavior around the nest territory. An active nest was defined as one that contained eggs being incubated (Johnsgard 1990, USDA Forest Service 1993). Nest activity was confirmed by visual sighting of adults incubating, eggs in the nest (confirmed with the use of a special camera called a “tree peeper”), and nestling/fledgling activity at the nest site. If there was no indication that a nest was active, and no other nests in the territory were confirmed active, a nest search was performed within a 0.4-km (0.25-mi) radius of the inactive alternate nests. Such a nest search was also performed when a territory was presumed to be active due to the presence of adults and/or fledglings within the territory.

Analysis

Following data collection, the data were analyzed using the statistical software SAS v9.1 (SAS Institute Inc. 2002-2005). We performed two separate analyses. In order to gain an understanding and an overall picture of the habitat the goshawks were using, and also to see how each national forest compared with another and with the literature, we performed an analysis of variance (ANOVA) on the habitat variables and nest activity associated with each nest within each known territory.

Using SAS v9.1 (SAS Institute Inc. 2002-2005), we also ran a Proc mixed logistic analysis of covariance (ANCOVA). We created a model using nest site characteristics and percent activity based on the ratio of number of years a nest was active to the number of years it was monitored. We used type III tests to test our hypothesis that the presences of certain nest site characteristics affected the probability of a nest being active (n=3,174). Variables that affected probability of activity could then be used to predict future activity. The independent variables we included were cover type, slope, elevation, national forest, and nest tree type and, we tested them against our dependent variable, nest activity. These variables were selected because they were the standard variables recorded during nest monitoring and had the highest number of observations associated with them. The variable, national forest, was included merely to separate the data by forest. We excluded the variables diameter at breast height (dbh), topography (side slope or flat, bottom, middle, or top of slope) and nest aspect because many monitoring records from two of the national forests were missing these variables. We defined cover type as the most abundant and/or dominant tree species in the stand surrounding the nest tree (USDA Forest Service 1993). Slope referred to the angle or slope of the ground at the

point where the nest tree was rooted. Elevation measurements were taken at the nest tree. Nest tree type refers to the tree species of the nest tree.

RESULTS

At the end of the 2006 field season, Dixie National Forest had 147 confirmed goshawk nesting territories and 373 nests, Fishlake National Forest had 39 known territories and 72 nests, and Manti-La Sal National Forest had 65 known territories and 132 nests (Table 1). Most territories contained anywhere from one to five alternate nests. On Dixie National Forest, we had three territories with six alternate nests each and one territory with seven alternate nests (Fig. 3).

In southern Utah, the most common forest cover types of nest sites were aspen, ponderosa pine, white fir, Douglas fir, and subalpine fir. It is logical, then, that the most abundant cover type species, if suitable as nest trees, would also be selected by goshawks most frequently for nests and in general we found this to be so. Figures 4 and 5 show the breakdown of cover type and nest tree type by national forest. Aspen, or some combination of aspen and conifer, was the most abundant cover type and nest tree type on all three forests followed by ponderosa pine. The dbh of nest trees ranged from 21.59 cm to 127 cm (8.5-50 in) with a mean dbh of 52.22±18.72 cm (20.56±7.37 in) on Dixie National Forest, 37.38±7.95 cm (14.72±3.13 in) on Fishlake, and 44.68±10.08 cm (17.59±3.97 in) on Manti-La Sal (Table 2).

Nest tree aspect ranged from 0 to 360 degrees. Due to the nature of the variable aspect degree, which numerically cannot be easily statistically analyzed, we constructed a histogram to visualize the frequency of nest aspects on each national forest (Figs. 6-8).

We found that a large number of nesting goshawks selected trees on north and east facing slopes.

The slope of nest sites on each forest ranged from 0% to 65% with an average of 10.97±6.98% on Dixie National Forest, 12.77±7.19% on Fishlake, and 22.75±15.14% on Manti-La Sal (Table 2). The minimum and maximum elevations of nest sites on all three national forests ranged from about 1,928 m to 3,204 m (6,325 to 10,512 ft) with an average elevation of 2,629±225 m (8,625±738 ft) on Dixie National Forest, 2,804±266 (9,199±873 ft) on Fishlake National Forest, and 2,711±197 (8,894±646 ft) on Manti-La Sal National Forest (Table 2).

When we compared the mean slope, elevation, and aspect measurements among the forests using ANOVA, we found that nest site slope (n=564) differed significantly between the Dixie and Manti-La Sal (P<0.0001), between the Fishlake and Manti-La Sal (P<0.0001); but not between the Dixie and Fishlake national forests (P=0.1506). Nest site Nest site elevation (n=578) differed significantly among all the forests (between the Dixie and Fishlake P<0.0001, between the Dixie and Manti-La Sal P=0.0004, and between the Fishlake and Manti-La Sal P=0.0036). Nest site aspect (n=576) did not differ significantly among the forests (Table 3).

When we performed an ANCOVA we found that the high number of factors in the variable, cover type, significantly affected the outcome, so we removed cover type from the analysis. The following variables were significant in their ability to predict nest activity: Nest tree type (P<0.0001), national forest (P=0.0008), the interaction of slope and national forest (P=0.0009), and the interaction of elevation and national forest (P=0.0003) (Table 4). The significance of the variable national forest indicated that

activity differed significantly among forests. The two interaction terms of national forest x slope and national forest x elevation indicated that the effect, slope and activity, had on nest activity differed between national forests. The variables slope and elevation, themselves, were not significant.

The two interaction terms in our model indicated that the variables slope and elevation differed significantly in their effects on activity among forests. We found that slope and elevation had a negative effect on the probability of a nest being active on the Dixie National Forest, slope had a negative effect, but elevation had a positive effect on the probability of a nest being active on the Fishlake National Forest, and neither slope nor elevation had any effect on the probability of nest activity on the Manti-La Sal National Forest (Table 5).

DISCUSSION

The discrepancy between the known number of territories and nests on each forest (Table 1) may be due in part to the survey efforts exerted and the resources available to each forest for monitoring projects. Goshawk nest searches generally depended on and were highly correlated with proposed projects on each forest. The Dixie National Forest historically had a larger number of proposed projects (mainly timber harvesting) than either the Fishlake or Manti-La Sal national forests, and as such, had invested the time and resources to conduct a greater number of goshawk nest surveys. We know from the literature that goshawk territories contain anywhere from one to eight nests per territory (Squires and Reynolds 1997). The territories we monitored fell within that range with all but three territories containing one to five alternate nests.

We found that the habitat characteristics elevation, slope, aspect, dbh, cover type, and nest tree type on the three forests were in concurrence with those found in the literature to be favored by goshawks in selecting nest habitat. Elevation plays a large part in climate, and therefore, vegetative cover type in Utah. We found nests restricted to elevations ranging from 1,927.86 m to 3,203.75 m (6,325 ft to 10,510.99 ft), where the suitable habitat is found. Johansson and others also found goshawk nesting habitat to be restricted to higher elevations on Dixie National Forest (Johannson et al. 1994).

Average slope ranged between 11% and 23%, with an outlier maximum slope of 65% on Manti-La Sal National Forest. The average slopes of nest sites on all three of the forests as well as the maximum slopes on Dixie and Fishlake national forests fell below the reported and rarely exceeded value of 40% slope in the literature (Shuster 1980, Reynolds et al. 1982, Bosakowski 1999). The significance of the ANOVA test of slope variance between Dixie and Manti-La Sal national forests and between Fishlake and Manti-La Sal national forests can be explained by the high maximum slope on Manti-La Sal National Forest. The extreme angle of a 65% slope is an unlikely place for a large nest tree to be rooted, and as such, this value is most likely observer error.

Most goshawks on all three national forests selected nest sites with north or northeast aspects. In the literature, nest site aspect varied according to regional climate, but researches in locations with arid climates reported observing a majority of goshawk nests on north slopes (Hennesey 1978, Reynolds et al. 1982, Hall 1984, Crocker-Bedford and Chaney 1988, Yonnk and Bechard 1992, Bosakowski 1999). Northerly aspects, dense canopy cover, location within drainages, and proximity to water are all thought to create a cooler microclimate around the nest tree protecting nests from high summer

temperatures, as well as buffering them from extreme weather (Hennessey 1978, Reynolds et al. 1982, Hall 1984, Crocker-Bedford and Chaney 1988, Squires and Reynolds 1997). Because of individual monitoring bias and incomplete records, we were unable to include percent cover, location, and proximity to water.

Dbh of nest trees varied considerably in our results most likely due to the variation in nest tree species. Our mean dbhs were much higher than those reported by Hennesey (1978), who reported a mean nest tree dbh of 23.8 cm (9.37 in) in northern Utah, and Fischer (1986), who reported a similar mean dbh of 27.5 cm (10.83 in). Dbh measurements were only available for a small selection of nest trees in our data set. Therefore, our means may not be representative of the actual dbh means of all our nest trees. Our means may also be larger than those reported in the literature due to the large variation between nest tree species we observed. Aspens generally have much smaller dbh measurements than larger-trunked trees such as ponderosa pine, and we found both to be prominent nest tree and cover type species.

Aspen was selected prominently as both a cover type to nest in, and as a nest tree, which is supported by the assertion of Graham and others (1999) when they stated, "…quaking aspen is one of the most important cover types supporting goshawks in Utah." However, there are a few factors we considered that might also result in aspen being so prominent as both a cover type and nest tree type. A high percentage of goshawks nesting in aspen may be a direct result of the prominence of aspen as a cover type in upland forests in southern Utah. In addition, there are a number of prey species, primarily small passerines, which inhabit the aspen forests of Utah. Nest tree types available to nest in are usually a direct reflection of the cover type of a nest area. An

increased number of nests found in aspen might also be a direct artifact of search image. Because of their open structure, aspens are generally easier to spot nests in; both from the ground and especially from the air, especially during the winter and early spring while the trees are bare of leaves (Rodriguez 2007). We believe that the prominence of aspen as a nest tree type is not wholly determined by these factors because mature aspens have a stable open branching structure that provides a good base for a large nest as well as unimpeded access to the nest.

Nest tree type was the only habitat variable included in the model that was significant in its ability to predict nest activity. We found that the other habitat variables we included, elevation and slope, were not significantly able to predict nest activity individually or in concert with nest tree type. Other important variables we could not include in our analysis such as percent cover, cover type, dbh, spring weather conditions, and prey availability probably contribute to our model's predictability as shown in other studies (Crocker-Bedford & Chaney 1988, Jorgenson 2007). Further testing of our hypothesis with these other variables would require several more seasons of monitoring and a higher degree of effort than previously applied. We believe that if other variables were included in our model, we would find a higher degree of predictability of goshawk activity and support for our hypothesis that nest site habitat variables are associated with, and can predict nest activity.

MANAGEMENT IMPLICATIONS

The habitat data we analyzed were in concurrence with current knowledge of goshawk nesting habitat preferences. The significance of this is that current goshawk management protocol on the Dixie, Fishlake, and Manti-La Sal national forests is

sustained by an accurate knowledge base of goshawk nesting habitat and the protocol itself should be sufficient to monitor goshawk populations. However, we found problems existing among the three forests in implementation of the monitoring protocol. This limited the analyses we performed in our attempts to develop a habitat model that could predict future nesting activity in existing goshawk territories and as yet un-surveyed areas. Survey efforts and monitoring practices differed significantly among the three national forests. Only one forest had an established and thorough monitoring program where a complete record of the nest site data was maintained adequate for detailed analyses. The other forests were not entirely following goshawk-monitoring protocol previously established for all forests in the Intermountain Region (USDA Forest Service 1993). Available resources and monitoring priorities may lie elsewhere for some of the forests, which could explain deficiencies in their monitoring records. At the forest level, with current practices, only very localized effects of management actions will be apparent. Standardization in effort and implementation of goshawk monitoring practices must occur across all the forests to obtain the information that will allow for an understanding of goshawks population trends and habitat selection at larger scales.

Spruce bark beetle mortality

One of the important issues with the potential to affect goshawk nesting habitat that has come to light in recent years is spruce bark beetle mortality. In recent years, the spruce bark beetle (*Dendroctonus rufipennis*) infestation has devastated large areas of spruce forests in Utah. When the infestation moved through Dixie National Forest, huge tracts of spruce were killed, leaving only skeletons behind. There was some concern about the effect this might have on goshawk territories found within the infected areas.

Table 6 shows the percentages of nests found in cover types made up of spruce and combinations of spruce and other species. On the Dixie and Manti-La Sal national forests, between 12% and 15% of the goshawk nests were in cover types made up of spruce or spruce/other species combinations. Fishlake National Forest was much lower, with no nests in pure spruce stands, and less than 2% of its nests in the mixed aspen/spruce cover type. These numbers might seem high to dismiss the effects of the die-off on goshawk habitat, but the actual use by goshawks of spruce species as nest tree types is much lower. Table 7 shows the breakdown in percentage and actual number nests that were found in spruce on all three national forests.

The low percentage of goshawks nesting in the spruce growth cover type supports our theory that spruce growth type is generally too dense to accommodate a goshawk nest and allow unobstructed access to the nest by adult goshawks. Few recorded nests in spruce trees indicate that the effect of the spruce die-off was probably minimal at the population level. In addition, nest territories on the Dixie National Forest found in areas of high spruce bark beetle mortality remained active following die-offs (Dixie National Forest 1997, Graham et al. 1999). This may be explained by the increased level of woodpecker activity that occurred following the widespread spruce mortality providing additional prey for goshawks (Rodriguez 2007).

Aspen decline

Another species-specific habitat issue that is being addressed by the national forests in Utah is the noted decline of aspen. Occurring particularly in southern Utah, aspen stands are maturing and dying off without sufficient regeneration for stand replacement (Campbell and Bartos 2001, Rodriguez 2007). Over-browsing by wildlife

and livestock significantly reduces the vigor of regenerating aspen sprouts and their capability to compete with encroaching conifer and sagebrush (Smith et al.1972, Campbell and Bartos 2001, USDA Forest Service 2007). Because aspen makes up a significant portion of goshawk nesting habitat in Utah, there is an increasing need to maintain it throughout the landscape.

Wildlife managers must work together with vegetation specialist to harvest decadent stands of aspen and encourage regeneration. The management of short-term species viability is an important component of managing a population at the landscape scale. The integrity of known goshawk nest sites must be maintained while managing decadent stands of aspen. While this is not an easy task, managers must ensure the short-term viability is sustained in order to have the long-term persistence of the species. Therefore, effective short-term management and conservation of goshawk nest habitat will ultimately allow for the long-term viability of goshawk populations.

LITERATURE CITED

Bosakowski, Thomas. 1999. The Northern Goshawk: Ecology, behavior, and management in North America. Hancock House Publisher Ltd. Surrey, British Columbia, Canada.

Cambell, Jr., Robert B., and Dale L. Bartos. 2001. Aspen ecosystems: objectives for sustaining biodiversity. IN: W. D. Shepperd, D. Binkley, D. L. Bartos, T. J. Stohlgren, and L. G. Eskey, compilers. 2001. Sustaining aspen in western landscapes; symposium proceedings; 13-15 June 2000; Grand Junction, CO. Proceedings RMRS-P-18. USDA, Forest Service, Rocky Mountain Research Station, Fort Collins, CO. 460 p.

Crocker-Bedford, D. Coleman and B. Chaney. 1988. Characteristics of goshawk nesting stands. Southwest Raptor Management Symposium and Workshop 210-217.

Detrich, P.J., and B. Woodbridge. 1994. Territory fidelity, mate fidelity, and movements of color-marked Northern Goshawks in the southern cascades of California. Studies in Avian Biology 16:130-132.

Dixie National Forest. 1997. Northern goshawk habitat us of pinyon/juniper, ponderosa pine, and dead spruce/harvest history in ponderosa pine. Unpublished paper on file at: U.S. Department of Agriculture, Forest Service, Dixie National Forest, Cedar City, UT.

Fischer, D. L. 1986. Daily activity patterns and habitat use of coexisting *Accipiter* hawks in Utah. Ph.D. Thesis. Brigham Young University, Provo, UT.

Graham, Russell T., R.L. Rodriguez, K.M. Paulin, R.L. Player, A.P. Heap, and R. Williams. 1999. The Northern Goshawk in Utah: Habitat assessment and management recommendations. Gen. Tech. Rep. RMRS-GTR-22. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 48 p.

Hall, P.A. 1984. Characterization of nesting habitat of goshawks (*Accipiter gentilis*) in northwestern California. M.S. Thesis, Humboldt State University, Arcata California 70 p.

Hennesey, S.P. 1978. Ecological relationships of *Accipiters* in northern Utah-with special emphasis on the effects of human disturbance. Logan, UT: Utah State University. Thesis. 66 p.

Johansson, C., P.J. Hardin, and C.M. White. 1994. Large area goshawk habitat modeling in Dixie National Forest using vegetation and elevation data. Studies in Avian Biology 16:50-57.

Johnsgard, P. 1990. Hawks, eagles, & falcons of North America. Smithsonian Institution Press, Washington.

Jorgenson, J. M. 2007. Biotic and environmental variables of Northern Goshawk nesting on the Dixie National Forest, Utah. Unpublished Master's Thesis. Brigham Young University, Provo, UT. 49 p.

Joy, Suzanne M., R.T. Reynolds, and D.G. Leslie. 1993. Northern Goshawk broadcast surveys: Hawk response variables and survey costs. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Ft. Collins, CO.

Kennedy, Patricia L., and D. W. Stahlecker. 1993. Responsiveness of nesting northern goshawks to taped broadcasts of three conspecific calls. Journal of Wildlife Management 57:249-257.

Marvel, Keeli Shea. 2006. Personal observation of potential Northern Goshawk nest predator claw marks on trunk of nest tree in Powell Ranger District, Dixie National Forest.

McGowan, J.D. 1975. Distribution, density, and productivity of goshawks in interior Alaska. Federal Aid Wildlife Restoration Project Report W-17-4, W17-5, W-17-6, Job 10.6A. Alaska Department of Fish and Game.

Moore, Kevin R., and Charles J. Henny. 1983. Nest site characteristics of three coexisting accipiter hawks in northeastern Oregon. Journal of Raptor Research 17(3): 65-76.

Patla, S. 1990. Northern goshawk monitoring project report, 1989, Targhee National Forest. Final Rep. P.O. No. 43-02 S 2-8-1931. St. Anthony, ID: U.S. Department of Agriculture, Forest Service, Targhee National Forest. 22p.

Reynolds, Richard T. 1987. The Status of *Accipiter* populations in the western United States. Western Raptor Management Symposium and Workshop Proceedings. p. 91-101.

Reynolds, Richard T., and H. M. Wight. 1978. Distribution, density, and productivity of *Accipiter* hawks breeding in Oregon. Wilson Bulletin 90(2): 182-196.

Reynolds, Richard T., E.C. Meslow, and H.M. Wight. 1982. Nesting habitat of coexisting *Accipiter* in Oregon. Journal of Wildlife Management 46:124-138.

Reynolds, Richard T., R.T. Graham, M.H. Reiser, R.L. Bassett, P.L. Kennedy, D.A. Boyce Jr., G. Goodwin, R. Smith, E.L. Fisher. 1992. Management recommendations for the Northern Goshawk in the southwestern United States. Gen. Tech. Rep. RM-217. U.S. Department of Agriculture, Forest Service, Fort Collins, CO, Rocky Mountain Forest and Range Experiment Station.

Rodriguez, R.L. 2007 (November). Personal communication. Forest biologist U.S. Department of Agriculture, Forest Service, Dixie and Fishlake national forests, Cedar City, UT.

SAS Institute Inc., Version 9.1 (TS1M3). Copyright (c) 2002-2005 by SAS Institute Inc., Cary, NC, USA.

Saunders, L.B. 1982. Essential nesting habitat of the Goshawk (*Accipiter gentilis)* on the Shasta-Trinity National Forest, McCloud District. M.S. thesis, California State University, Chico.

Shuster, W. C. 1980. Northern Goshawk nesting requirements in the Colorado Rockies. Western Birds 11:89-96.

Sidle, Winifred B., and L. H. Suring. 1986. Management indicator species for the National Forest lands in Alaska. USDA Forest Service, Alaska Region Technical Publication R10-TP-2.

Smith, A. D., P. A. Lucas, C. O. Baker, and G. W. Scotter. 1972. The effects of deer and domestic livestock on aspen regeneration in Utah. Publication No. 72-1. Utah Division of Wildlife Resources, Logan, UT. 32 p.

Squires, J.R., and R.T. Reynolds. 1997. Northern Goshawk (*Accipiter gentilis*). *In* The Birds of North America, No. 298 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and the American Ornithologists' Union, Washington, D.C.

USDA Forest Service. 1982. National Forest System land and resource management planning. Fed. Reg. 47: 43026-43052.

USDA Forest Service. 1988. Forest Service Manual, Wildlife, fish and sensitive plant habitat management. WO Amendment 2600-95-6. Threatened, endangered, and sensitive species management. 19 p.

USDA Forest Service. August 1993. Northern Goshawk survey protocol. Intermountain Region. Ogden, UT. Unpublished document on file at: U.S. Department of Agriculture, Forest Service, Dixie National Forest, Cedar City, UT.

USDA Forest Service. 1999. Utah Northern Goshawk Project. USDA Forest Service, Intermountain Region. October 1999, 1-2.

USDA Forest Service. 2007. Dixie National Forest aspen problem statement and charter. Mark Loewen: Team Lead. R. L. Rodriguez, P. Eisenhauer, K. Harris, and B. Campbell (ad hoc). On file at supervisor's office, Dixie National Forest, Cedar City, UT.

Watson, J.W., D. W. Hays, and D. J. Pierce. 1999. Efficacy of Northern Goshawk broadcast surveys in Washington State. Journal of Wildlife Management 63:98-106.

Wiens, J. David, R.T. Reynolds, and B.R. Noon. 2006. Juvenile movement and natal dispersal of Northern Goshawks in Arizona. The Condor 108:235-269.

Woodbridge, B. and P. J. Detrich. 1994. Territory occupancy and habitat patch size of northern goshawks in the southern Cascades of California. Studies in Avian Biology 16: 83-87.

Yonnk, J. V. and M. J. Bechard. 1992. Effects of gold mining activities on Northern Goshawks breeding in Nevada's Independence and Bull Run Mountains. Annual Report, Boise State University, Boise, ID.

FIGURES & TABLES

Figure 1. Location of Dixie, Fishlake, and Manti-La Sal national forest administrative boundaries in the state of Utah.

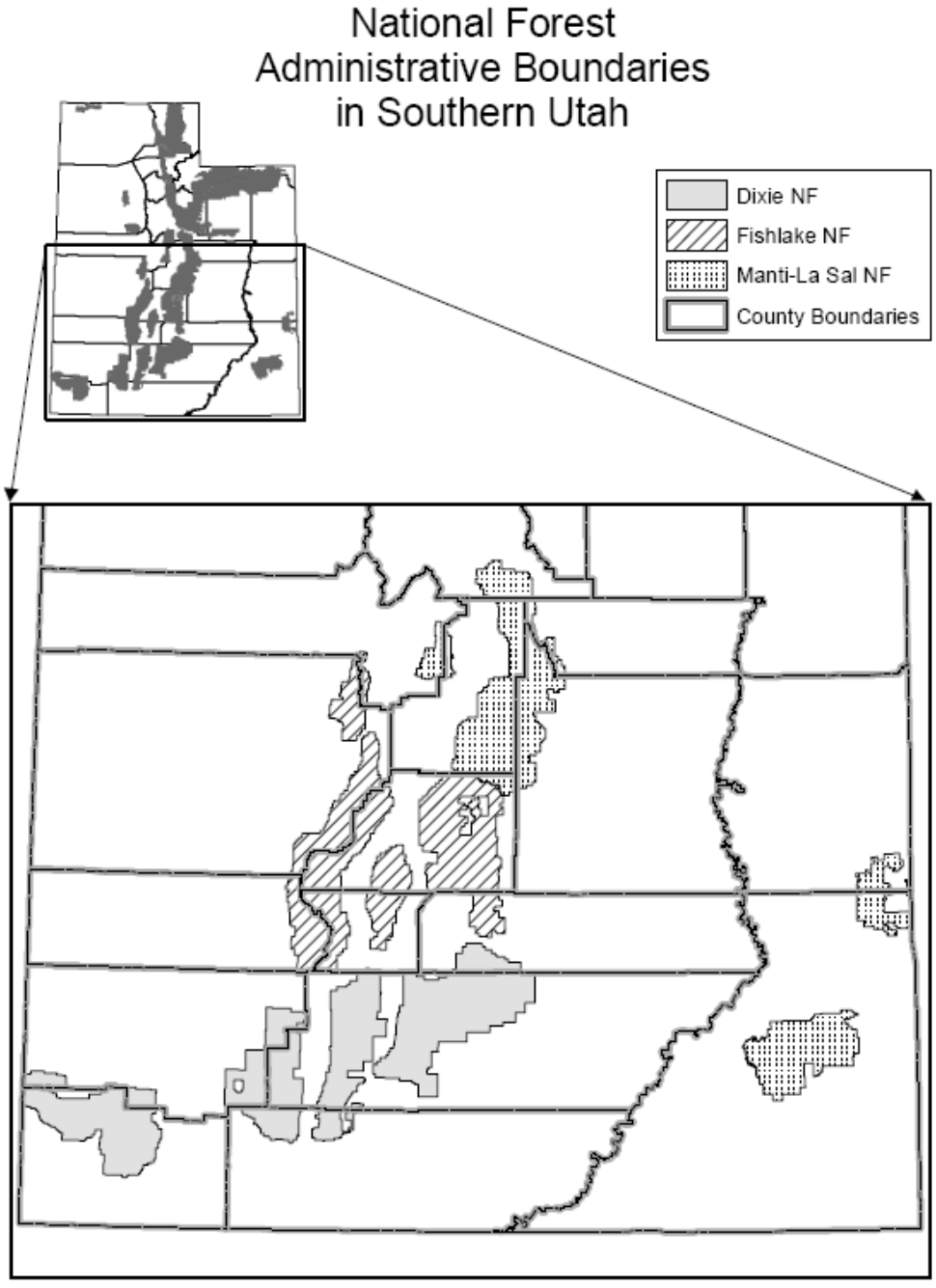

Figure 2: Northern Goshawk nest site locations on Dixie (red), Fishlake (blue), and Manti-La Sal (green) national forests as of August 2006.

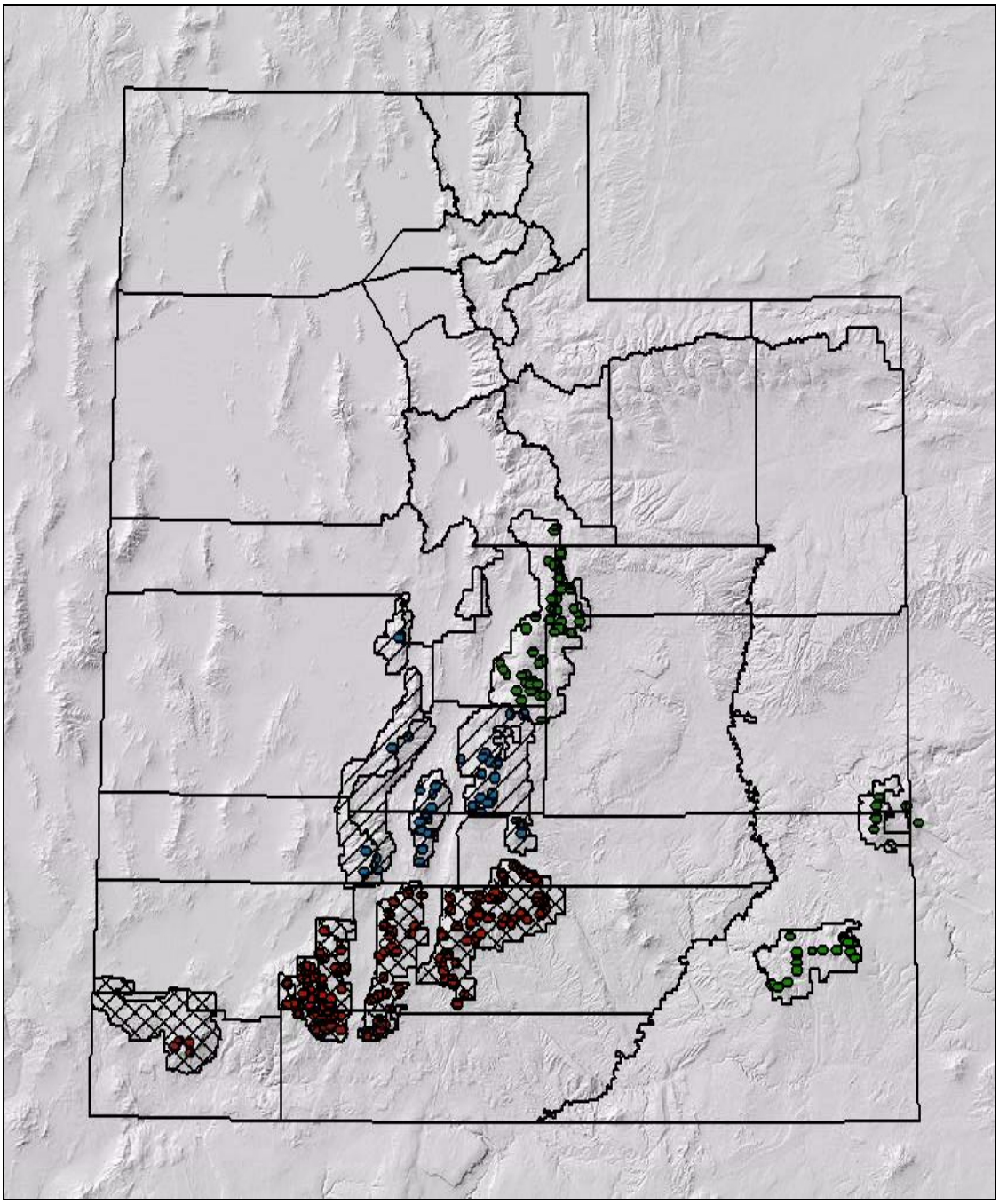

Figure 3: Frequency of number of alternate nests per Northern Goshawk territory monitored on the Dixie, Fishlake, and Manti-La Sal national forests 1992-2006.

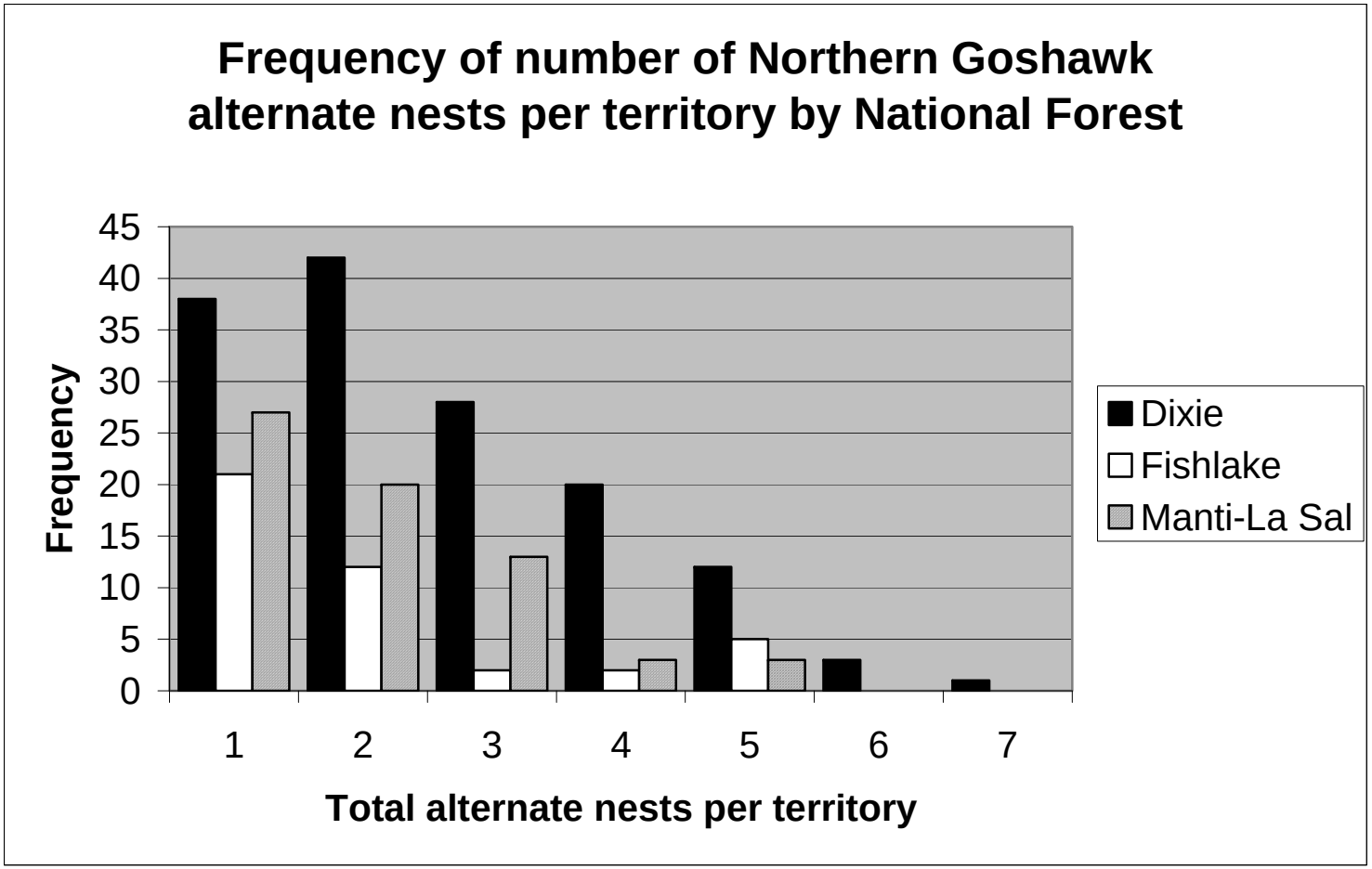

Figure 4. Breakdown of forest cover types of Northern Goshawk nest sites on Dixie, Fishlake, and Manti-La Sal national forests monitored 1992-2006.

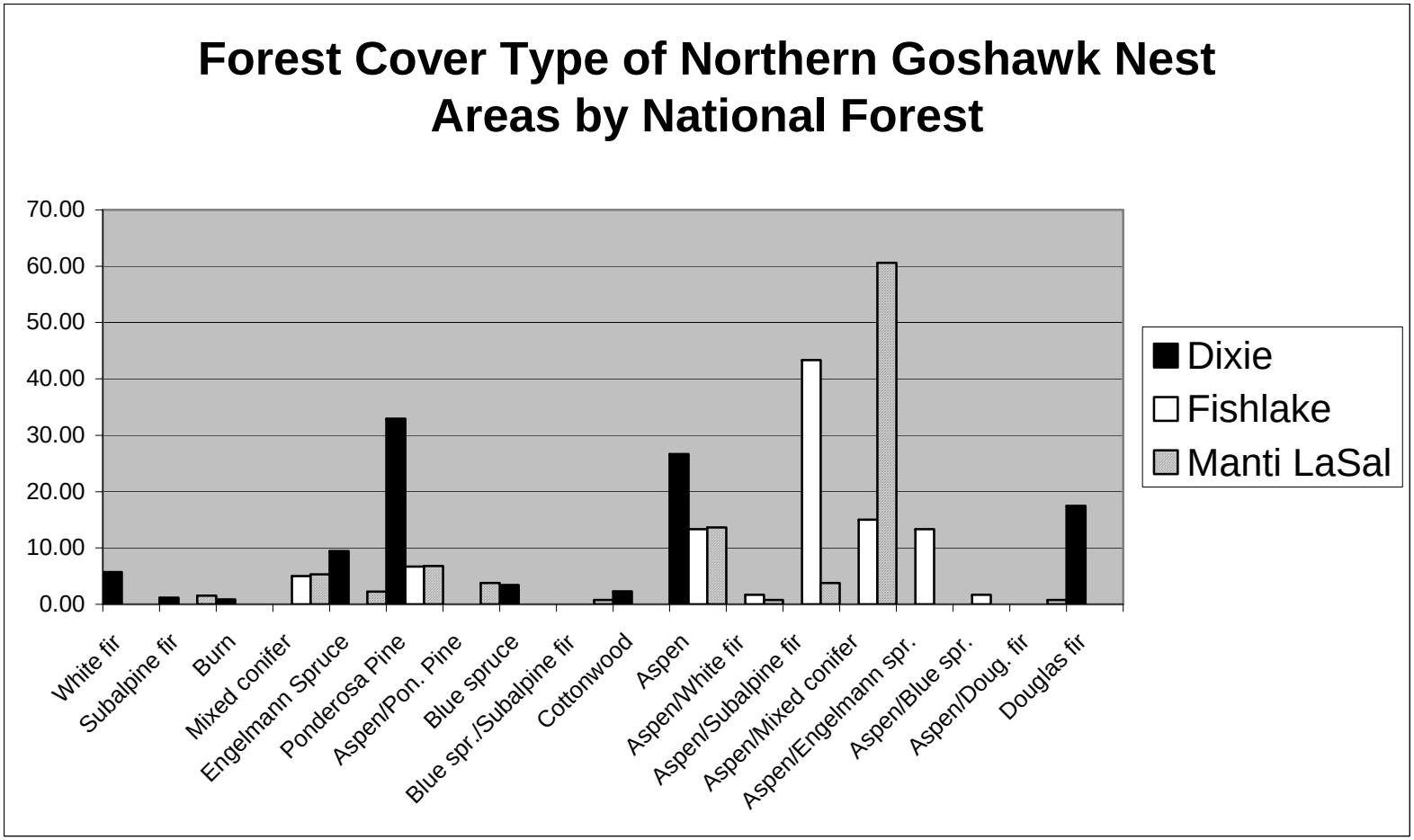

Figure 5. Nest tree types of Northern Goshawk nest sites for nests on Dixie, Fishlake, and Manti-La Sal national forests monitored 1992-2006.

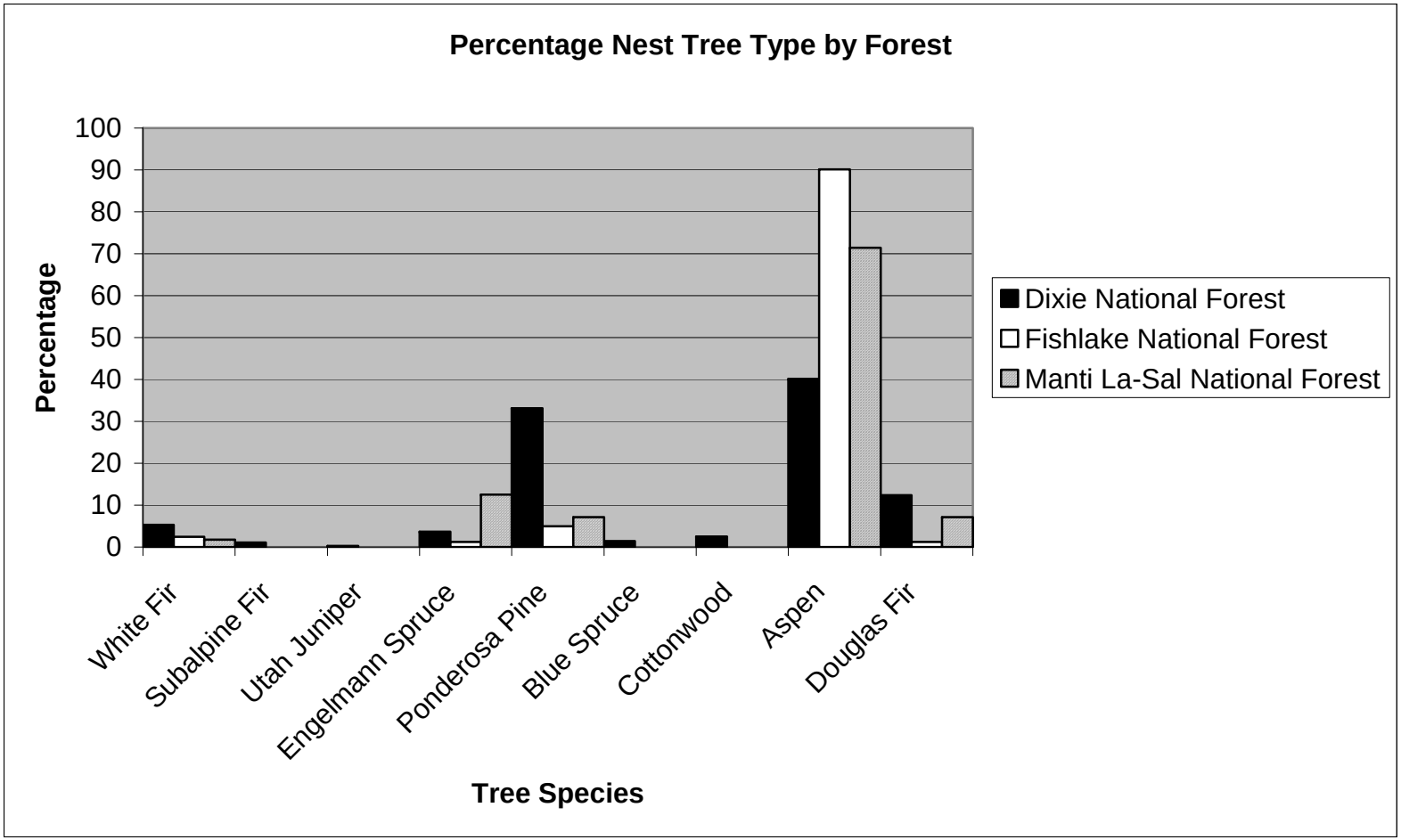

Figure 6. Histogram of frequency of aspects for Northern Goshawk nest sites monitored on the Dixie National Forest 1992-2006.

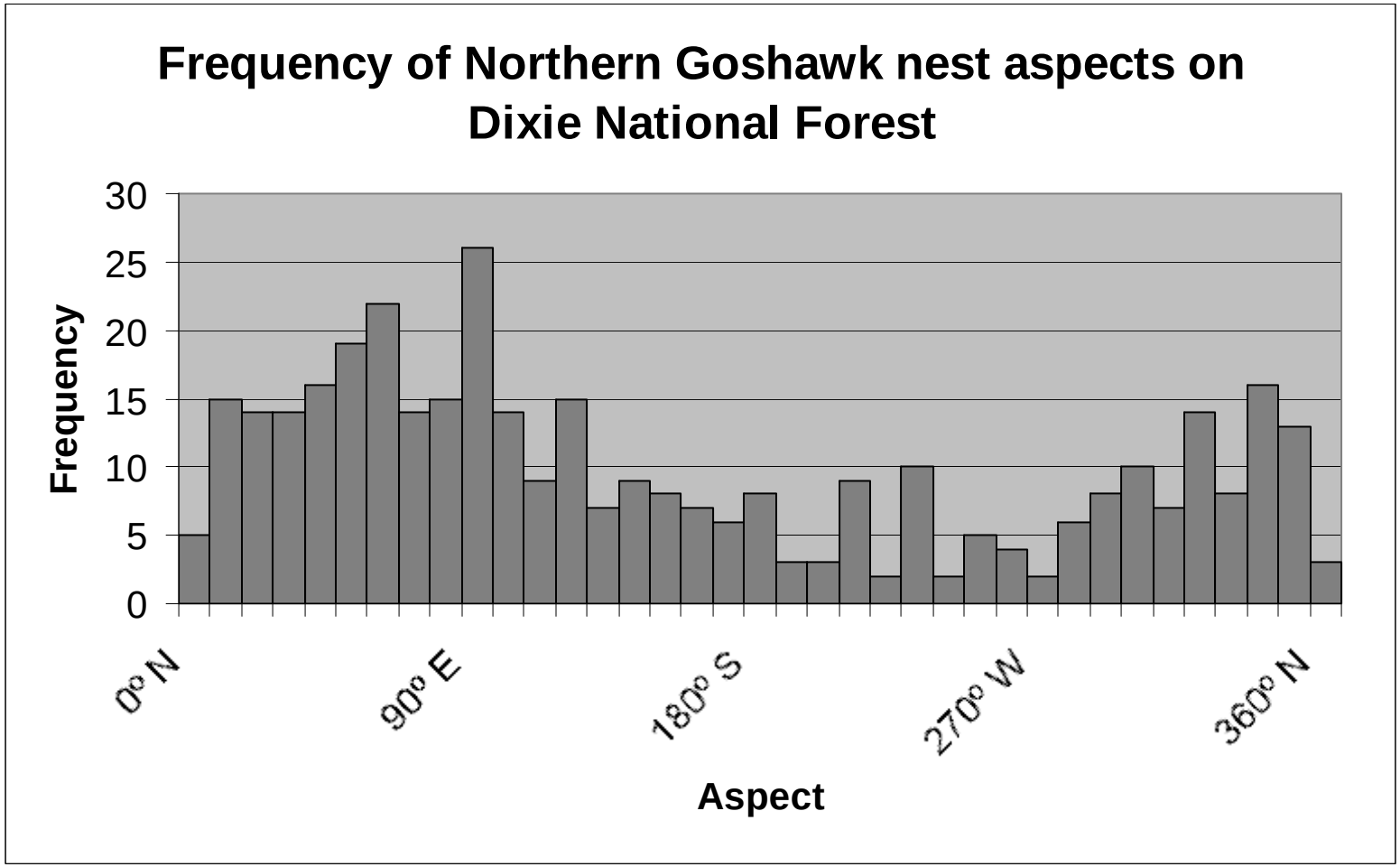

Figure 7. Histogram of frequency of aspects for Northern Goshawk nest sites monitored on the Fishlake National Forest 1992-2006.

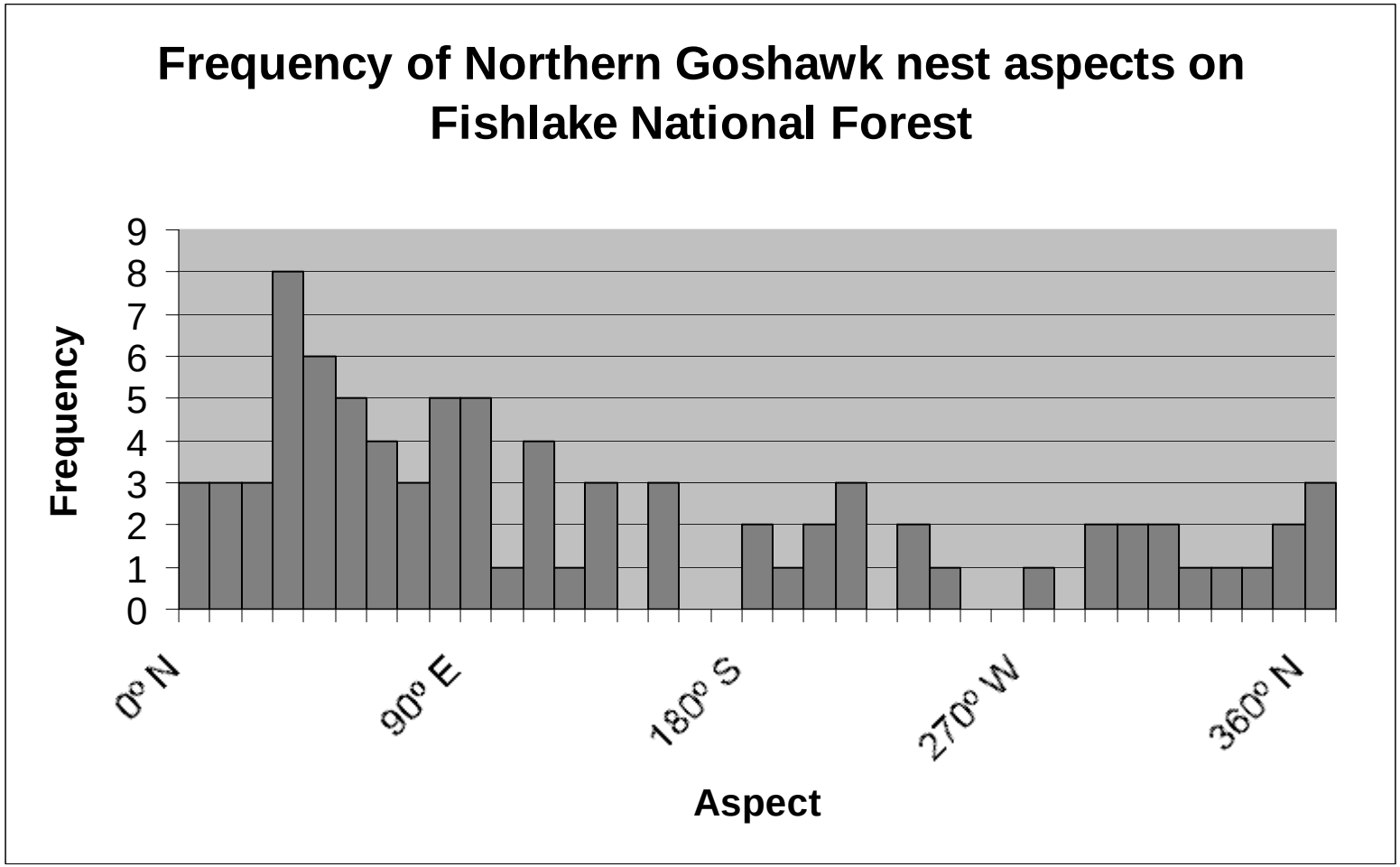

Figure 8. Histogram of frequency of aspects of Northern Goshawk nest sites monitored on the Manti-La Sal National Forest 1992-2006.

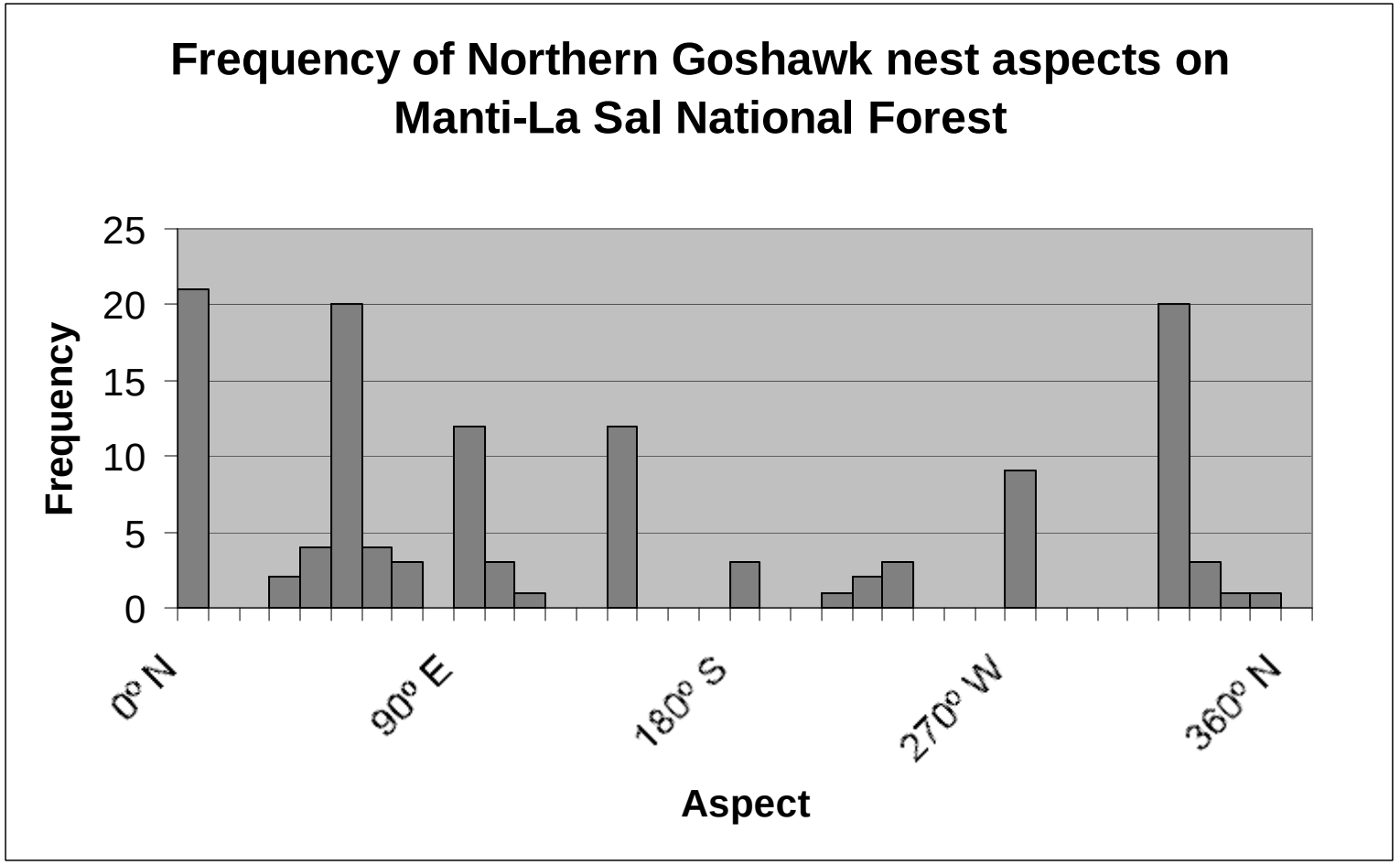

Table 1. Total territory and nest counts at the end of the 2006 breeding season for Dixie, Fishlake, and Manti-La Sal national forests in Utah.

	Dixie	Fishlake	Manti-La Sal
Territories	147	39	65
Nests	373	72	132

Table 2. Minimum, maximum, and mean slope, elevation, and diameter of nest tree at breast height (dbh) of Northern Goshawk nest sites monitored on the Dixie, Fishlake, and Manti-La Sal national forests 1992 to 2006.

Dixie National Forest

Variable	N	Mean	SD	Min	Max
Slope (%)	355	10.97	6.98	0	38
Elevation (m)	355	2628.68	224.91	1967.18	3203.75
DBH (cm)	312	52.22	18.72	22.86	127

Fishlake National Forest

Variable	N	Mean	SD	Min	Max
Slope (%)	72	12.77	7.19	2.21	36.21
Elevation (m)	83	2803.64	265.73	1927.86	3125.88
DBH (cm)	28	37.38	7.95	21.59	60.96

Manti-La Sal National Forest

Variable	N	Mean	SD	Min	Max
Slope (%)	125	22.75	15.14	0	65
Elevation (m)	127	2710.86	196.63	2279.90	3124.20
DBH (cm)	45	44.68	10.08	26.92	78.7

Table 3. P-values from ANOVA comparisons of Northern Goshawk nest site slopes, aspects, and elevations monitored on the (1) Dixie, (2) Fishlake, and (3) Manti-La Sal national forests 1992-2006.

Dependent Variable: Slope

	1	2	3
1		0.1506	<0.0001
2	0.1506		<0.0001
3	<0.0001	<0.0001	

Dependent Variable: Aspect

	1	2	3
1		0.1055	0.3935
2	0.1055		0.4415
3	0.3935	0.4415	

Dependent Variable: Elevation

	1	2	3
1		<0.0001	0.0004
2	<0.0001		0.0036
3	0.0004	0.0036	

Table 4. SAS The Mixed Procedure: Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Tree	9	3156	4.00	<0.0001
Slope	1	3156	2.36	0.1246
Elevation (m)	1	3156	0.43	0.5100
National Forest	2	3156	7.21	0.0008
Slope*forest	2	3156	7.09	0.0009
Elevation*forest	2	3156	8.06	0.0003

Table 5. SAS The Mixed Procedure, Solution for Fixed Effects

Effect	Forest	Estimate	SE	DF	t-value	Pr > | t |
Slope*forest	Dixie	-0.03783	0.01007	3156	-3.75	0.0002
Slope*forest	Fishlake	-0.02003	0.02299	3156	-0.87	0.3837
Slope*forest	Manti-La Sal	0	.	.	.	.
Elevation*forest	Dixie	-0.00139	0.00059	3156	-2.36	0.0182
Elevation*forest	Fishlake	0.00081	0.00076	3156	1.06	0.2878
Elevation*forest	Manti-La Sal	0	.	.	.	.

Table 6. Percent of total known goshawk nests on the Dixie Fishlake, and Manti-La Sal national forests found in Engelmann spruce, or spruce/other combination forest cover types.

	Engelmann Spruce (%)	aspen/ spruce (%)	spruce/ subalpine fir (%)
Dixie	12.9	0	0
Fishlake	0	15	0
Manti-La Sal	2.27	0	0.76

Table 7. Percentage of total and number of known goshawk nests found in Engelmann spruce on the Dixie, Fishlake, and Manti-La Sal national forests.

	%	number of nests
Dixie	5.05	18/373
Fishlake	1.23	1/72
Manti-La Sal	12.5	16/132