Assessment of Goshawk Territories within the Lake Tahoe Basin
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INTRODUCTION

The northern goshawk (*Accipiter gentilis*) was listed as a sensitive species by the Southwestern Region of the United States Forest Service (USFS) in 1981. Government agencies have attempted to reduce disturbance to goshawks by implementing spatial and temporal buffers around nest trees. Currently, each active goshawk territory on USFS lands in the Pacific Southwest region is delineated using Protected Activity Centers (PAC's), which consist of the best available 200 acres (~ 80 ha) of forested habitat in the largest contiguous patches. In addition, goshawk nests are protected from disturbance by Limited Operating Period (LOP) from 15 February to 15 September. Within the Lake Tahoe Basin (the Basin), Tahoe Regional Planning Agency (TRPA), a regulatory agency, has the ultimate and strictest management standards. The TRPA Code of Ordinances (1987) established 800 m non-disturbance zones around each goshawk nest. Habitat within the non-disturbance zones is not to be manipulated in any manner unless doing so enhances the quality of goshawk habitat.

Government agencies within the Basin have been monitoring northern goshawks since 1977. Active nests have been found within 26 territories within the Basin. At least 10 years have passed since breeding pairs have been found within 30% of the Basin territories. This suggests that the territories have been degraded in some way or that current protection has been inadequate. Protection measures were designed to primarily protect goshawks from disturbances caused by timber harvesting but provide little protection from impacts such as recreation and urbanization. Investigating why these territories were abandoned and identifying actions needed to reverse or reduce conditions negatively impacting goshawks should lead to more successful goshawk conservation.

There are many natural factors controlling northern goshawk populations such as weather and prey abundance (Keane et al. 2006). While land managers cannot control factors such as weather, they can alter other factors such as forest structure and anthropogenic disturbance within goshawk territories.

The structure and composition of the forests within the Tahoe Basin have been modified since the arrival of European settlers. About two-thirds of all marketable timber were harvested, with an estimated 60 percent of land in the Lake Tahoe watershed clear-cut (Murphy and Knopp 2000). Historically the basin was dominated by pine but is now dominated by white fir (*Abies concolor*). Current forest conditions throughout much of the Basin no longer reflect pre-settlement conditions due to such activities as logging, grazing, fire suppression and development. Due to the policy of fire suppression much of the Basin now consists of dense stands of small stunted trees. Such forest conditions may not be suitable for goshawks. Goshawks use areas with high canopy closure, a high density of large trees, and open understories (Drennan and Beier 2003, Keane1999, Reich et al., in press). Timber management is currently thinning and burning the understory of forests throughout the Basin in order to reduce fuel loads and restore the forest structure and composition to pre-settlement conditions. Habitat loss/degradation from timber harvesting can cause goshawks to abandon their nests (Squires and Reynolds 1997), but most of the timber management currently taking place within the Basin should create or enhance existing goshawk habitat.

There is little reason, however, to restore structural conditions for the goshawk if human disturbance will negate any positive benefits. Anthropogenic disturbances can cause goshawks to abandon territories with suitable forest structure (Squires and Reynolds 1997). Human activities are known to impact raptors in several ways: 1) by indirectly and directly altering habitats, 2) physically harming or killing eggs, young, or adults, and 3) by disrupting normal behavior (Postovit and Postivit 1987). Disturbance can indirectly influence goshawk reproductive success by affecting the time female goshawks allocate to incubation and foraging. Impacts from anthropogenic disturbance such as urbanization and recreation, the primary types of anthropogenic disturbance within the Basin are not well understood. Camping near nests has caused goshawks to abandon their nests (Speiser 1992), but most of the published information on the impacts of recreation has been anecdotal (e.g., Keane 2000 [*in* LT Watershed Assessment]).

The Basin receives more than 23 million visitor days per year (Murphy and Knopp 2000). The United States Forest Service Lake Tahoe Basin Management Unit, (LTBMU) receives over 3 million visitors each year (USFS 2002*a*). About 96% of the forest visitors surveyed reported that their primary purpose on the forest was recreation. Such high levels of outdoor recreation increase the potential for direct human disturbance. Although the presence of humans is known to negatively impact goshawks, especially during the breeding season, little specific data are available for the location and intensity of disturbance that causes the birds to abandon an area (e.g., Reynolds et al. 1992, Keane 2000[*in* LT Watershed Assessment]). A better understanding of goshawks vulnerability to anthropogenic disturbance will enable land managers to minimize conflicts between goshawks and humans.

Occupancy as an Indicator of Habitat Quality

Many studies have used occupancy to as an indicator of habitat quality (Kruger and Lidstrom 2001, Kostrzewa 1996, Linkhart and Reynolds 1997). Sergio and Newton (2003) reviewed 22 studies of 17 species and found occupancy to be correlated with productivity or some other measure of habitat quality in all of the studies. They concluded that occupancy may be a reliable method of quality assessment for populations in which all territories are not occupied, or for species in which checking occupancy is easier than finding nests.

In order to assess the condition/suitability of goshawk territories we felt it appropriate to assume that goshawks follow the Ideal free distribution (IDF) theory of occupancy. IDF is a density dependent dispersal concept in which animals occupy territories where potential success is the highest (Fretwell and Lucas 1970). The similar concept of ideal despotic distribution (Fretwell and Lucas 1970) is more appropriate for goshawks. The best territories are occupied at low population densities and then territorial species such as the goshawk exclude others by defending these territories. Thus we would expect low quality territories to only be inhabited when densities within high quality territories were high.

Goal

The goal of this project is to develop a restoration plan for maintaining a viable population of northern goshawk in the Lake Tahoe Basin. Results will be synthesized to develop recommendations for restoration and management of goshawks in the Basin and will include: 1) an assessment of the viability of each activity area to support goshawks given current and likely future levels of human disturbances, and 2) recommendations for restoration actions within each activity area, including short- and long-term vegetation management and management of disturbance.

This final report thus directly addresses the needs stated in Project #10081, "Northern Goshawk Nesting Territory Needs Assessment", namely to identify habitat improvements, including evaluation of the level of human disturbance, mile of trails/road impacting territory, vegetation treatments needed, and coarse wood/snag requirements). The final report will thus allow Project #10082 to proceed (i.e., implementation of treatments within goshawk territories).

Objectives

Specific objectives addressed to meet the project goal are:

1. Analyze historical and current spatial and temporal extent of goshawks in the Lake Tahoe Basin to:

   a. Evaluate territory fidelity/occupancy in relation to environmental and anthropogenic activity variables

   b. Evaluate reproductive and territory activity patterns

   c. Evaluate nest and territory location patterns from a landscape scale

2. Assess current habitat conditions within goshawk territories

3. Determine tolerance threshold of goshawks to human-related disturbance activities

4. Develop a restoration and long-term management strategy for the goshawk population in the Lake Tahoe Basin.

METHODS

Occupancy as an Indicator of Habitat Quality

Occupancy and Reproductive Activity in 2004 and 2005.--If occupancy is an indicator of habitat quality we would expect reproductive success to be higher within the frequently occupied territories. Ideally we would have used reproductive information from the historical surveys to assess which territories have had the greatest reproductive success throughout all years. However, agencies within the Basin focused on finding active nests, determining reproductive success was secondary. As a result, often too much time passed between when the nest was first found and return visits to determine the reproductive outcome of nests. We prioritized determining reproductive success in 2004 and 2005 and used these years as pilot years to examine whether reproductive success was higher within the most frequently occupied territories.

We conducted surveys within all historical goshawk territories located in the Basin following protocol from "Survey Methodology for Northern Goshawks in the Pacific Southwest Region" (U.S. Forest Service, 2002*b*). Surveys were conducted in coordination with USFS, California State Parks (CSP), Nevada Department of Wildlife (NDOW) and private consultant firms. After a goshawk nest was located, we monitored the nest once every one to three weeks, depending on the age of the nestling(s). We used fledgling per nest (the number of young detected outside the nest) as the reproductive unit. Once the nest was empty we returned every 3 to 5 days until fledglings were detected. A two sample *t*-test was used to compare the reproductive success between frequently and infrequently occupied territories.

Historical Occupancy.--Given that agencies within the Basin have conducted goshawk surveys for nearly 30 years, we felt it appropriate to evaluate territories based on occupancy. We evaluated past survey effort and goshawk occupancy by reviewing all survey forms, written descriptions, maps, and annual reports of all agencies who have conducted goshawk surveys within the Basin. Because all territories were not surveyed each year, we created an occupancy index: number of years occupied divided by the number of years surveyed (from 1977 to 2005). We defined a territory as a cluster of alternate nests (Greenwald et al.2005) with confirmed breeding activity within at least one of the nests. Since nest sites in California are usually separated by at least 1.3 km (Woodbridge and Detrich 1994), all territories were separated by 1.6 km unless active nests were found at lesser distances within the same year. A territory was considered adequately surveyed if a biologist searched the entire stand surrounding the most recent nests during the breeding season. Only territories that were surveyed at least 3 years were included. A territory was considered occupied if direct observations (audible or visual) were made during surveys. We then ranked the territories based on the occupancy index (Fig. 1). Territories were then separated into three equal groups based on their occupancy rates: frequently, moderately, and infrequently occupied territories.

Anthropogenic Disturbance

We predicted the infrequently occupied territories would have higher levels of human activity, a greater extent of roads and trails, and closer proximity to human development as compared to the frequently occupied territories.

Human Activity.--Trailmaster ® 1550 Active Infrared Trail Monitors were used to quantify the level of human activity. Trail monitors were placed within historical territories throughout the Basin boundary from April to Sept 2004 and from Feb to Sept 2005. Our unit of analysis was the non-disturbance zones. Trail monitors were randomly placed along USFS roads and trails within 800 m of the most recent active nest within territories. The trail monitors were operated for 5-7 days before being rotated to a new territory. All sampling periods included the weekend when recreation levels were generally the highest. All trail counter locations were recorded with Global Positioning Systems (GPS). Our results represent an index of human activity, not an absolute measure. For example, local roads and highways existed within some of the 800 m buffers but trail counters could not be placed on such travel ways. Therefore our methods underestimate levels of human activities such as auto traffic and are more representative of levels of recreational activity taking place within territories. Occasionally the counters malfunctioned due to weather or misalignment. In such cases we used the data up to the point of malfunction. The amount of human activity within each goshawk territory was calculated by dividing the total amount of detections by the time the trail monitors were placed (detections/hr).

We used two-sample *t*-tests to compare human activity between 1) frequently and infrequently occupied territories, 2) occupied and non-occupied territories (in 2004 and 2005), and 3) territories with nests vs. territories without nests (in 2004 and 2005). Only the months of April through September were used when comparing human activity between years since trail monitors were not placed out until April in 2004.

Human Activity Relative to the Goshawk Breeding Season.--We examined human activity within historical territories relative to the goshawk breeding season. Only the 2005 season was examined because trail counters were not placed until April in 2004. Courtship and nest building begin in February, and incubation is initiated from mid April to early May (Keane 1999). We first observed fledged chicks on 30 June in 2005. Based on this information we divided the breeding season into 3 periods: pre-incubation (17 Feb – 24 April), incubation/nestling (25 April – 29 June), and fledgling (30 June – 12 Sept). We then compared human activity levels between the frequently and infrequently occupied territories during the three breeding periods.

Reproduction and Anthropogenic Disturbance.--Linear regression was used to determine if there was a relationship between the extent of road/trails, amount of human activity, and reproductive success. We used fledglings per nest in 2004 and 2005 as the dependent variables and extent of road/trails and human activity levels as independent variables.

Occupancy Index and Road/Trails and Human Activity.--We used linear regression to examine the relationship between the occupancy index and road/trail extent and human activity. The occupancy rate of individual territories was the dependent variable and the extent of different types of travel ways and human activity within non-disturbance zones (800 m from the most recent nest in each territory) were independent variables.

Extent of Roads and Trails.--We used GIS (Geographic Information System) to measure the extent of roads and trails within territories. Road/trail layers and historic goshawk nest locations were provided by the USFS Lake Tahoe Basin Management Unit (LTBMU). Road and trail locations were first gathered with GPS and then verified using Inkonis satellite photography (up to 3 m accuracy). All trails, local roads, USFS roads, and highways were merged into a single shape file. This merged trail/road shape file was then clipped using an 800 m buffer around the most recent nest within each goshawk territory. The extent of roads and trails was calculated from these clipped road and trail buffers. Occasionally there was overlap between two different types of travel ways (e.g. a section of trail merged onto a USFS road). In such cases the less developed travel way was omitted. We used two sample *t*-tests to compare the extent of roads and trails between frequently and infrequently occupied territories. Linear regression was used to examine whether there was a relationship between the extent of roads/trails (independent variable) and human activity (dependent variables).

Distance of Human Development from Nests.--We used GIS to measure the distance of urban development and various road/trail types from the most recent nest within each territory. We used urban wildland intermix and road/trail GIS layers provided by LTBMU. Urban development was defined as areas with at least 1 house per 5 acres. We then used 2 sample *t*-tests to compare urban development and road/trail distances between the frequently and infrequently occupied territories.

Forest Structure and Composition

If forest attributes (structure and composition) within the territories influenced occupancy we would expect there to be a difference between the infrequently and frequently occupied territories. We measured the forest structure and composition of goshawk territories on two spatial scales, 1) nest cores-50 m from nests, and 2) non-disturbances zones-800 m from nests.

Nest Cores.-- For nest cores, we measured the amount of shrub cover, number of young trees, canopy cover, course woody debris, live tree diameter at breast height (DBH), live tree height, dead trees DBH, and dead tree height within 50 m of the most recent nest within all historical territories. We ran transects using a 50 m measuring tape at 60 and 330 degrees radiating from the nest tree. The line-intercept method was used to measure shrub cover. Small tress (<20 cm) that fell within 1 m of the width of transects were tallied. We measured canopy cover at 5 m intervals along the transect using a concave densiometer. We measured course woody debris that crossed transects and had a DBH > 25 cm. A Biltmore stick was used to measure the DBH of all live and dead trees that fell within 1m of the transects and had a DBH >20 cm. We used a clinometer to measure the height of all live and dead trees that fell within 1m of the transects and had with a DBH >20 cm.

Nests had not been found within some territories in >10 years. In such cases, when nest structures no longer existed or could not be found, we used a GPS unit to reach the approximate nest location and walked to the nearest area with suitable habitat. We assumed that the vegetation characteristics we measured had not changed significantly since none of the areas appeared to have been logged. We used 2 sample t tests to compare the structural characteristics between frequently and infrequently occupied territories.

Non-disturbance Zones.--We used GIS to measure the forest structure and composition within the non-disturbance zones. Cover types were derived from CALVEG, a coverage containing polygon features of existing vegetation, obtained from the USDA Forest Service Remote Sensing Lab (http://www.fs.fed.us/r5/rsl/clearinghouse/forest-eveg.shtml). This National Forest vegetation layer was derived by appending tiles a-n and clipping the resulting layer to the outermost 7.5 minute quad extent. Tree size and canopy cover of dominant trees were classified based on the California Wildlife Habitat Relationship (CWHR) information system within the CALVEG coverage. The CALVEG layer was buffered 800 m from the most recent goshawk nest in each territory. The buffers were then clipped and the vegetation data were exported into Excel for analysis. We calculated 1) the percentage of dominant vegetation types or land-use categories, 2) various size classes measured in DBH, and 3) canopy cover within 800 m of the most recent nest of all historical territories. We then used 2 sample *t*-tests to compare the forest structure and composition of frequently and infrequently occupied territories.

RESULTS

Occupancy as an Indicator of Habitat Quality

As we had hypothesized, reproductive success (fledglings per nest) was significantly higher within frequently occupied territories ($\bar{X} = 0.72, \pm 0.67$, $n = 18$) compared to infrequently occupied territories ($\bar{X} = 0.17, \pm 0.51$, $n = 18$, $P = 0.009$). This suggests occupancy was a valid indicator of habitat quality.

Anthropogenic Disturbance

Human Activity.--Human activity within individual territories was generally consistent between years (Fig. 2). Overall, human activity decreased 33% from 2004 to 2005 (1.68 and 1.12 detections/hr, respectively). Human activity levels were 380% higher on paved versus non-paved surfaces (Fig. 3). Human activity was twice as high within infrequently as compared to frequently occupied territories (0.99 and 2.32 detections/hr respectively, $P = 0.052$). Human activity was 84% higher within non- nesting versus nesting territories (1.71 and 0.93 detections/hr respectively, $P = 0.133$). Human activity was 25% higher within non-occupied versus occupied territories (1.54 and 1.23 detections/hr respectively, $P = 0.612$).

Human Activity Relative to the Goshawk Breeding Season.--Human activity increased as the season progressed: pre-incubation = 0.24 detections/hr, $\pm$ 0.25, incubation/nestling period = 0.54 detections/hr, $\pm$ 0.77, fledgling period = 1.61 detections/hr, $\pm$ 2.03. Overall, human activity was 7 times greater during the fledgling period compared to the pre-incubation period. Human activity during the pre-incubation period was extremely low within 10 of the territories (< 0.05 detections/hr). No human activity was measured within the Angora 2 or Big Meadow territories prior to incubation. Human activity increased from the pre-incubation period to the incubation/nestling period within all territories except Cold Creek which is a popular destination for snowmobiles. Human activity levels were greater within infrequently occupied territories than the frequently occupied territories during all breeding periods (Fig. 4).

Extent of Roads and Trails.--The mean extent of roads and trails within 800 m of the most recent nest within all goshawk territories was 5374 m $\pm$ 4399. There was a greater extent of all types of roads and trails within the infrequently occupied territories (Table 1). The extent of local roads was 25 times greater within the infrequently occupied territories. Only one of the frequently occupied territories had local roads within the non-disturbance zone. In addition, there were no highways within the non-disturbance zones of frequently occupied territories. The extent of all roads/trails combined was 165% higher within the infrequently occupied territories as compared to the frequently occupied territories. The relationship between the extent of USFS roads and trails and human activity levels within the non-disturbance zones was weak ($r^2 = 0.0014$, $P = 0.862$).

Distance of Human Development from Nests.--The mean distance of all territories from urban development was 1607 m $\pm$ 1552. Infrequently occupied territories were 17% closer to urban development than frequently occupied territories (mean =1478 m $\pm$ 790 vs. 1732 m $\pm$ 411, respectively, P =0.78). The mean distance of any road or trail type from the most recent nest in each territory was 224 m $\pm$ 163. With the exception of trails, all types of travel ways were within closer proximity to infrequently occupied territories. Trails were 20% further away from nests within the infrequently versus the frequently occupied territories (X = 429 m $\pm$ 135 and X = 358 m, $\pm$ 96, respectively, $P = 0.668$). USFS roads were 62% closer to nests within the infrequently versus the frequently occupied territories (X = 401 m $\pm$ 83 and X = 650 m $\pm$ 171, respectively, $P = 0.211$). Local roads were 208% closer to nests within the infrequently versus the frequently occupied territories (X = 666 m $\pm$ 241 and X = 2052 m $\pm$ 389, respectively, $P = 0.009$). Highways were 136% closer to nests within infrequently versus the frequently occupied territories (1069 m $\pm$ 293 and 2523 m $\pm$ 402, respectively, $P = 0.011$). Distances of any road or trail type were 10% closer within the infrequently than frequently occupied territories ($\bar{X} = 252$ m $\pm$ 70 and $\bar{X} = 276$ m $\pm$ 61 respectively, $P = 0.802$).

Reproduction and Anthropogenic Disturbance.--There was a negative relationship between human activity and reproductive success, but the result was not statistically significant ($r^2 = 0.066$, $P = 0.222$). There was a negative relationship between the extent of roads/trails and reproductive success, but the result was statistically weak ($r^2 = 0.127$, $P = 0.081$).

Occupancy Index and Road/Trails and Human Activity.--There was a negative relationship between the occupancy index and the extent of local roads ($r^2 = 0.210$, $P = 0.015$), highways ($r^2 = 0.202$, $P = 0.024$), and all roads/trails combined ($r^2 = 0.117$, $P = 0.056$). There was no relationship between the occupancy index and USFS roads ($r^2 = 0.001$, $P = 0.931$) or trails ($r^2 = 0.001$, $P = 0.865$). There was a negative relationship between the occupancy index and human activity, but the relationship was statistically weak ($r^2 = 0.114$, $P = 0.111$).

Forest Structure and Composition

Forest Structure and Composition within Nest Cores.--The average canopy cover for all nest cores was 79% $\pm$ 11.38. The average DBH and height of live trees within all nest cores was 49 cm, $\pm$ 13.8 and 22 m $\pm$ 8.22, respectively. The average DBH and height of dead trees within all nest cores was 42 cm, $\pm$ 28.38 and 11 m $\pm$ 8.02, respectively. Shrub cover ranged from 0-25% within all nest cores ($\bar{X} = 9\%$ $\pm$ 11.6).

The DBH of lives trees was 13% greater within the frequently as compared to the infrequently occupied nest cores (51.36 cm ± 10.5 and 45 cm, ± 9.7, respectively, P = 0.254). The DBH of dead trees was 119% greater within the frequently as compared to the infrequently occupied nest cores (57.65 cm, ± 35.74 and 26 cm, ± 28, respectively, P = 0.219). Canopy cover was 5% higher within the frequently than the infrequently occupied nest cores (84% and 80%, respectively). There was almost 3 times as much course woody debris within the infrequently occupied nest cores as compared to frequently occupied nest cores (9.58% and 3.42%, respectively, P = 0.037). The number of young trees was 16% higher within the infrequently as compared to the frequently occupied nest cores (14.6 stems ± 22.7 and 12.6 stems ±10.1, respectively, P = 0.823). Shrub cover was twice as great within the frequently as compared to the infrequently occupied nest cores (10% ± 8.7 and 5% ± 4.9, P = 0.150). The elevation of nest sites were 6% higher within the frequently occupied territories as compared to infrequently occupied territories (2127 m ± 46 and 2009 m ± 29, respectively, P = 0.048).

Forest Structure and Composition within Non-disturbance Zones.--Small trees (28-61 cm DBH) made up nearly 95% of the trees within the non-disturbance zones of all territories. Conifer forest/woodland was the most common type of vegetation cover (89%). Moderate (40.0-59.9%) and open (25.0-39.9%) canopy closure were the most common classes within all non-disturbance zones (61% and 27%, respectively). The most common types of vegetation within all non-disturbance zones were mixed conifer and Jeffery pine (*Pinus jeffreyi*), (50% and 25%, respectively).

Small trees (28-61 cm DBH) made up 95% of the tree size classes within the non-disturbance zones of the frequently and infrequently occupied territories. The extent of saplings (3 –15 cm DBH) was 53 times greater within the non-disturbance zones of the frequently as compared to the infrequently occupied territories. In addition, there was 80% less ha of pole trees (15-28 cm DBH), 62% more ha of small trees (28-61 cm DBH), and 118% more ha of medium/large trees (>60 cm DBH), within the non-disturbance zones of the frequently as compared to the infrequently occupied territories. The most common canopy cover classes within the frequently occupied territories were moderate (65%), open (17%), and dense (15%). The most common canopy cover classes within the infrequently occupied territories were moderate (48%) and open (46%) classes. The aerial extent of dense canopy cover was 90 times greater within the frequently occupied as compared to the infrequently occupied territories (249 and 2.76 ha, respectively). Conifer forest/woodland made up 86% and 93% of the cover types within the non-disturbance zone of the frequently and infrequently occupied territories, respectively. The most common vegetation types within the frequently occupied territories were Sierra mixed conifer (62%), Jeffery pine (13%) and lodgepole pine (*Pinus contorta*, 12%). The most common vegetation types within the infrequently occupied territories were Jeffery pine (43%) and Sierra mixed conifer (42%). The extent of red fir (*Abies magnifica*) and lodgepole pine was much greater within the frequently as compared to infrequently occupied territories (800 and 28 times greater, respectively).

DISCUSSION

Frequency of Occupancy as an Indicator of Habitat Quality. -- Our results indicate that frequent occupancy of territories was a good indicator of habitat quality. Reproductive success within frequently occupied territories was significantly higher than infrequently occupied territories. Differences in anthropogenic disturbance and forest structure between the frequently and infrequently occupied territories suggest both factors likely affect goshawk territory occupancy.

Anthropogenic Disturbance

Our results indicate that anthropogenic disturbance within the Basin plays a major role in the occupancy of goshawk territories. Human activity levels and the extent of roads/trails were higher within the infrequently occupied territories. In addition, nest sites within the infrequently occupied territories were significantly closer to local roads and highways. Infrequently occupied territories had significantly higher levels of human activity, suggesting human activity has contributed to the abandonment or avoidance of the infrequently occupied territories.

Goshawks appear to avoid nesting near development in a hierarchal manner, based on the intensity of traffic. Trail distances were actually closer within the frequently occupied territories and while USFS roads were closer within the infrequently occupied territories, the distance was not as significant as highway and local road distances. Only one of the frequently occupied territories had local roads within the non-disturbance zone and there were no highways within any of the frequently occupied territories the non-disturbance zones. There were highways and local roads within 50% and 75% of the infrequently occupied territories, respectively. Highways and local roads receive relatively heavy traffic year-round and are the most apparent during the winter when birds establish nest sites. Frequently occupied territories were also located further from urban development and situated at higher elevations. This suggests that urbanization which is more concentrated at lower elevations has pushed goshawks into higher elevations. In Britain, increased altitude was correlated with delayed mean laying date, increased number of addled eggs, and smaller brood sizes (Marquiss and Newton 1982).

The magnitude of human activity was higher between nesting vs. non-nesting territories as compared to occupied vs. non-occupied territories. In other words, goshawks may be more tolerant of human activity in regards to where they choose to occupy but less so when choosing where to nest. Goshawks may occur within infrequently occupied (lower quality) territories while waiting for nesting opportunities within the frequently occupied (higher quality) territories to become available.

While birds are probably less like to settle in areas with high levels of human activity, human activity on USFS roads/trails was substantially lower during the winter than the summer. Therefore, in most cases peak human activity levels are not evident when goshawks choose nest sites. Snow-covered USFS roads and trails may not be evident to goshawks at the time of nest site selection. Once the snow melts, goshawks may find themselves nesting next to a road or trail with heavy traffic. USFS roads/trails could be ecological traps. Goshawks may be attracted to the openings that roads provide for approaching or exiting nests. While roads provide openings that aid approach and departure from the nest, birds that nest next to roads experience more human disturbance.

Once the birds select a nest site they are usually committed to it for the entire breeding season since goshawks rarely lay a replacement clutch (Squires and Reynolds 1997).

The extent of USFS roads/trails may be a more import factor than human activity since birds often use alternate nests between years. Nesting goshawks are more likely to avoid encountering humans within territories with high human activity levels but few roads/trails than territories with low human activity levels but many roads/trails. For example, birds have a higher probability of establishing their nests further away from USFS roads/trails within territories with low road/trail densities. This would not be the case in territories with a myriad of roads and trails running throughout the area.

We were not able to qualify human activity types using trail counters. If certain types of human activities cause much more stress than others, then counting the number of people moving through the territories may not be the most appropriate method of measuring the effects of human activity.

FOREST STRUCTURE AND COMPOSTION

Forest Structure and Composition within Nest Cores.--The nest site characteristics we found associated with goshawk nests were similar to those found in other goshawk studies (Drennan and Beier 2003, Keane 1999). The nest cores of the frequently occupied territories had older forest characteristics than the infrequently occupied territories. Dense stands of young trees lead to increased fuel loading as trees are killed by major insect attacks or competition (Oliver et al. 1996). Thus, the higher proportion of young trees within the nest cores of the infrequently occupied territories probably contributed to greater extent of coarse woody debris. While shrub cover was twice as great within the frequently occupied territories, the percentage was rather low.

Forest Structure and Composition within Non-disturbance Zones.--The frequently occupied territories had larger trees and a greater extent of dense canopy cover as compared to the infrequently occupied territories. In addition, canopy closure was more closed and tree diameter was larger within the nest cores as compared to the non-disturbance zones. This suggests a hierarchal process where goshawks are selecting forests with older structural conditions and then selecting stands within those forests with greater closed canopies and larger diameter trees for nest sites.

RECOMMENDATIONS

Restoration Assessment--.Our results suggest that goshawk protection within the Basin has been insufficient and that some of the territories require actions to restore vegetation to pre-settlement conditions. We recommend land mangers use the occupancy index of territories as a guide when planning restoration actions. The most frequently occupied territories should be used as reference sites to decide how to reduce anthropogenic disturbance and improve vegetation conditions within individual territories. Tables 2-4 provide 1) anthropogenic disturbance, 2) nest core vegetation, and 3) territory vegetation variables within the reference and non-reference territories. By examining these tables managers can determine the specific types of restoration actions that should improve conditions within the non-reference sites. See appendix 2 for restoration recommendations within individual territories.

Enforcement of spatial and temporal protection rather than restoration should be assigned to the most frequently occupied territories. The most frequently occupied territories appeared to be the most viable territories and territories with the highest quality typically produce a disproportionately large number of young relative to the overall population (Sergio and Newton 2003). Restoration actions would be most appropriate for territories with moderate and low occupancy rates. If resources are limited, triage could be used to prioritize restoration within individual territories. Improving conditions within the moderately occupied territories would be the most economically and biologically feasible. Improving conditions within the territories with the lowest occupancy rates would probably be the most expensive and challenging since these territories are located closer to chronic disturbance, have a greater extent of roads and trails, higher human activity levels, and most have been unoccupied for several years.

Anthropogenic Disturbance.--Our results suggest anthropogenic disturbance within territories has negatively affected territory occupancy. Actions that will reduce anthropogenic disturbance within territories include reducing and/or re-routing human activity, and eliminating, reducing, and/or rerouting the extent of roads and trails within territories.

Suter and Jones (1981) found a clear line of sight to be an important factor in how raptors responded to human disturbance. We found that goshawks seem most disturbed from stationary pedestrians in the immediate vicinity (< 100m) of nests. We recommend realigning roads/trail so that they are visually and audibly shielded from nests. Such actions should reduce potential human/goshawk interactions and decrease disturbance to goshawks since we seldom observed humans traveling off trail/road. In addition, goshawks are often extremely aggressive when defending nest from intruders; capable of striking and drawing blood (Squires and Reynolds 1997). When active nests are found near trails or roads we recommend imposing temporary closures if birds are observed or reported being aggressive or disrupted due to traffic.

Goshawks appear to be avoiding areas with highways and local roads the most. Decommissioning or reducing traffic on such travel ways is not an option, but it does suggest that these types of travel ways have lead to the degradation of territories. Agencies could purchase undeveloped land adjacent to goshawk territories in order to prevent degradation.

Territories with the greatest extent of USFS roads and trails did not necessarily have the highest human activity levels. Therefore decommissioning roads/trails within territories will not necessarily decrease human activity levels. However, such actions would probably benefit goshawks since reducing roads/trails would decrease the likelihood of goshawk/human interactions.

Human activity levels appeared to depend on the ease and accessibility of travel ways. For example, paved surfaces had higher human activity levels than non-paved surfaces and gated roads appeared to receive much less human activity than non-gated roads. Thus, if agencies wish to limit human activity within individual territories they should consider limiting accessibility. Such actions include decommissioning or placing gates on existing roads/trails, limiting upgrades of roads, as well as limiting parking availability.

Timber management was suspected of causing 11% of the nests found during the study to fail. For detailed information on timber management observed within occupied territories, see Appendix 1. As stated earlier, current timber management within the Basin should benefit goshawks in the long term. However, during the duration of this study timber management posed the greatest threat to breeding pairs. The amount of forest thinning taking place within the Basin is unprecedented. While it is important to prevent catastrophic fires, such work could be completed with minimal impact to goshawks. Improved communication between the timber and wildlife managers would prevent nest failures caused by timber management activities within historical territories. Timber managers need to take protective boundaries into consideration and discuss management implications with wildlife managers when planning management activities. When timber managers identify areas to be altered, wildlife managers should prioritize the order of surveys of areas according to the likelihood of encountering goshawks.

Management of Forest Structure.--Goshawks are found in a variety of cover types throughout the West. Goshawks are generalists in terms of forest composition (DeStefano 1998) and specialists in terms of forest structure (Greenwald et al. 2005). Canopy cover was the most consistent structural feature across studies of goshawk nesting habitat (Siders and Kennedy 1996). Furthermore, goshawk nesting density appears to be closely associated with dense overstories and open understories (Crocker-Bedford 1990). Greenwald et al. (2005) found that removing forest cover within the goshawk home range reduced occupancy rates and also resulted in reduced productivity since there were fewer active breeding territories. Goshawks were also found to avoid open areas, particularly logged open areas.

Managing forests to provide prey is recognized as a primary need to maintain goshawk populations (Reynolds et al. 1992). Measuring food supply was beyond the scope of this study due to field work constraints. Goshawks consume a wide variety of prey including medium-sized birds and small mammals (Drennan 2006). Douglas' squirrels (*Tamiasciurus douglasii*) are the primary prey species of Goshawks in the Lake Tahoe region (Keane et al. 2006). Habitat for Douglas' squirrels consist of mature conifer stands capable of producing adequate cone crops and other food sources such as fungi, lichen, and berries. Keane et al. (2006) found a correlation between cone crop production and goshawk reproduction. Keane suggested that agencies maintain both high cone crop production and Douglas squirrel abundance, which can be accomplished by sustaining mature forests. Douglas' squirrels quickly respond reproductively to increasing conifer seed availability (Smith 1970). Cone crop production differs in both magnitude and frequency across tree size classes and between conifer species. Cone production is greater by mature conifers, in terms of both magnitude and frequency relative to younger, smaller conifers (Keane 2006). In contrast, Beier and Drennan (1997) found breeding goshawks selected foraging sites not for higher prey abundance but for higher canopy cover and a greater density of large trees. This indicates that prey availability (as determined by forest structure) is more crucial than prey abundance.

Goshawk habitat may be improved through silvicultural activities that reduce the densities of shrubs, saplings, and small poles, while maintaining or enhancing the canopy of large trees (Crocker-Bedford 1990). Graham et al. (1999) recommended increasing the numbers and distribution of large trees in the landscape by cleaning, thinning, and weeding using mechanical means or fire. Clearing the forest floor of small trees and lower vegetation should allow for easy hunting access (Graham et al. 1999).

Structural differences between the forests of the frequently and infrequently occupied territories suggest that structure may have played a role in the avoidance or abandonment of some of the territories. Agencies should maintain large trees and dense canopies with open understories within territories. Graham et al. (1999) recommended approximately 40% of the landscape consist of large trees (relative to average for the cover type and potential vegetation type). Currently, less than 5% of the forests surrounding nest sites within the Basin are comprised of large trees. Older forest characteristics in the Basin should be protected and forests should be managed so that they are allowed to develop in proportion to pre-settlement conditions Greenwald et al. (2005).

Monitoring--.According to the current protocol, goshawk researchers are not to monitor territories between 16 April and 1 June in order to limit disturbance to the goshawks. We recommend quick checks of all known nest sites in mid-May. Briefly checking previously occupied nests during the incubation period is an effective way of determining breeding status prior to broadcast surveys (McClaren et al 2002). By doing so, agencies can identify potential goshawk/human conflicts prior to hatching, when adults often become extremely aggressive. In addition, the earlier nest locations are determined, the earlier land managers can delineate non-disturbance zones. Agencies should consider putting more effort into determining reproductive success in order to determine whether the relatively low reproductive success in 2004 and 2005 was an anomaly or a trend. After reviewing historical survey forms it was apparent that many nests were discovered after biologists followed up on reports of incidental sightings. We recommend agencies continue to follow up on incidental sightings.

Marking of Nest Trees.-- In 2005 all known nest trees within the Basin were marked with nest tags and assigned nest id's to be used by all agencies. In addition, the nest condition was noted, the exact location was recorded, and the nest trees were photographed. As of October 2005, there were 25 existing nest structures known within the Basin. Two nests fell out of the trees (Spring Creek 2004 and an alternate Saxon nest found in 2005) during the study and 2 are believed to have been harvested in 2005 (Tahoe City 2005 and Sugar Pine 2000). Marked nest trees should help biologists relocate nests and prevent the harvesting of nest trees in the future. It is important to protect historical nest trees because goshawks are known to reuse nest trees several years after little or none of the previous nest persisted (Crocker-Bedford 1990). Having marked nest trees will also make determining nest tree status easier. In the past, when historical nests were not found, it was unclear whether the nest fell down or was intact but not found. We recommend agencies continue to mark all new nests found.

Survey Polygon and PAC Names.--Current names of many of the survey polygons and PAC's are very confusing and often used inconsistently. Multiple names have been used for the same survey polygons between years and among different agencies. In addition, some biologists have referred to survey areas by their PAC name while others referred to areas by their survey polygon name. We recommend including the PAC and survey polygon name on all survey forms. Doing so will reduce confusion, especially when two survey polygons exist within the same PAC. We also recommend naming PAC's and survey polygons based on natural features whenever possible. Naming PAC's and survey polygons based on nearby drainages is a good idea but many of the current territory names are very misleading. For example, Trout Creek runs through the Cold Creek survey polygon and Saxon Creek runs through the Trout Creek survey polygon. We recommend the names assigned during this study become the official names of the territories.

We recommend other agencies turn their survey forms into the USFS at the end of the season. We gathered all existing historical goshawk survey information from all agencies and compiled it into the USFS filing system in the fall of 2005. We recommend the USFS create a master cross-reference sheet for their filing system. The cross-reference sheet should be kept in the filing cabinet and updated each time a new territory is found or a PAC or survey polygon name is altered. Because of the recent increase in timber activities throughout the Basin, more and more areas with suitable habitat but no known goshawk activity is being surveyed. We recommend the USFS file all goshawk surveys according a two color-coded system: 1) survey polygons associated with breeding activities (i.e. within existing or impending PAC's and polygons and areas with historical nests that do not have PAC's such as those found on other agencies properties) and 2) survey polygons without historical nests (i.e. areas of incidental sightings, suitable habitat, and/or project areas).

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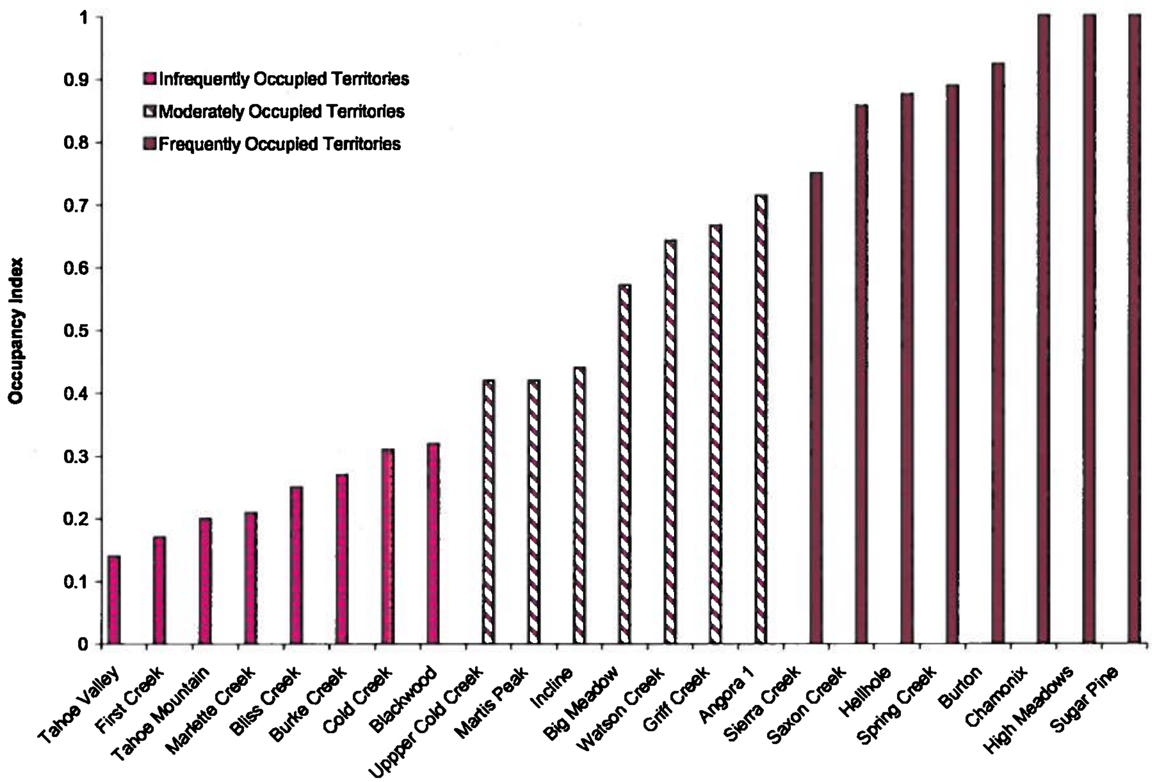

Fig.1. Occupancy Index (number of years occupied /number of years surveyed) of goshawk territories within the Lake Tahoe Basin.

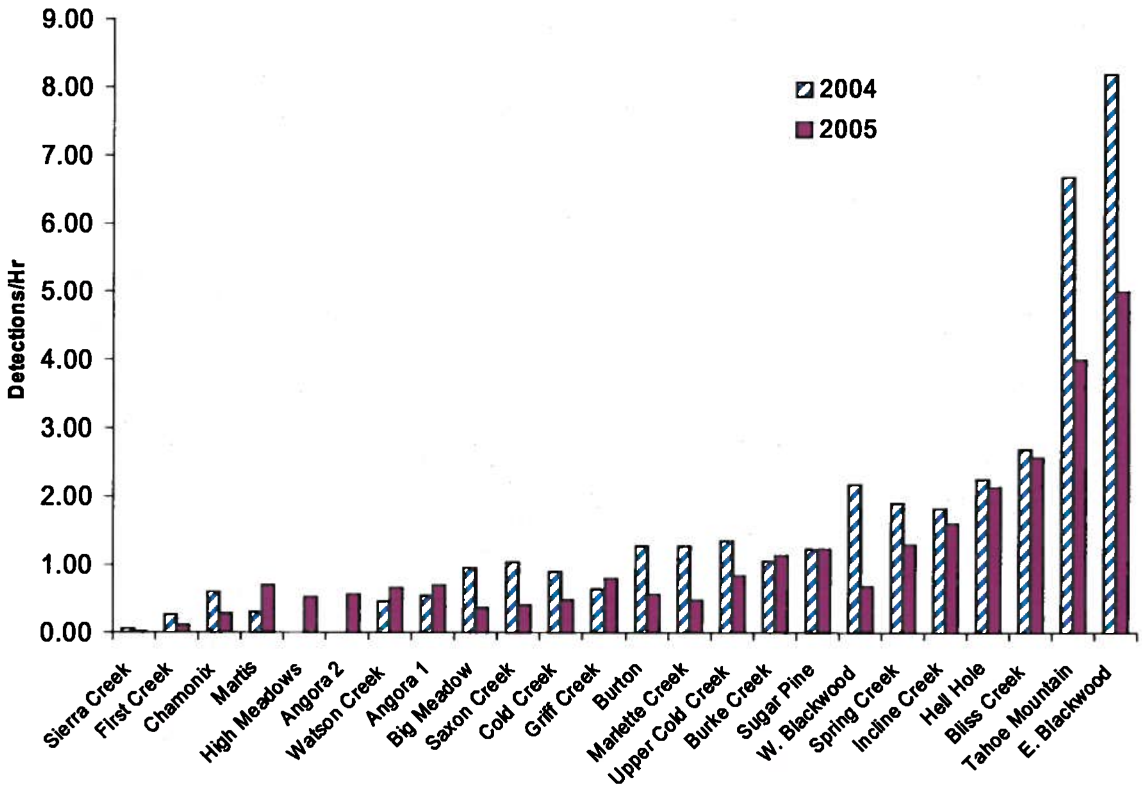

Fig. 2. Mean human activity levels (detections/hr) recorded by goshawk territory within the Lake Tahoe Basin April-September 2004 and 2005. Human activity was not measured within the Angora 2 or High meadows in 2004 because nests were not discovered within those territories until 2004.

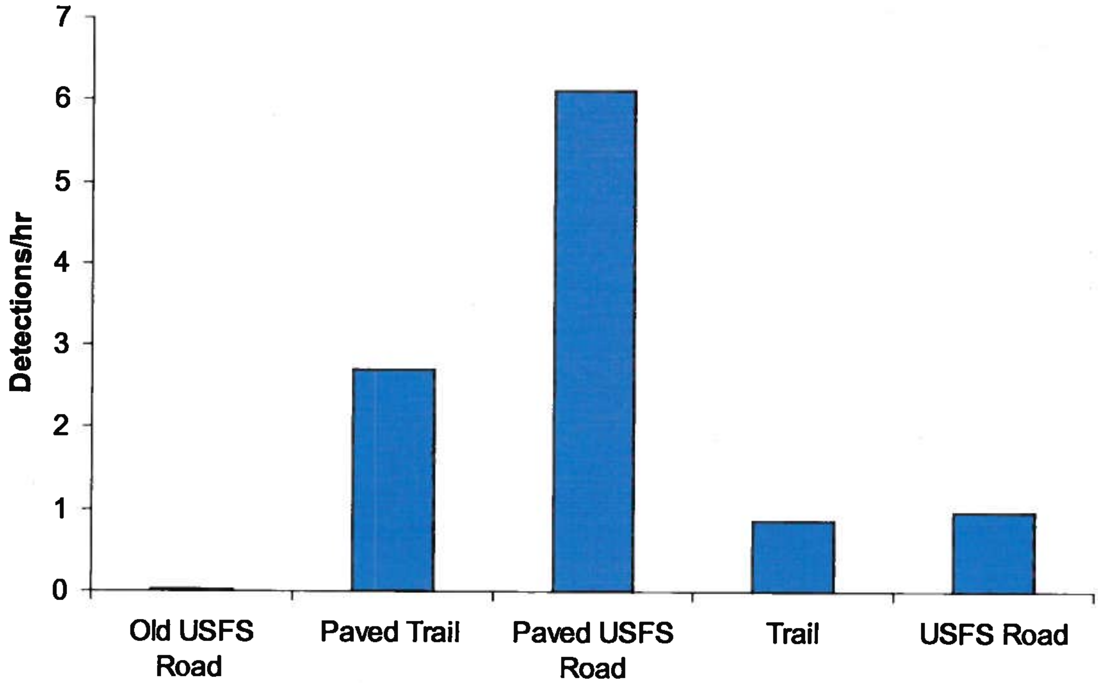

Fig. 3. Mean human activity levels (detections/hr) measured on various types of travel ways within goshawk territories in the Lake Tahoe Basin in 2004 and 2005.

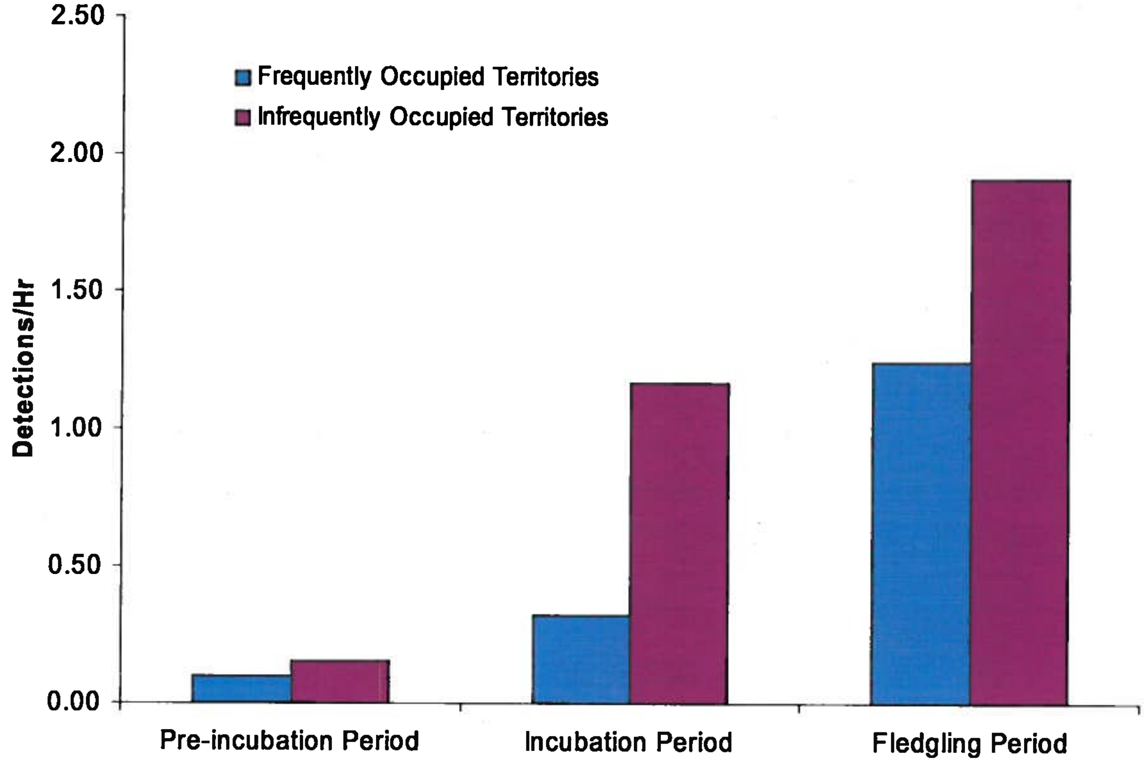

Fig 4. Levels of human activity (detections/hour) within frequently and infrequently occupied Lake Tahoe goshawk territories throughout the 2005 breeding season.

Table 1. Extent (mean m $\pm$ SE) of roads and trails within Lake Tahoe Basin goshawk non-disturbance buffers (800m radius centered on the most recent nest within each territory).

Road/Trail Type	Frequently Occupied Territories	Infrequently Occupied Territories	P-Value
Trails	1453 (± 476)	2041 (±1257)	0.669
USFS Roads	1538 (± 485)	1920 (± 539)	0.606
Local Roads	160 (± 160)	3957 (± 1432)	0.012
Highways	0 (± 0)	438 (± 201)	0.047
All Roads/Trails	3152 (± 575)	8357 (± 2372)	0.051

Table 2. Anthropogenic disturbance occurring within reference and non-reference goshawk territories located within the Lake Tahoe Basin.

TERRITORY	Occupancy Index	Human Activity	Extent of Trails	Distance to Trails	Extent of USFS Roads	Distance to USFS Roads	Extent of Local Roads	Distance to Local Roads	Extent of Highway	Distance to Highways	Extent of all Roads and Trails	Distance to Urbanization
Burton	0.92	0.90	825	387	1572	465	0	1822	0	2377	2397	1992
Chamonix	1.00	0.45	0	401	3508	214	1279	623	0	2620	4787	575
Hellhole	0.88	2.18	0	885	1824	550	0	2145	0	2305	1824	2137
High Meadows	1.00	0.53	1802	165	3404	144	0	3976	0	4973	5206	3935
Saxon Creek	0.86	0.67	3099	217	0	1427	0	1589	0	2318	3099	1468
Sierra Creek	0.75	0.04	540	586	539	474	0	812	0	954	1079	713
Spring Creek	0.89	1.60	3510	111	1459	568	0	2662	0	1884	4968	554
Sugar Pine	1.00	1.24	1852	112	0	1360	0	2791	0	2751	1852	2480
Reference Site Averages	**0.91**	**0.95**	**1453**	**358**	**1538**	**650**	**160**	**2052**	**0**	**2523**	**3152**	**1732**
Angora 1	0.71	0.64	4214	281	1725	421	0	908	0	3495	5939	877
Angora 2	NA[1]	0.56	0	874	1496	387	1982	477	0	3683	3478	396
Big Meadow	0.57	0.65	1565	299	0	1411	0	1863	0	920	1565	1830
Bliss Creek	0.25	2.62	0	1206	1606	580	0	2176	0	1293	1606	3070
Burke Creek	0.27	1.10	10638	4	615	512	11689	139	186	743	23129	132
Cold Creek	0.31	0.68	881	291	3827	139	0	1142	0	1271	4709	1165
East Blackwood	0.32	6.46	2541	102	4433	3	3772	323	869	599	11615	162
First Creek	0.17	0.20	887	333	935	572	5156	380	0	858	6978	334
Griff Creek	0.67	0.73	2409	373	5511	86	1616	439	0	1224	9536	398
Incline Creek	0.44	1.71	2708	38	1879	164	0	1380	0	985	4587	1318
Marlette Creek	0.21	0.92	271	351	2362	351	332	560	1189	412	4153	6423
Martis Peak	0.42	0.49	1540	251	6738	170	0	3338	0	3799	8277	3378
Tahoe Mountain	0.20	5.34	495	484	1422	360	3728	360	0	2944	5645	462
Tahoe Valley	0.14	NA[2]	619	663	164	688	6978	250	1261	433	9022	77
Upper Cold Creek	0.42	1.05	2993	0	382	719	0	1449	0	2316	3829	1444
Watson Creek	0.64	0.58	383	759	5172	217	20	783	0	1141	3374	840
West Blackwood	0.32	1.37	0	1704	3255	133	0	4136	0	4561	5575	4014
Non-reference Site Averages	**0.38**	**1.57**	**1891**	**471**	**2442**	**407**	**2075**	**1183**	**206**	**1805**	**6648**	**1548**

[1] Angora 2 does not have an occupancy index because the area was only surveyed two seasons.
[2] Trail counters were not placed within Tahoe Valley because most of the area around the historical nest site has been degraded by urban development.

Table3. Nest site conditions of reference and non-reference goshawk territories located within the Lake Tahoe Basin.

TERRITORY	Occupancy Index	% Canopy Cover	Live Tree DBH	Live Tree Height(m)	Dead Tree DBH	Dead Tree Height(m)	% Shrub Cover	Duff Depth (cm)	Coarse Woody Debris (tons)	Elevation (m)
Burton	0.92	89.80	41.20	17.50	94.00	11.00	6.20	2.64	2.95	2057
Chamonix	1.00	92.10	48.30	25.00	35.30	16.50	0.00	7.00	7.00	2155
Hellhole	0.88	92.40	59.50	21.00	107.00	40.00	19.50	4.02	2.50	2050
High Meadows	1.00	74.00	34.80	20.90	19.60	13.00	15.40	3.00	3.30	2408
Saxon Creek	0.86	64.80	63.10	28.30	46.50	13.40	6.00	4.26	3.10	2182
Sierra Creek	0.75	86.00	62.00	62.10	31.00	12.00	2.00	4.80	1.62	2127
Spring Creek	0.89	91.60	45.40	18.40	29.80	9.70	24.80	6.25	2.10	2071
Sugar Pine	1.00	83.60	56.60	26.50	98.00	11.00	10.00	2.30	4.77	1972
Reference Site Averages	**0.91**	**84.29**	**51.36**	**27.46**	**57.65**	**15.83**	**10.49**	**4.28**	**3.42**	**2128**
Angora 1	0.71	75.00	46.60	20.40	47.50	3.00	1.10	6.00	8.61	2004
Angora 2	NA[1]	51.00	34.00	8.00	87.60	16.00	22.45	4.30	4.10	2076
Big Meadow	0.57	76.70	42.00	12.00	34.00	8.50	57.50	3.20	6.10	2262
Bliss Creek	0.25	87.80	38.30	16.00	32.50	15.25	0.20	3.10	12.48	2165
Burke Creek	0.27	60.00	41.90	18.60	0.00	0.00	4.00	3.50	7.88	1999
Cold Creek	0.31	73.10	38.40	27.20	39.60	23.10	14.40	3.25	0.80	1987
East Blackwood	0.32	68.90	63.70	24.00	57.25	17.00	13.60	3.80	2.60	1926
First Creek	0.17	67.70	60.90	21.70	28.00	13.75	5.00	4.80	5.12	2071
Griff Creek	0.67	71.00	34.80	14.50	55.00	5.50	5.10	3.00	21.37	2018
Incline Creek	0.44	61.30	49.00	21.45	50.20	16.00	12.20	2.21	4.30	2356
Marlette Creek	0.21	88.00	57.30	18.80	0.00	0.00	0.20	3.40	19.60	1975
Martis Peak	0.42	66.20	52.30	25.20	27.50	6.15	2.00	2.20	0.61	2515
Tahoe Mountain	0.20	92.15	41.80	20.30	31.00	4.00	4.95	7.10	19.30	2036
Upper Cold Creek	0.42	89.90	34.00	20.00	0.00	0.00	2.10	7.00	1.00	2086
Watson Creek	0.64	72.80	42.90	20.10	38.00	12.50	1.00	4.60	24.12	2054
West Blackwood	0.32	81.70	50.30	23.10	84.30	20.00	10.00	2.12	10.47	1982
Non-Reference Site Averages	**0.39**	**73.95**	**45.51**	**19.46**	**38.28**	**10.05**	**9.74**	**3.97**	**9.28**	**2095**

[1] Angora 2 does not have an occupancy index because the area was only surveyed two seasons.
[2]Nest core characteristics were not measured at Tahoe Valley because the nest site area had been logged due to an insect infestation.

Table 4. Percentage of non-disturbance zones covered by various tree sizes (DBH) and canopy cover within reference sites and other sites located within the Lake Tahoe Basin.

		WHR Size Classes					Canopy Cover				
TERRITORY	Occupancy Index	Saplings	Pole Trees	Small Trees	Medium/Large Trees	Unknown	Dense Cover	Moderate Cover	Open Cover	Sparse Cover	Unknown
Burton	0.92	0.00	0.00	85.07	12.11	2.82	1.66	78.81	16.71	0.00	2.82
Chamonix	1.00	0.00	0.00	94.37	0.57	5.06	42.27	44.24	8.43	0.00	5.06
Hellhole	0.88	0.00	0.00	97.90	0.00	2.10	10.24	76.34	11.32	0.00	2.10
High Meadows	1.00	7.92	0.00	66.85	0.00	25.23	0.00	31.53	28.80	14.43	25.23
Saxon Creek	0.86	0.00	0.00	99.85	0.00	0.15	18.42	68.80	9.72	2.90	0.15
Sierra Creek	0.75	0.00	0.00	88.33	7.38	4.30	11.05	72.32	12.33	0.00	4.30
Spring Creek	0.89	0.00	0.00	87.62	2.47	9.90	20.97	59.68	9.44	0.00	9.90
Sugar Pine	1.00	0.00	1.95	94.10	1.56	2.40	3.16	70.91	20.79	2.74	2.40
Reference Site Average	**0.91**	**0.99**	**0.24**	**89.26**	**3.01**	**6.50**	**13.47**	**62.83**	**14.69**	**2.51**	**6.50**
Angora 1	0.71	1.85	0.00	92.64	2.92	2.58	15.96	45.06	30.24	6.16	2.58
Angora 2	NA[1]	0.00	0.00	79.34	9.38	1.83	9.04	71.16	15.33	2.44	2.02
Big Meadow	0.57	0.00	0.00	84.44	4.19	1.92	5.18	75.36	17.35	0.00	2.12
Bliss Creek	0.25	0.00	5.99	75.22	1.99	7.35	0.00	47.77	35.64	8.48	8.11
Burke Creek	0.27	0.00	0.00	79.25	0.00	11.30	0.00	21.23	60.93	5.37	12.48
Cold Creek	0.31	0.00	0.00	89.46	0.00	1.09	0.00	78.37	19.80	0.63	1.20
East Blackwood	0.32	0.00	0.00	71.74	2.91	15.89	14.24	60.38	7.05	0.78	17.55
First Creek	0.17	0.00	0.00	81.39	0.00	9.16	0.00	62.74	26.60	0.54	10.11
Griff Creek	0.67	0.00	0.00	85.26	0.00	5.29	8.41	58.54	18.91	8.30	5.84
Incline Creek	0.44	0.00	0.90	55.65	0.00	34.00	0.00	16.59	31.22	14.63	37.55
Marlette Creek	0.21	0.00	2.52	80.06	2.27	5.70	0.61	36.60	48.17	8.33	6.29
Martis Peak	0.42	0.00	2.01	57.94	25.61	4.99	7.25	50.02	34.12	3.10	5.51
Tahoe Mountain	0.2	0.00	0.00	78.94	6.97	4.64	0.77	65.80	27.57	0.73	5.13
Tahoe Valley	0.14	0.17	0.00	55.44	0.00	34.94	0.00	16.05	39.98	5.39	38.58
Upper Cold Creek	0.42	0.00	0.00	79.54	0.00	11.01	1.58	38.77	38.80	8.69	12.16
Watson Creek	0.64	0.00	0.00	87.21	0.77	2.57	0.00	53.46	33.60	10.10	2.84
West Blackwood	0.32	0.00	0.00	68.43	4.06	18.06	0.91	55.65	23.50	0.00	19.94
Non Reference Average	**0.38**	**0.12**	**0.67**	**76.59**	**3.59**	**10.14**	**3.76**	**50.21**	**29.93**	**4.92**	**11.18**

[1] Angora 2 does not have an occupancy index because the area was only surveyed two seasons.