United States
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Forest
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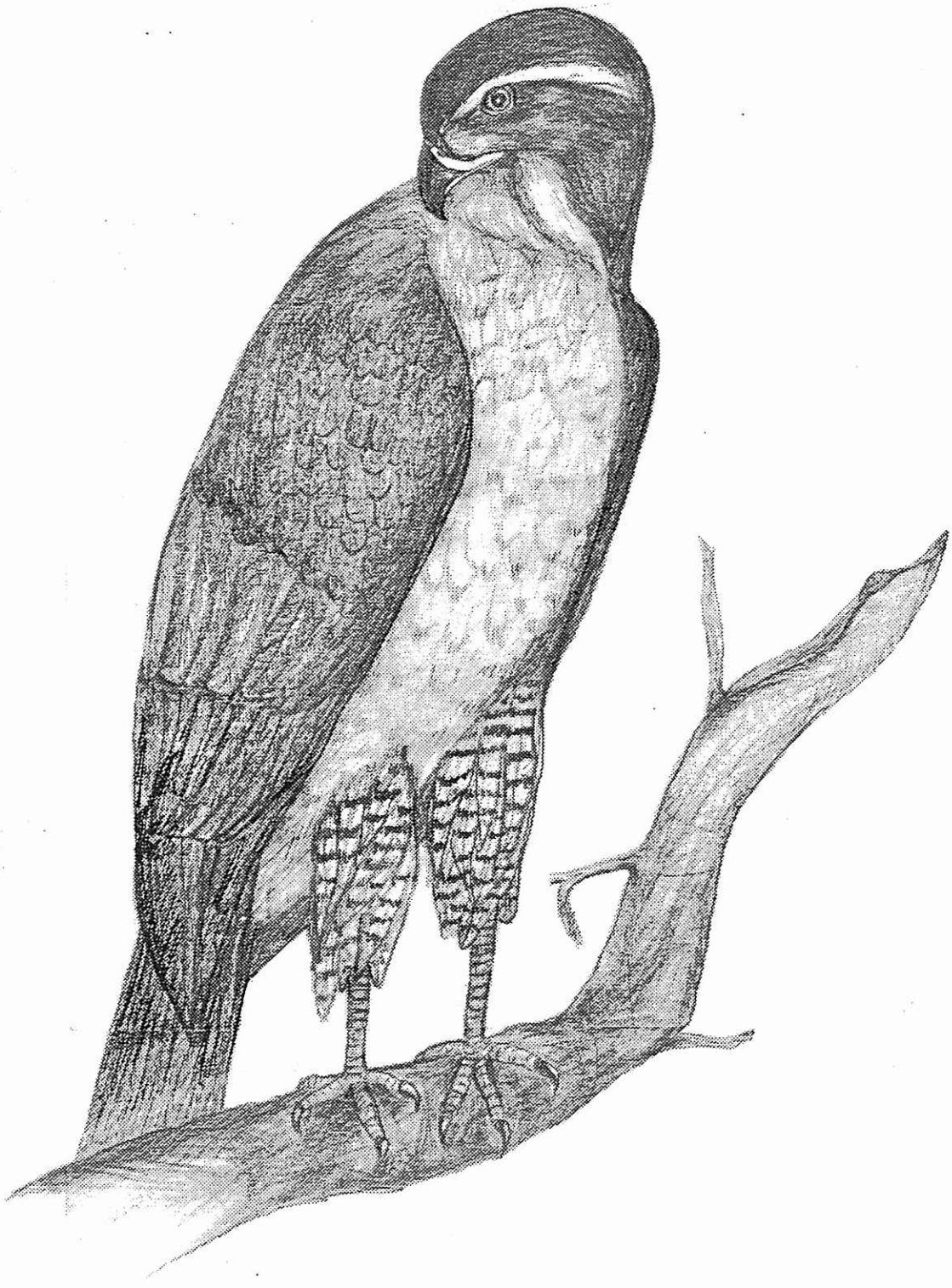
Pacific
Southwest
Region

Tahoe
National
Forest

Habitat Capability Model

Northern Goshawk



REGION 5 - USDA FOREST SERVICE

HABITAT CAPABILITY MODEL FOR THE NORTHERN GOSHAWK

May 1988

by

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PREFACE

Because goshawk habitat is rare and frequently disturbed during timber harvests, the vegetative and topographic features of their nesting sites have been widely investigated. Researchers have characterized nesting habitat for goshawks (Accipiter gentilis) in various localities; Schnell (1956) in California, McGowan (1975) in Alaska, Shuster (1980) in Colorado, Reynolds et al. (1982) in Oregon, Saunders (1982) and Hall (1984) in California, and Speiser and Bosakovski (1987) in New York and New Jersey.

Goshawks are a species of special concern because timber harvest activities have reduced the extent of older-aged forests. Of the three species of forest nesting Accipiter, the goshawk has the most stringent requirements for nesting habitat (Reynolds 1987). The nesting habitat structure is specific, generally displaying the following characteristics; high canopy closure, north to east aspects, gentle slopes and older-aged trees. Two studies suggest that the number of nesting pairs of goshawks is decreasing in Nevada and northern California, and both speculate loss of habitat as the cause of the decline (Herron et al. 1985, Bloom et al. 1986). This loss is attributed to habitat rendered unsuitable, primarily as a result of logging activity throughout the species' range.

In this document I review reproductive habitat requirements of western populations of the northern goshawk. I then present an HSI model and identify threats to the habitat and populations, and suggest management prescriptions to minimize these effects.

The model and management prescriptions apply to goshawk breeding habitat needs for the west slope of the Sierra Nevada in California. It also includes considerations for east side Sierra Nevada habitat. The model was developed for the Tahoe National Forest which includes both east and west side Sierra Nevada habitats. It is based on current information and revisions should be made as new data become available.

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ACKNOWLEDGEMENTS

I gratefully acknowledge Richard Reynolds, Bradley Valentine, Patricia Hall, William Laudenslayer, Michael Chapel and Brian Woodbridge for their thorough review of this habitat model. Their individual comments and suggestions added significantly to the quality and strength of the model.

NORTHERN GOSHAWK (Accipiter gentilis)

HABITAT USE INFORMATION

STATUS AND RANGE

The northern goshawk (Accipiter gentilis), largest of the three species of North America Accipiter, is a raptor associated with woodlands and forests. The American Ornithological Union (1957) recognizes two races of northern goshawk; A.g. atricapillus and A.g. laingi for North America. The dominant form, A.g. atricapillus occurs over most of the mountainous United States, including Alaska and boreal Canada. A.g. laingi coexists with A.g. atricapillus in the Pacific Northwest up to Alaska.

Goshawk populations are characterized by fairly regular fluctuations. These fluctuations are thought to be related to changing prey abundance on their northern breeding grounds (Meuller et al. 1977). McGowan(1975) found the goshawk common in interior Alaska, yet annual fluctuations in numbers were considerable as a result of changing prey densities.

In the Sierra Nevada, goshawks breed from the mixed conifer forests at low elevations up to and including high elevation lodgepole pine forests and eastside ponderosa pine habitats. Goshawks winter from the lodgepole pine forest downslope to blue oak savannah (Verner and Boss 1980).

Goshawks generally breed in older-age, coniferous, mixed and deciduous forest habitat. This habitat provides large trees for nesting, a closed canopy for protection and thermal cover, and open spaces allowing maneuverability below the canopy.

Assuming a pair of goshawks returns to the same nesting area, it may either repeatedly use the same nest, alternate between existing nests, or build a new nest (McGowan 1975). In Oregon, goshawks occupied sites for a maximum of 5 years (Reynolds 1978). In Alaska goshawks alternated between sites but use of traditional sites was between 83% and 100% and non-traditional sites were usually occupied by yearling females (McGowan 1975).

FOOD HABITS

Diet

In Oregon and California goshawks feed primarily on birds and mammals (Schnell 1958, Reynolds and Wight 1978, Reynolds 1979, Reynolds et al. 1984, Bloom et al.1986).

In the Sierra Nevada, Schnell (1958) alternately monitored prey items brought to a nest, and pellets and prey remains from plucking perches. He found the four most common prey items were: American robin (31%), Steller's jay (25%), golden-mantled ground squirrel (7%), chickaree (6%) and chipmunk species (6%). In observing items brought to the nest, nestling birds accounted for the largest portion of the goshawks' summer diet. Prey determinations from pellets may underrepresent avian constituents because unossified bone remains and incomplete feathering may be absent.

Bloom et al. (1986) collected one or two pellets from nests throughout California in a three year period. He identified 234 prey items representing 31 species. According to Table 4 of his report, avian prey accounted for 48% and mammals 52% of the total number of prey items represented. The four most commonly encountered prey species were Douglas squirrel (21%), Steller's jay (12%), golden-mantled ground squirrel (9%), northern flicker (7%).

In a study of prey pellage and plumage from 59 nests in eastern Oregon, 55% of the diet consisted of birds and 45% of mammals (Reynolds 1984). The mean prey weight was 306.6 grams (11 ounces) for goshawks which was more than twice that of the smaller Cooper's hawk (Accipiter cooperii). In comparison to the Cooper's hawk and the sharp-shinned hawk (Accipiter striatus), goshawks preyed upon a greater percentage of mammals such as tree squirrels and rabbits. Reynolds (personal communication) ascribed this to the greater size of the goshawk.

Foraging

The name "Accipiter" is derived from the Latin "accipere" meaning to take or seize, describing the general predatory nature of all species in the family Accipitridae (Jones 1981). Their morphology is characterized by short, rounded wings, and a long tail; characteristics that enhance flight agility in dense vegetation.

Despite the number of habitat studies concerning the goshawk, knowledge of foraging habitat is poor. Reynolds and Meslow (1984) found that the goshawk is a height zone generalist, taking prey from the ground-shrub, shrub-canopy, and canopy layers. In his radio telemetry study of foraging by nesting goshawks, Fischer (in prep) found a preference for woodlands with large, mature trees. Bloom et al. (1986) stress the need for protecting meadows, streams and aspen stands within the nest stand. These areas may be important to the prey species on which the goshawks feed. However, Reynolds (1987) observed that all three North American Accipiter are opportunists with respect to habitat. They forage in a variety of habitats probably along edges as well as in deep forests, provided there is available prey and the vegetation is not too dense to prevent flight.

During the breeding season, only a small fraction of foraging actually occurs at the nest site. Typically only the female forages in the site. During the initial stages of brooding the female will leave the nest only to receive food from the male, to capture food near the nest, to cache prey items and to collect sprigs to bring to the nest (Schnell 1958). Schnell found that the

female is responsible for only 15% of the food brought to the nest. The structure of foraging and nesting habitat is not necessarily different, but the areas generally are (Reynolds, personal communication).

Prey Plucking Sites

Accipiters typically secure the head of their prey and immediately begin to pluck it or pull the fur out. Prey plucking sites are usually within the nesting territory (Schnell 1958). Such perches consist of stumps, fallen logs, snags, arched trees, rocks, or horizontal tree limbs below the canopy (Bartelt 1974, Reynolds et al. 1982). Bartelt (1974) reports plucking posts to be within 100 m (328 ft) of the nest. Schnell (1958) reported such posts to range 31 m to 129 m (102 ft to 423 ft) from the nest, with a mean distance of 69 m (226 ft). Reynolds (1983) reports a distance range of 27 m to 74 m (89 ft to 243 ft) with a mean of 45 m (148 ft). Factors influencing the choice of a plucking post are sturdiness, height, and accessibility (Schnell 1958).

WATER REQUIREMENTS

In California, Saunders (1982) found that distances from goshawk nests to water ranged from 15 m to 1700 m (44 ft to 5576 ft) (mean = 665 m [2027 ft], n = 12). Seventy-five percent of these nests were over 100 m (328 ft) from water. Also in California, Hall (1984) found a range from 0 m to 357 m (1171 ft) (n = 12). On the Klamath National Forest, California, nests are frequently greater than one mile from a permanent source of water (B. Woodbridge, personal communication).

In Oregon, northern goshawks nest in stands that averaged 199 m (653 ft) (SD = 239 m [784 ft], n = 34) from the nest tree to a permanent water source (Moore and Henny 1983). In eastern Oregon, goshawk nests averaged 119 m (390 ft) (SD 171 m [561 ft]), range 2 m to 610 m (7 ft to 2001 ft), (n = 50) from water (Reynolds et al. 1982). However, 22 of the 74 nest sites (an area of approximately 8 ha to 10 ha [20 ac to 25 ac] around the nest) were dry. Reynolds suggested that a permanent water source does not appear to be required, but that there may be a preference for this condition.

COVER REQUIREMENTS

Cover requirements, which are satisfied by high tree foliage densities, are similar to the reproductive needs of goshawks (Reynolds et al. 1982, Saunders 1982, Moore and Henny 1983, Hall 1984). In addition to contributing to the desired microclimate within a nest stand, high foliage densities may reduce

predation by providing cover. Cover requirements are assumed under the Food Habits and Reproduction sections of this document.

REPRODUCTIVE REQUIREMENTS

Nest Sites

A goshawk nest site is defined as the area surrounding the nest tree, including the vegetation and topographic features, used by a nesting pair during an entire nesting season, exclusive of foraging areas (Reynolds et al. 1982). Often, nest sites have limits that coincide with boundaries between stands of different age or species composition. Nest sites can also be bordered by topographic features such as ridgelines (Reynolds 1983).

Studies of nesting habitat (Shuster 1980, Reynolds et al. 1982, Saunders 1982, Moore and Henny 1983, and Hall 1984), show that goshawks nest in older-aged stands of coniferous, mixed, or deciduous forest. Tree species is highly variable.

Reynolds et al. (1982) suggest that the use of dense stands by Accipiters is adaptive because the vegetation protects the adults and fledged young from predators, and, combined with a northern aspect and water source, it provides shaded, relatively cool environments. On the basis of this statement, goshawks would choose a nest site based on the overall appearance of a stand.

The most consistent vegetative characteristic of goshawk nest sites is high percent canopy closure. The only exceptions are the extremely low measurements of canopy cover on the east side Sierra Nevada on the Inyo National Forest, and in lodgepole stands in eastern Oregon. Canopy closure at 11 nests on the Inyo ranged from 27% to 63% (McCarthy unpub.). In eastern Oregon, 3 (4%) of the nests were either in pure, mature lodgepole stands or in stands dominated by mature lodgepole (Reynolds et al. 1982). These nests were characterized by single-layered canopies with an average closure of 38%. However, most of the 74 nests sites in eastern Oregon were dense, mature conifer stands with a mean canopy closure of 60%. In northern California the average canopy closure was 76.9% (range = 53% to 92%, n = 12)(Saunders 1982). In northwestern California, Hall (1984) measured 10 nests stands and found a mean canopy closure of 94% (range = 84% to 100%).

Goshawks commonly choose north to east aspects for nest sites. Stands on northerly aspects are typically denser and therefore more suitable (Reynolds 1983). The dense quality probably functions to reduce solar radiation and therefore, temperatures within the stand. Reynolds et al. (1982) found a significant ($p<0.05$) preference for nest stands with northerly aspects. Of the 59 sites, 61% were on northwest to northeast facing slopes. Only 8% were on southwest to southeast slopes. Moore and Henny (1983) detected no preference for aspect, although 12 nests out of 23 were on northwest to northeast slopes. Shuster (1980), Saunders (1982) and Hall (1984) consistently found nest stands

with north to east aspects. The only exception is Alaska where the majority of nests were on south facing slopes (McGowan 1975).

Nest sites show considerable variance in the presence of understory vegetation and stand structure. Stands range from those containing few mature trees and numerous smaller understory conifers, to those with park-like understories of few trees and closed canopies. Nest locations in Oregon are generally found in dense multi-layered stands (Reynolds 1971, 1982), while nests sites in Colorado and California are generally found in open park-like understory (Shuster 1980, Saunders 1982, Hall 1984). The average tree size of nest sites in Colorado ranged from 20.6 cm to 50.0 cm (8 in to 20 in) dbh. Shuster believes the upper size range was probably limited by the absence of older stands as nests were found in the oldest stands in the area. In Oregon, mean tree diameters in the nest stand were 51.6 cm (20 in) (SD = 14.9 cm [6 in]) (Moore and Henny 1983), and 82.3 cm (32 in) (SD = 28.3 cm [11 in]) (Reynolds et al. 1982). In northwestern California, goshawks nested in mature stands with a mean tree diameter of 46 cm (18 in) dbh for trees comprising the nest stand and 58 cm (23 in) dbh for trees within a 0.04 ha (0.1 ac) plot centered at the nest (Hall 1984). In northern California, nest sites were in stands of pole size timber (Saunders 1982). Pole sized timber in northern California was single storied whereas the pole sized timber in Oregon was multi-storied. The ages of stands in northwestern California and Oregon were equivalent.

Slope also appears to influence nest placement because nest sites are usually on flat to moderately sloped land (0% to 30%). The slope of a given area probably interacts with tree density and size (Hall, personal communication). As long as trees can grow as large and as dense, the steepness of the slope is probably of secondary importance. The slope of nest sites in Oregon averaged 9% (range = 0% to 75%) for 59 sites in the east (Reynolds et al. 1982) and 14% (SD = 11) for 34 sites in the northeast (Moore and Henny 1983). In Colorado, nests were located on benches or basins surrounded by steeper slopes. Slopes varied from 0% to 40% with a mean of 13% (Shuster 1980). In northern California the mean slope was 12% (range = 0% to 38%) (Saunders 1982) whereas in northwestern California the slopes were more precipitous with a mean of 41% (range = 4% to 87%) (Hall 1984). Nests in steep areas were usually low on the slope. In the east side Sierra Nevada habitat the slopes of 11 nests were consistent with other data having a range of 0% to 16% (n = 7) (McCarthy unpub.).

Reynolds (1987) believes that excessive weight has been placed on the importance of broken forests and edges for the choice of nesting habitat by Accipiters. He feels that the birds use forested habitat opportunistically, and has found nests in broken forests as well as in continuous pristine blocks.

Nesting Densities and Home Range

Estimates of densities of northern goshawk nests range from a high of 11.0 pairs per 100 km^2 (62 mi^2) in Arizona (Crocker-Bedford and Chaney, in prep) to a low of 2.4 pairs per 100 km^2 (62 mi^2) in Alaska (McGowan 1973). Reynolds and Wight (1978) intensively surveyed an 11,741 ha (29,000 ac) area for Accipiter nests in each of five breeding seasons. Every year, four nests

were active, resulting in a nesting density of 4.3 pairs per 100 km^2 (62 mi^2). Sampling areas of optimum habitat in California produced an estimate of 3.2 nesting territories per 100 km^2 (62 mi^2) (Bloom et al. 1986). Gross population estimates were calculated for California and Nevada by multiplying the number of nesting territories per township by the number of townships with suitable habitat in each region. In California, Bloom et al. (1986) approximated a total of 1,300 nesting territories of which 61% were estimated to be active each year. A gross estimate of 500 nesting territories was made for Nevada (Oakleaf 1975).

Home range size of goshawks during breeding can be estimated using a number of different methods. One method is to assume that ranges are circular and nonoverlapping, and can be measured by nest spacing (Newton et al. 1977, Reynolds 1979). A number of studies have calculated distances between goshawk nests. In Oregon, distances between nests ranged from 2.4 km to 8.4 km (1.5 mi to 5.2 mi) (mean 5.6 km [3.5 mi]) (Reynolds and Wight 1978). This translates to a range of 2463 ha (6084 ac). In the Warner Mountains of California, average distances between nests were calculated in four intensively surveyed areas. Twenty-two active nests were found within the four areas and the mean distances between nests for each area were 2.3, 2.6, 2.7 and 4.0 km (1.4, 1.6, 1.7, 2.5 mi). Six of the nests (27%) were within 1.6 km (1 mi) of another active nest (Camilleri 1982). In the east side Sierra Nevada habitat densities are similar to that of eastern Oregon with a spacing of 6 km (3.7 mi) between active nest sites (McCarthy unpub.).

Another method of estimating home range size is to plot the location of capture of marked prey whose remains were found at goshawk nests (Eng and Gullion 1962). Using this method, Eng and Gullion (1962) determined the goshawks' ranges were approximately circular and although they foraged primarily in an area of 1250 ha (3088 ac), they foraged up to 2.5 km (1.6 mi) and possibly beyond (home range estimated to be 1979 ha [4888 ac]).

Minimum Habitat Area

In this document, minimum habitat area is defined as the minimum amount of contiguous habitat that is required before an area will be occupied by a species. Distances between alternate nests and nest activity can give an indication of the minimum size needed for goshawks. On the Klamath National Forest in northern California, management areas were established in 1985 and then monitored in subsequent years. During a three year study period, 11 out of 29 pairs moved outside of a 50.6 ha (100 ac) area centered on the nest (Woodbridge 1988). The median distance was 237 m (777 ft) and the mean distance was 601 m (1971 ft). Some birds moved 100 m to 500 m (328 ft to 1640 ft) per year for three consecutive years. The same study observed nest occupancy to develop an index of stand size vs. activity. Nest stands ranging from 0 acres to 40 acres were occupied 15% of the time that they were monitored (n = 7); nest stands ranging from 41 acres to 80 acres were occupied 48% (n = 24); nest stands ranging from 81 acres to 120 acres were occupied 32% (n = 12); nest stands ranging from 121 acres to 160 acres were occupied 74% (n = 17); nest stands ranging from 161 acres to 200 acres were occupied 96% (n = 14).

HABITAT CAPABILITY INDEX

Model Applicability

This model was developed for application on the western slope of the Sierra Nevada with consideration for the east side. At this time, the model addresses only the size and character of the primary nest core to be established for each territory. There is a need for an additional habitat zone to encompass alternate nest sites and foraging habitat. The size of this area can not be addressed because of insufficient data at this time. Nesting habitat structure is specific but year-round forage needs are poorly understood.

The model evaluates goshawk nesting habitat in the mixed conifer (MC), Jeffrey pine (JP), red fir (RF), ponderosa pine (PP), lodgepole pine (LPP), and riparian deciduous (middle and upper elevations) (RID) habitats as defined by Verner and Boss (1980). Quaking aspen is a montane species that is used for nesting by goshawks (Reynolds et al. 1982). The species is not mentioned as a habitat component species by Verner and Boss (1980) but should be considered as providing suitable nesting habitat.

Model Description

This model integrates the cover and reproductive requirements of the northern goshawk into a Habitat Suitability Index (HSI). It is designed to evaluate the quality of a forested area for application of management zones. The model assumes that free water and the availability of prey plucking sites are not limiting factors. Prey plucking sites will probably be inherent in the general stand structure. No estimate will be made on the minimum size of the habitat area needed to supply all life requisites but an estimate has been made for the retention size of a primary nest core. Data on home range sizes are lacking and future assessments can be made as data become available.

Five variables were chosen because they are thought to be the most limiting factors for the northern goshawk in the Sierra Nevada. The model considers habitat variables that reflect habitat stage; canopy closure; size; slope; and aspect. The variable representing habitat stage was compiled from Verner and Boss (1980) and information from species authorities. The variable addressing slope was borrowed from an HSI model by Camilleri (1982). New variables were developed for canopy closure, size and aspect. The habitat variables have the following relationship in the model:

	Habitat Variable	Life Requisites
V1	Habitat Stage (MC,JP,RF,PP,LPP,Aspen,RID)	Cover, Reproduction
V2	Canopy Closure	Cover, Reproduction
V3	Size	Reproduction
V4	Slope	Reproduction
V5	Aspect	Cover, Reproduction

Mixed conifer, red fir, Jeffrey pine and ponderosa pine forests at large tree stages provide optimal habitat. Suitable habitat is provided by the same forests at pole/medium stage and by large tree stages of lodgepole pine and aspen habitats. Suitable habitat is also provided by riparian deciduous habitat when it is present with adjacent stands. Marginal habitat is provided by isolated riparian deciduous areas. For the east slope of the Sierra Nevada the model should be adjusted for the habitat stage and canopy closure variables. Where more suitable habitat is absent, lodgepole pine can provide optimum habitat for nesting.

High tree canopy closure is characteristic of all goshawk nest stands. In this model 60% to 100% is optimal, 50% to 59% is suitable and 30% to 49% is marginal. On the east side of the Sierra Nevada, where more dense habitat is absent, tree canopy closures of 20% to 40% should be included as marginal.

The minimum size of the primary core to be left around a nest is 50 ha (124 ac). Stands less than 50 ha will reduce protection from disturbance and increase the possibility of inactivity and abandonment.

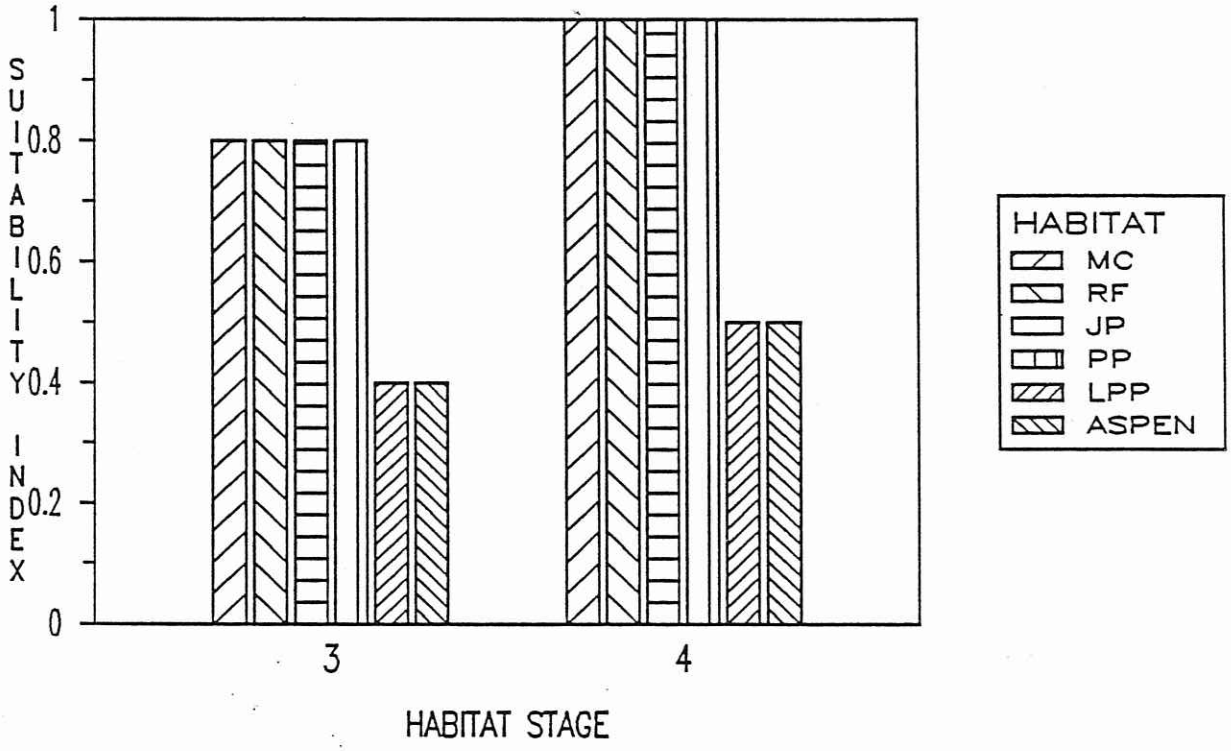
Goshawk nests are generally found on gentle to moderate slopes (less than 25%). In this model slopes of 0% to 25% are optimal, 26% to 50% are suitable and greater than 50% are unsuitable.

Aspect is an important component in the choice of a nest stand. Nest stands with a north to east aspect are considered optimal in this model. North to northwest and east to southeast slopes are considered suitable. All other aspects are considered marginal.

Model Relationships

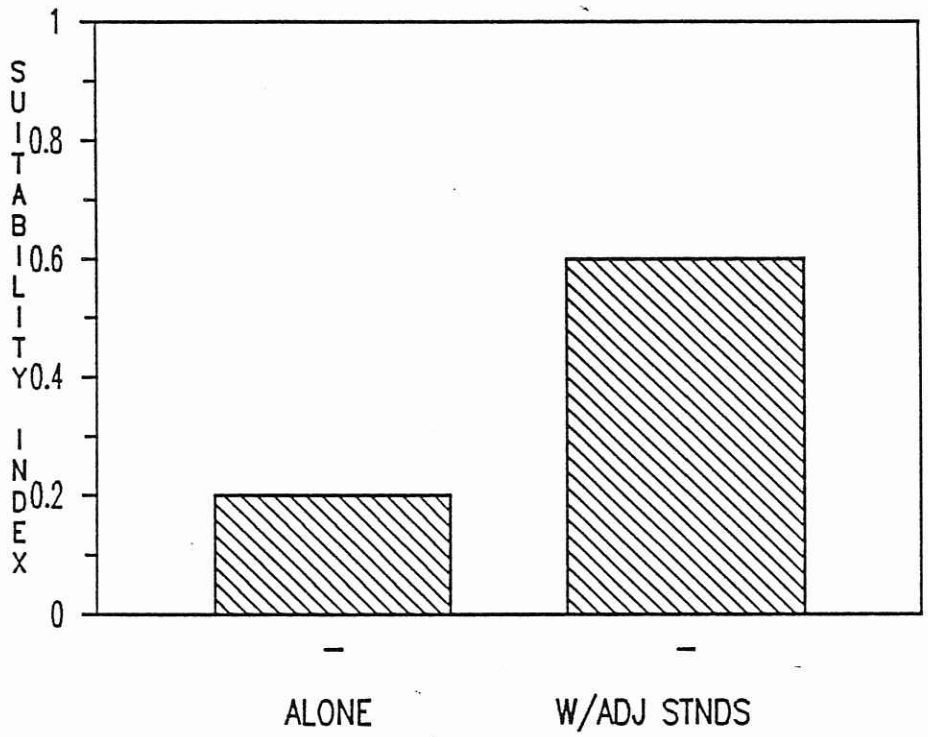
The graphs used to assign coefficients for the habitat variables are as follows.

V1 HABITAT STAGE
MC,RF,JP,PP,LPP,ASPEN

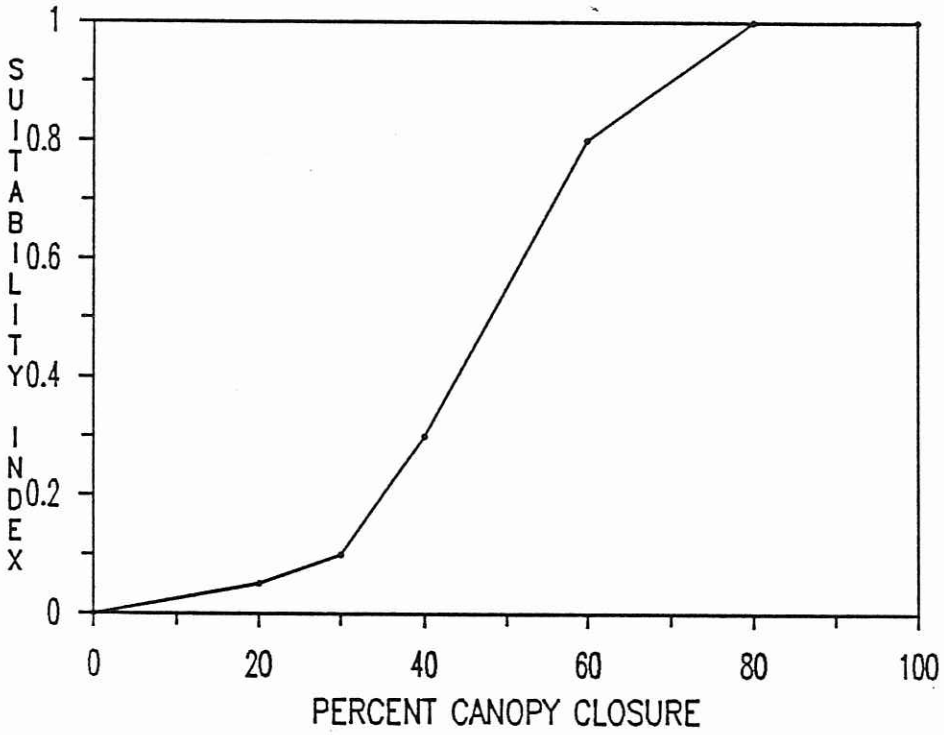


V1 HABITAT STAGE

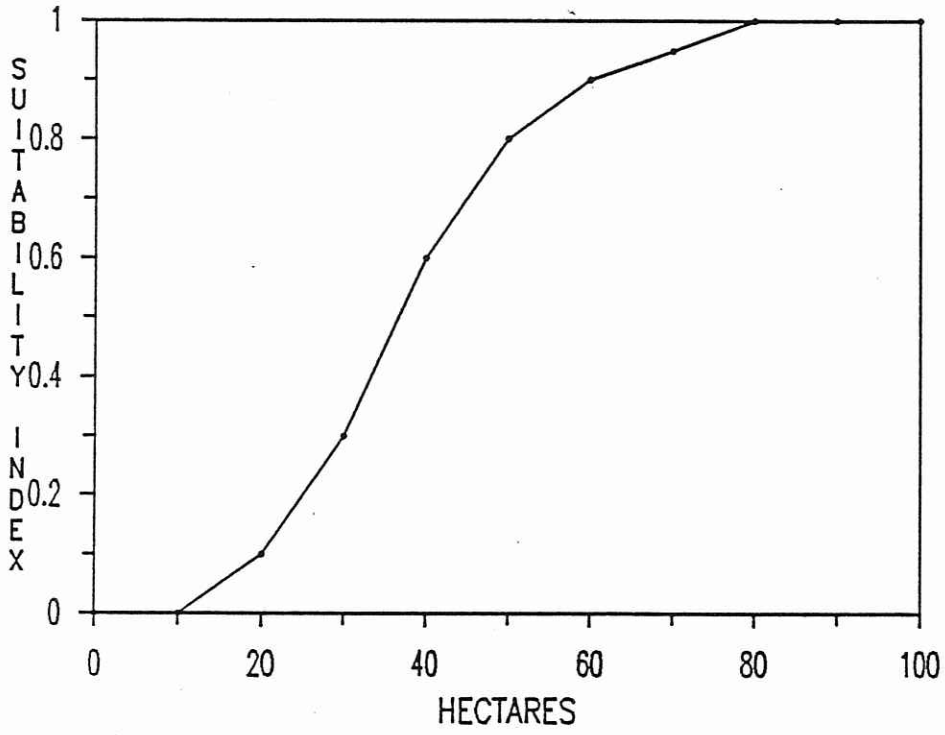
RIPARIAN DECIDUOUS



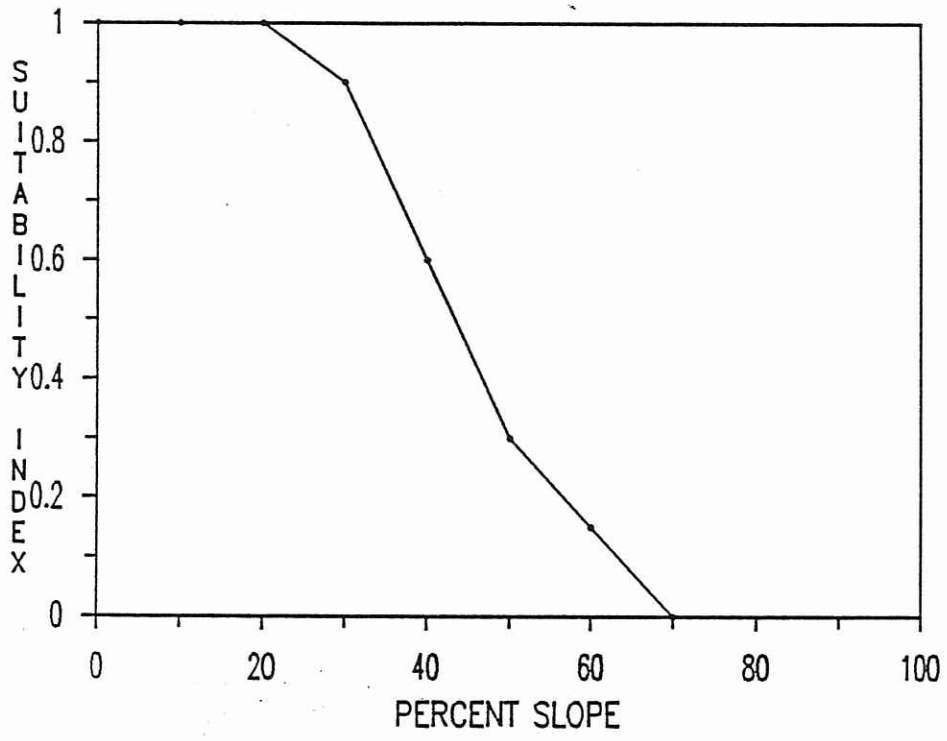
V2 TREE CANOPY CLOSURE



'/3 NEST STAND SIZE



V4 SLOPE


SUITABILITY INDEX
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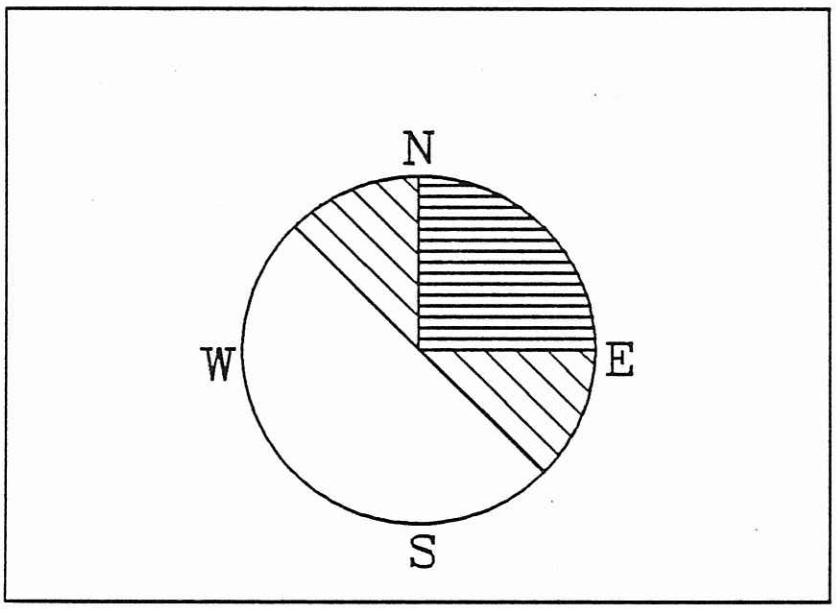
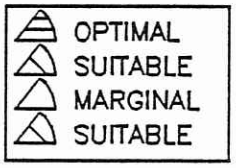
0.2
0
0
20
40
60
80
100
PERCENT SLOPE

'/5 ASPECT





Application of the Model

To use the model for habitat assessments, coefficients for each of the variables used in the HSI equation should be determined from the graphs on the previous pages. The coefficients should be combined through the use of the following equation:

$$HSI = \left[V1 \times V2 \times V3 \times \frac{V4 \times V5}{2} \right]^{1/4}$$

The variables can be determined by using the following techniques:

V1,V2 - Match standard timber inventory maps with the habitat descriptions in Verner and Boss (1980, pages 2-7).

V3 - Aerial photo.

V4 - Determine the slope with clinometer or contour maps once V1, V2 and V3 have been assessed for capability.

V5 - Aerial photos, contour maps or visual.

Model Reliability

This model represents the impressions of goshawk authorities and is based on limited field data. Until it is field-tested, its reliability will remain uncertain.

Sources of Other Models

Camilleri (1982) constructed a habitat capability model for the northern goshawk. Kings River Conservation District developed a subsequent model in 1986 based on Camilleri's model and the literature.

MANAGEMENT PRESCRIPTION

Population Objective

Establishing a population objective is the most critical and most difficult task in developing a management prescription. Goshawks are vulnerable to changes in the forest habitat and populations are believed to be limited by nest site and prey availability.

Managed forests that strive to maintain current goshawk population levels should adopt a target of four nesting pairs per township. As new data become available, adjusting the population objective may be desirable.

Nest Cores

Where continued nest core occupancy is the objective, a minimum of 49 ha (120 ac) of forested habitat is recommended for primary nest cores. Additional forage habitat should also be defined. To maintain a density of four pairs per township, nest cores should be within the range of 1.6 km to 5.6 km (10 mi to 3.5 mi) from each other. If management for only two pairs of goshawks per township is desired, the distances between pairs should be no greater than 7.9 km (4.9 mi). The density varies in proportion to the square of the distance and a doubling of the distance between pairs could result in a 75% reduction in pairs (Reynolds 1983).

Habitat Potential

Nesting habitats with the best potential for northern goshawk management are older-age, closed-canopy stands of mixed conifer, Jeffrey pine, red fir and ponderosa pine forests that are on gentle north to east facing slopes. Moderate potential is provided by the same forests with smaller pole/medium tree stage and by large tree stages of lodgepole pine and aspen forests. Riparian deciduous habitat offers marginal habitat. Riparian deciduous habitat can be managed as nest core where present with adjacent optimum stands; but riparian stands should not be used for the entire nest core.

In addition, meadows and streams should be considered as sources of goshawk prey. Other habitats should not be considered for goshawk management emphasis.

Habitat Characteristics

Suitable breeding habitat for northern goshawks can be maintained by providing the principal characteristics of older-age forests. Those characteristics are: older-age stands offering dense canopy and large trees dominating the overstory; and small snags and downed logs for prey plucking sites.

Disturbance in the primary nest core should be reduced. Precommercial and commercial thinning should be prohibited. Fuelwood harvests should also be discouraged because of human disturbance and the resulting loss of downed materials for prey plucking sites.

Managed forests that strive to maintain current goshawk population levels should adopt a target of four nesting pairs per township. As new data become available, adjusting the population objective may be desirable.

Nest Cores

A minimum of 21 ha (50 acres) of suitable habitat is needed for the nest core. Where continued nest core occupancy is the objective, a minimum of 49 ha (120 ac) of forested habitat is recommended for primary nest cores. Additional forage habitat should also be defined. To maintain a density of four pairs per township, nest cores should be within the range of 1.6 km to 5.6 km (10 mi to 3.5 mi) from each other. If management for only two pairs of goshawks per township is desired, the distances between pairs should be no greater than 7.9 km (4.9 mi). The density varies in proportion to the square of the distance and a doubling of the distance between pairs could result in a 75% reduction in pairs (Reynolds 1983).

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Disturbance in the primary nest core should be reduced. Precommercial and commercial thinning should be prohibited. Fuelwood harvests should also be discouraged because of human disturbance and the resulting loss of downed materials for prey plucking sites.

Management Prescription

The following are recommendations for managing northern goshawk habitat in the Sierra Nevada:

1. Organize matrices of goshawk breeding habitat areas as follows:

    a) Use Order 1 watersheds as the basic planning unit for developing the matrices.

    b) Where managment for the current population is desired, establish at least four territories per township across suitable habitat.

    c) The area should be intensively surveyed for active and potentially active sites. Where possible, include both sites in the nest core especially if the alternate site offers a variable habitat type. Identify the primary nest core and maintain the structural elements over time.

    d) Integrating goshawk habitat areas with pileated woodpecker and spotted owl management areas should be done with caution or avoided because of the potential for goshawk predation on these species. However, it may be possible to incorporate goshawk territories in the earlier stages of spotted owl habitat development provided the habitat is suitable for goshawks.

2. Develop management plans for each area established for goshawks to ensure that the following conditions are provided in all time periods:

    a) The preponderance of lands classified as suitable habitat should be older-age forests with tree canopies that exceed 60% closure. Overstory tree sizes should average at least 25 inches to 30 inches DBH.

    b) Include portions of the stand upslope from the nest containing plucking and roost sites.

    c) The shape of the core should be partly determined by topography; it should be round or oblong in flat, contiguous areas, and broad-based triangular or sectorial in steep terrain with bisecting radii beginning below the nest and running up through the nest tree (Reynolds 1983). Incorporate as much habitat variability as possible in the outline of the core.

    d) The area comprising the nest core should not be isolated by silvicultural treatments.

    e) Aspect should face to the north and east and provide gentle to moderate slopes.

f) Free water should be included in the management area whenever possible.

3. Use the following management practices for maintaining suitable habitat conditions for northern goshawks:

a) Develop a monitoring plan that will be used over time. The goshawk territories should be monitored annually for occupancy and suitable habitats within 1 km (.6 mi) of the previous year's nest.

b) Develop a timber management strategy that perpetuates suitable goshawk habitat in each management area over time. In some locations, dedicating old-growth stands may be desirable. If rotating suitable habitat through the successional sequence is the method of choice, choose rotations that match desired core habitat stage and diameter objectives with site-specific growth potential. Ensure that rotation ages allow for 20 years of existence after the habitat reaches maximum quality.

c) Maintain meadows and streams within the management area. Edges are important for increasing prey diversity but probably are not a limiting factor.

d) Maintain downed log densities by prohibiting fuelwood gathering and salvage logging activities in the management area.

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