Abert's Squirrel (*Sciurus aberti*)
Species Assessment

Prepared for the
Grand Mesa, Uncompahgre, and Gunnison National Forest

September 2005

First Abert's Squirrel Species Assessment Prepared by **Craig Grother**[1], 2001
A Species Viability Assessment was prepared by Craig Grother in 2003
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INTRODUCTION

In 2005, the Grand Mesa, Uncompahgre, and Gunnison National Forest (Forest) amended the Forest Plan for MIS; subsequently the Abert's squirrel was selected. In the 1991 Amended Land and Resource Management Plan for the Forest, Abert's squirrels were identified as a forest MIS because of their specialized association with late succession ponderosa pine forest habitat and for the ability to represent other species with similar habitat requirements (Land and Resource Management Plan, page II-42 to II-43, USDA Forest Service 1991). In the 2005 Forest Plan Amendment, Abert's squirrel was retained as an indicator for ponderosa pine ecosystems.

Keith (2003) has written a Technical Conservation Assessment for the Abert's squirrel that was prepared for Region 2 (USDA Forest Service, Rocky Mountain Region) as part of the Rocky Mountain Region's Species Conservation Project. In addition, Grother (2003) has written a Species Viability Assessment for the Abert's squirrel on the Forest within Region 2. Grother also prepared a Species Assessment for the Abert's squirrel that is included in the 2001 MIS Assessment for the Forest (USDA Forest Service 2001). Detailed information on the species management status and natural history, biology, distribution, abundance, habitat, and ecology on the Regional and Forest levels are included in these reports and summarized in the current report.

This report is tiered to the Technical Conservation Assessment for the Abert's squirrel (Keith 2003) and is intended to bring the broad-level Regional Assessment down to a local level. This report also supplements the 2001 Species Assessment and the 2003 Species Viability Assessment for the Abert's squirrel and incorporates new information that can be used for forest-level and project-level planning. The biology and conservation status of the Abert's squirrel on the Forest is addressed. The goal of this assessment is to summarize historical and current literature on the Abert's squirrel to provide land managers and the public with an objective overview of this species within the Forest. Peer-reviewed scientific literature and summarized data are the primary information sources used in this report. Local data sources (District wildlife biologists and technicians) were used to provide information on distribution, localized abundance, and habitat condition for the Forest. This assessment provides recommendations for the current Forest Plan revision in terms of integrating Abert's squirrel habitat requirements into forest management planning.

SUMMARY OF KEY FINDINGS

The Forest is located within the range of this species, but occurs at the northwest periphery of their overall range distribution. The Uncompahgre Plateau Geographic Area, including the Naturita Division south of Norwood, likely supports stable populations of Abert's squirrels as this area comprises the majority of high quality habitat on the Forest and contains the majority of known populations. Approximately 93% (41,949 acres) of optimal habitat occurs within the Uncompahgre Plateau Geographic Area. The Gunnison Basin Geographic Area contains primarily sink habitat characteristics, comprising only 7% (3,118 acres) of the total optimal habitat on the Forest. Total potential habitat, consisting of low quality, marginal, and optimum conditions, encompasses approximately 147,574 acres.

The Abert's squirrel currently has no federal legal status. The Global Heritage Ranking is G5; demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery (InfoNatura 2005). Keith (2003) reports that Abert's squirrel viability does not appear to be threatened, nor is the species in danger of extinction at a landscape or Forest-level anywhere in Colorado. The Colorado Division of Wildlife considers their status secure and persistent enough to support a hunting season. Hunting is not expected to have a significant impact on Abert's squirrel populations, although small, isolated populations could be adversely affected during high harvest years, especially on the Forests where Abert's squirrels are at the periphery of their distribution.

Survey methods used for the Abert's squirrel on the Forest have focused primarily on presence/absence, distribution, habitat inventory, monitoring, and squirrel density estimates. Survey results have provided relative abundance, distribution information and insight on general habitat characteristics and habitat quality. To obtain an accurate estimate of squirrel populations and population trends over time, index techniques should be implemented in suitable habitat Forest-wide based on the Combined Feeding Index sampling method (Dodd et al. 1998). Using this method, an estimate of squirrel density was obtained from portions of the Uncompahgre Plateau Geographic Area. Densities ranged from 0.20 to 0.69 squirrels per acre. Abert's squirrel densities appeared to be tied to the clumpiness of mature ponderosa pine trees with interlocking crowns.

The Abert's squirrel is an obligate species of ponderosa pine forests. The primary limiting factor to Abert's squirrel populations on theForest appears to be the condition of their habitat. Past activities that most severely influenced the habitat quality of the Abert's squirrel, resulting in the existing forest conditions we see today, include logging, grazing and wildfire. Forest management practices have caused reductions in stand density, structure, and diversity. Combined with fire suppression, replacement forests have developed that are often homogenous in structure and are not high quality squirrel habitat (Keith 2003).

To date, the primary restoration technique utilized on the Forest is the thinning of ponderosa pine to replicate pre-settlement forest tree density and structure. Ponderosa pine stands are thinned to a basal area of approximately 60-80 ft^2 per acre and then underburned to reduce susceptibility to bark beetles and stand replacing wildfires. Dodd et al. (2003) recommended a basal area greater than 153 ft^2 for high quality Abert's squirrel habitat. Techniques currently used on the Forests may be exacerbating the effects of past even-aged management by further reducing stand density, structure, and diversity (Grother 2003).

To benefit Abert's squirrel populations, forest management practices should be directed to ensure that forest structure enhances the availability of young vigorous trees for inner bark feeding, maintains large cone-producing trees, and provides blackjack clusters with high canopy cover to enhance fungi production and protections for travel (Keith 2003). Dodd et al. (1998, 2003) provides management options and recommendations that emphasize the importance of integrating Abert's squirrel habitat needs of interlocking canopies, hypogeous fungi, and structural diversity in ponderosa pine forest management to benefit squirrel populations.

Sufficient knowledge is now available of forest structure that is beneficial to Abert's squirrels, and forest managers should integrate Abert's squirrel habitat requirements into their objectives and activities (Keith 2003). It is possible to provide specific habitat requirements for Abert's squirrels while at the same time meeting multiple-use management objectives.

HABITAT CRITERIA USED IN FOREST-WIDE HABITAT EVALUATION

2001 MIS Habitat Criteria

In 2001, potential Abert's squirrel habitat was modeled for the Forest using existing vegetation data from the Forest Integrated Resource Inventory (IRI). In 2001, IRI data was available for 77% of the Forest. GAP vegetation data from the Colorado Division of Wildlife was utilized for the remaining 23% of the Forest. The criteria used to model habitat were cover type and habitat structural stage. Ponderosa pine was identified as the primary habitat cover type. The distribution of ponderosa pine in all habitat structural stages was determined for the Forests. Primary Abert's squirrel habitat included habitat structural stages 4A, 4B, and 4C, with potential squirrel nesting activity anticipated to occur primarily in 4B and 4C stands.

Rationale

The Abert's squirrel is highly dependent on ponderosa pine to meet all of its life history requirements. Based upon available research, they utilize all-aged ponderosa pine stands, especially trees in even-aged groups. Abert's squirrels have strong affinities for specific stand characteristics and structural attributes, which are primarily mature age class stands (structural stages 4A, 4B, and 4C). Research further indicates that Abert's squirrels prefer denser stands of mature ponderosa pine for nesting. Suitable nesting habitat attributes, particularly interlocking crowns, are found largely in habitat structural stages 4B and 4C. As an obligate species of ponderosa pine forests, the Abert's squirrel is an indicator species useful to managers in assessing the effects of management activities on ponderosa pine habitat.

2005 MIS Habitat Criteria

Following publication of the 2001 MIS Assessment, vegetation data (R2-Veg) now exists for all areas of the Forest. This database is continuously being updated. This should result in mapping that more reliably depicts suitable Abert's squirrel habitat on the Forest. Habitat queries utilizing R2-Veg were based on vegetation cover type and habitat structural stage. Figures 1, 2 and 3 displays modeled habitat from R2Veg for the Forest

Figure 1. Abert's squirrel cover and nesting habitat as modeled by R2Veg.

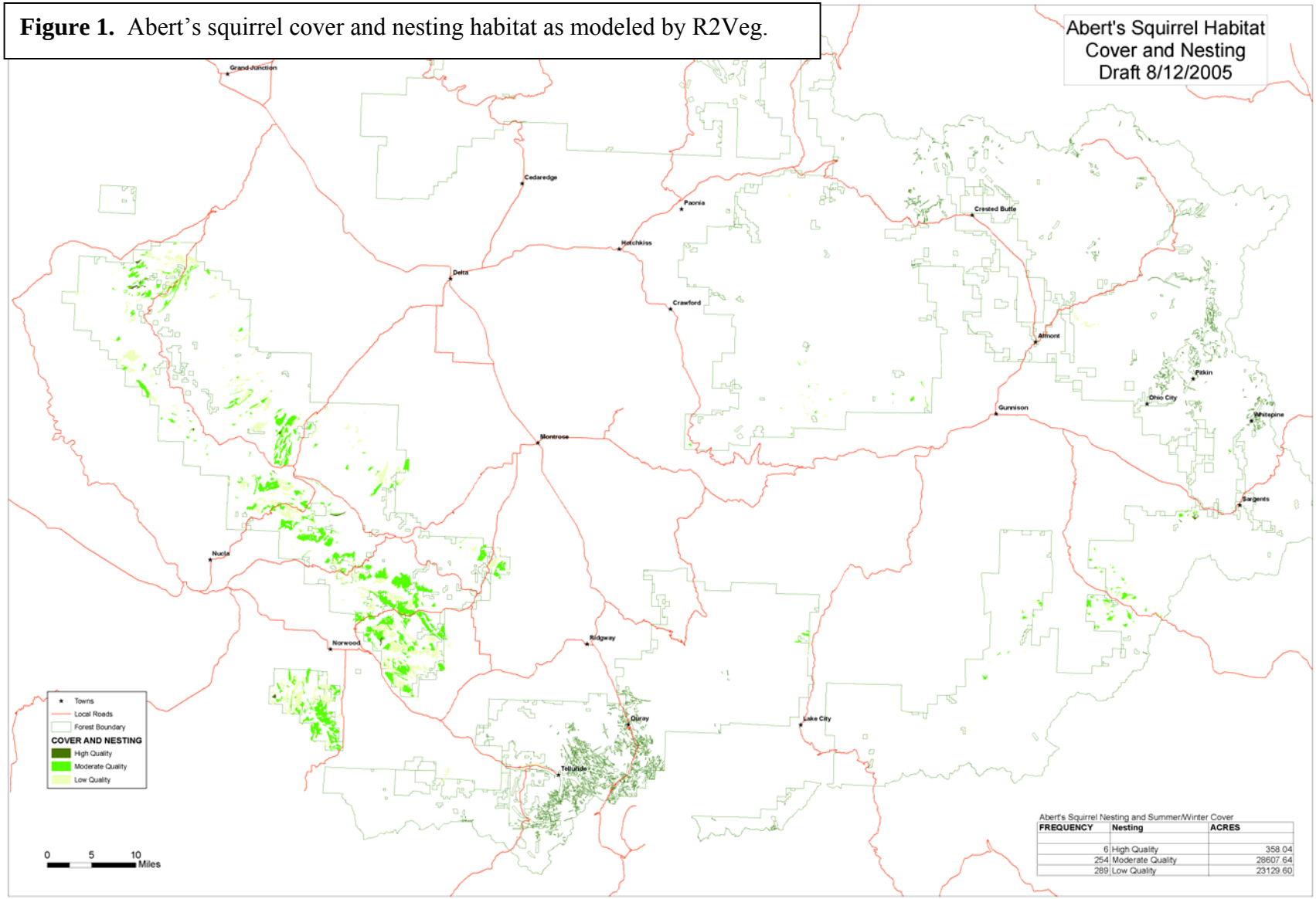


Figure 2. Abert's squirrel summer forage habitat as modeled by R2Veg.

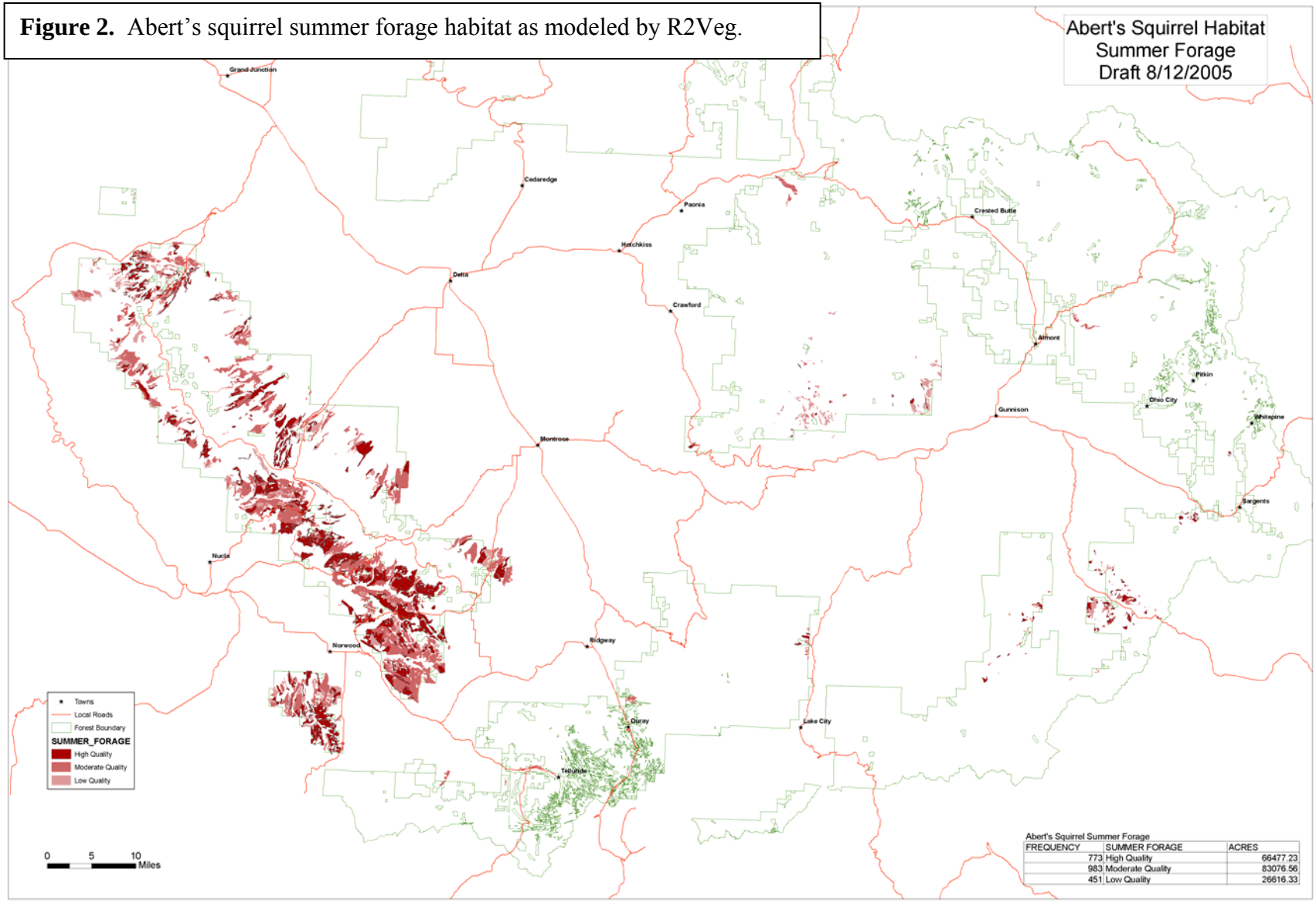
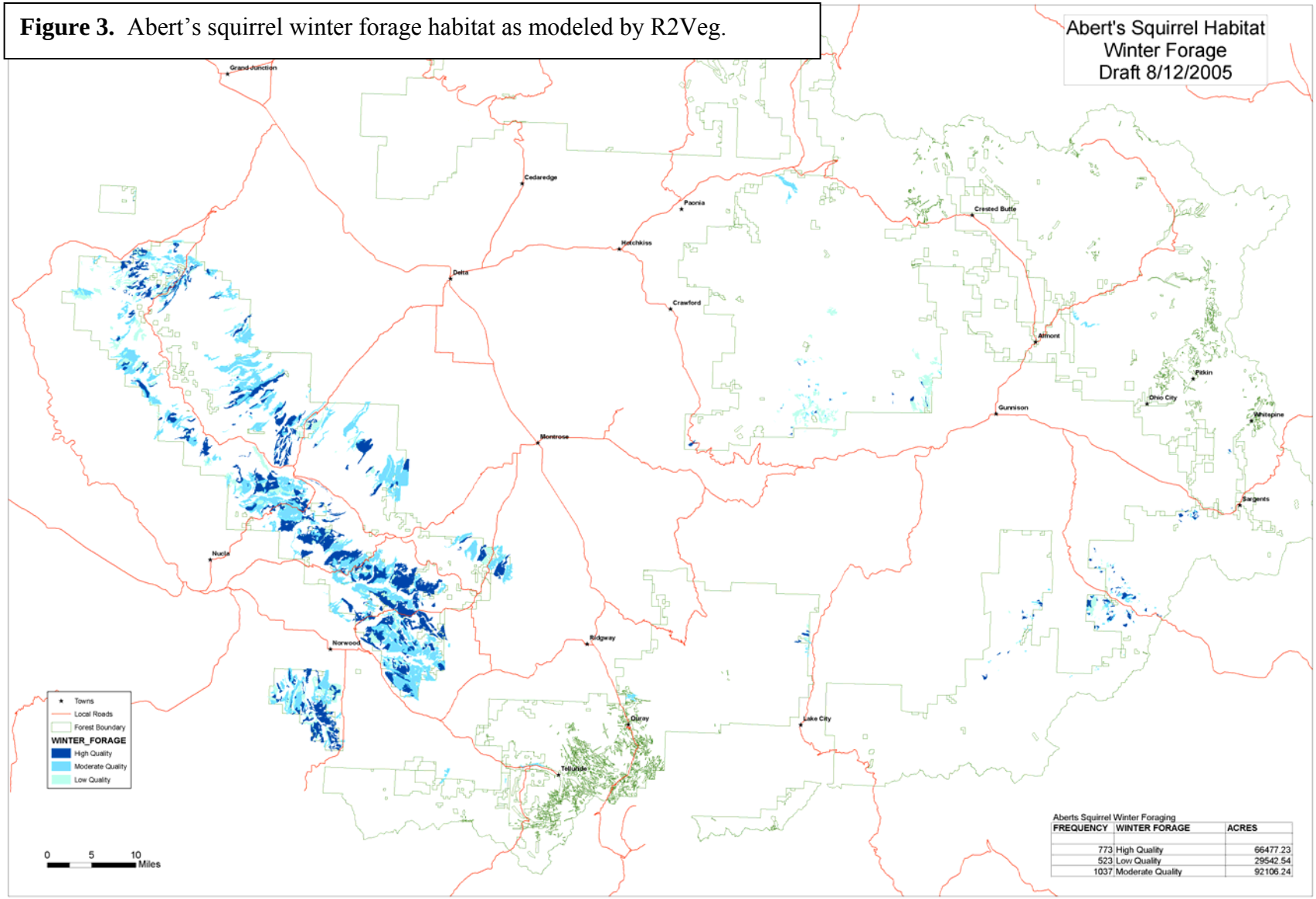


Figure 3. Abert's squirrel winter forage habitat as modeled by R2Veg.



Potential habitat was mapped based on three categories: low quality, marginal, and optimal habitat. Optimal habitat encompassed 4B and 4C/5 ponderosa pine and Gambel oak/ponderosa pine mixes, particularly since these structural stages are more likely to provide open, uneven-aged stands with clusters of even-aged groups connected by canopy corridors, in addition to containing trees within the age range that provide the most cone production. Gambel oak, where it is associated with ponderosa pine, may be an important component of winter foraging habitat. A further refinement of optimal habitat mapping would be to identify uneven-age classes within mature ponderosa pine stands by querying for multiple canopy layers from the layering attribute in R2-Veg. Low quality and marginal habitat included the distribution of all ponderosa pine dominated stands with habitat structural stages 3A, 3B, 3C, and 4A, and the Gambel oak, pinyon-juniper, and Douglas-fir cover types where they are associated with ponderosa pine or ponderosa pine is included in the species mix for those cover types. Habitat parameters used to model potential Abert's squirrel habitat on the Forest are summarized in Table 1 below. Keith (2003) identified desirable actions and forest characteristics of value to Abert's squirrels, which are the primary considerations for determining habitat parameters for Abert's squirrels in this assessment:

1) Stand densities of 300 to 600 trees per ha (121-243 trees per ac), mostly >30 cm dbh.
2) Trees clustered into small, even-aged groups (0.1 to 0.5 ha in size) in uneven-aged forest.
3) Stringers of canopy cover between tree clusters to give protection for escape and travel.
4) Protection of existing nest trees within groups of taller trees (several per hectare).
5) Protection of 20 trees per ha used for bark feeding (>20 twigs on ground under tree).
6) Retention of areas of dense canopy cover to form habitat on ground for truffle production.
7) Protection of groups of cone producing trees, especially those >50cm dbh.
8) High ROMPA (Ratio of Optimal to Marginal Patch Area) values (>50%).

Table 1. Habitat parameters for modeling Abert's squirrel habitat on the Forest.

Habitat Parameter	Optimum Habitat	Low Quality to Marginal Habitat	
	High Quality (Optimum 1.0)	**Moderate Quality (Marginal 0.5)**	**Low Quality (Minimal 0.2)**
Summer Foraging	4b, 4c, 5 ponderosa pine	3c, 4a, ponderosa pine	3a, 3b ponderosa pine
	4b, 4c Gambel oak where it is associated with ponderosa pine	3b, 3c, 4a, 5 Gambel oak where it is associated with ponderosa pine	3a Gambel oak where it is associated with ponderosa pine
Winter Foraging	4b, 4c, 5 ponderosa pine	3c, 4a, ponderosa pine	3a, 3b ponderosa pine
	4b, 4c Gambel oak where it is associated with ponderosa pine	3b, 3c, 4a, 5 Gambel oak where it is associated with ponderosa pine	3a Gambel oak where it is associated with ponderosa pine
		4a, 4b, 4c, 5 pinyon-juniper where it is associated with ponderosa pine	3a, 3b, 3c, 4a, 4b, 4c, 5 Douglas-fir where it is associated with ponderosa pine (Douglas-fir/ponderosa pine mixes w/<50% Douglas-fir)
Summer Cover	4c, 5 ponderosa pine	4b ponderosa pine	4a ponderosa pine
			4a, 4b, 4c, 5 Douglas-fir where it is associated with ponderosa pine
Winter Cover	4c, 5 ponderosa pine	4b ponderosa pine	4a ponderosa pine
			4a, 4b, 4c, 5 Douglas-fir where it is associated with ponderosa pine
Nesting	4c, 5 ponderosa pine	4b ponderosa pine	4a ponderosa pine
	Clusters of even-age trees 0.25-1.2 ac in size within uneven-age stands	Clusters of even-age trees 0.25-1.2 ac in size within uneven-age stands	Primarily even-age stands lacking clusters of trees
	On each acre of high quality habitat w/in the core habitat area, there should be clusters of interlocking trees with a mean of 15.7 inches dbh	On each acre of high quality habitat w/in the core habitat area, there should be clusters of interlocking trees with a mean of 15.7 inches dbh	Clusters of interlocking trees have a mean dbh <15.7 inches
	>3 interlocking crowns per ac[1]	2-3 interlocking crowns per ac	<2 interlocking crowns per ac
Canopy Layers	Primarily multiple layering	Primarily multiple layering	Single layering more prominent than multiple layering
Core Habitat Area Size[2]	1,235.5 ac	1. 1,235.5 ac	1,235.5 ac
	>40% (>494.2 ac) comprised of high quality habitat	35-40% (432.4-494.2 ac) comprised of high quality habitat	<35% (<432.4 ac) comprised of high quality habitat
	>252.3 ac foraging habitat	220.7-252.3 ac foraging habitat	<220.7 ac foraging habitat
	>241.9 ac cover habitat	211.7-241.9 ac cover habitat	<211.7 ac cover habitat

1 Interlocking crowns have been strongly correlated with squirrel recruitment (Dodd et al. 1998).

2 For every 1,235.5 acres of Abert's squirrel habitat, a minimum of 35 to 40% must be composed of high quality habitat for recruitment to occur. Stands with less than 35% will have declining populations of squirrels (Personal communication with Dodd by L. Spicer, 2002).

Acres of summer foraging, winter foraging, summer/winter cover, and nesting habitat based on habitat quality are provided in Table 2.

Table 2. Acres of Abert's squirrel habitat on the Forest based on habitat parameters and habitat quality.

Habitat Parameter	Habitat Quality			
	High	**Moderate**	**Low**	**Total**
Summer forage	66,477.23*	83,076.56	26,616.33	176,170.12
Winter forage	66,477.23*	92,106.24	29,542.54	188,126.01
Summer/winter cover	965.07*	44,102.23*	42,179.92*	87,247.22*
Nesting	965.07*	44,102.23*	42,179.92*	87,247.22*

* Similar habitat requirements occur between the different habitat parameters, thus there is some overlap between habitat types.

Rationale

Abert's squirrels are limited to ponderosa pine forests and are ecologically dependent on ponderosa pine for food and cover. However, Abert's squirrels may also be found in Gambel oak, pinyon-juniper, and Douglas-fir forest types when those cover types are associated with ponderosa pine (Hoover and Wills 1984, Frye 2004). Abert's squirrels have been reported in pinyon pine, Douglas-fir, and spruce-fir forests, and above treeline as high as 3,850 m on Humphrey's Peak, Coconino County, Arizona (Ferner 1974, Hall 1981, Cooper 1987). In addition, they have been observed using food sources other than ponderosa pine, including hypogeous fungi, acorns, dwarf mistletoe, and Douglas-fir cones (Keith 1965, Ferner 1974, Stephenson and Brown 1980, Brown 1984, Pederson et al. 1987). The squirrels eat acorns of Gambel oak when they are available and will use natural cavities in oaks for dens (Patton 1975, Keith 2003). Within the Uncompahgre Plateau Geographic Area, Abert's squirrels likely utilize Gambel oak trees where they occur within ponderosa pine forests. On the Kaibab Plateau in Arizona, Abert's squirrels ate both the inner bark and the seeds of pinyon pine and occasionally used the inner bark of Douglas-fir for food (Ratcliff et al. 1975, Keith 2003). In Colorado, some forests are a mixture of Douglas-fir and ponderosa pine; both the Abert's squirrel and the pine squirrel (*Tamiasciurus hudsonicus*) occur in these mixed stands (Keith 2003). Near Leadville, Colorado, an Abert's squirrel was observed sitting in a pinyon pine, ten miles from the nearest ponderosa pine forest (Bissell and Davis 1990). In the Gunnison Basin Geographic Area, Abert's squirrels have been documented at the edges of ponderosa pine and Douglas-fir associations; however, squirrels were primarily using ponderosa pine trees for nesting and feeding with the exception of one Abert's squirrel nest that was found in a Douglas-fir tree (Spicer pers. comm. 2005).

The potential exists for Abert's squirrels to be found in ponderosa pine and Douglas-fir associations, but Douglas-fir should not be considered as potential available habitat if it is not associated with ponderosa pine. In addition, if a Douglas-fir and ponderosa pine association is not dominated by ponderosa pine, then this habitat type should be classified as poor quality habitat. Douglas-fir and mixed stands of Douglas-fir and ponderosa pine typically occur on north facing slopes. Ponderosa pine commonly occurs on south facing slopes. Consequently, Douglas-fir stands found between ponderosa pine patches may serve as travel corridors for Abert's squirrels. These areas of connectivity may provide for natural dispersal of individuals within an area, allow genetic exchange between populations, and provide the opportunity to shift natural ranges in response to climate change (Noss and Cooperrider 1994).

The Habitat Capability Model (Habcap) is a computerized tool for quantitative habitat analysis. It provides estimates of the capability of habitats to support wildlife species based on the mix of vegetation cover types and structure present in an area. This model was developed for application at the planning area and project area analysis levels for Forest Plan implementation and is utilized as one of the tools for determining criteria to model Abert's squirrel habitat. The model generates a Habitat Capability Index (HCI) value that is a measure of overall habitat value of an area based on forage and cover quantity and quality. An HCI value of 1.0 represents optimum habitat. The cover types and habitat structural stages described as optimal habitat for the Abert's squirrel are given the highest coefficient values (HCI = 1.0) for both cover and forage habitat for Abert's squirrels in the Habcap model. Habcap provides values of 0.2 to 0.5 for ponderosa pine and Gambel oak cover types with habitat structural stages 3A to 4A, and values of 0.5 for pinyon-juniper with habitat structural stages 4B to 5. The Gambel oak and pinyon-juniper cover types may provide travel corridors to patches of ponderosa pine and may be important for dispersal, especially where these cover types are associated with ponderosa pine. Additionally, the Gambel oak cover type provides acorns that may be an important food supplement to Abert's squirrels for summer and winter foraging. Where it is associated with ponderosa pine, Gambel oak, with habitat structural stages 4B and 4C, is considered optimum habitat (HCI = 1.0). Habcap coefficients for Abert's squirrel cover and foraging habitat are provided in Table 4 below.

Table 4. Structural stage values from Habcap for Abert's squirrel cover and foraging habitat.

Summer Feeding									
Cover Type	**1**	**2**	**3A**	**3B**	**3C**	**4A**	**4B**	**4C**	**5**
Gambel Oak	0	0	0.2	0.5	0.5	0.5	1	1	0.5
Ponderosa Pine	0	0	0.2	0.2	0.5	0.5	1	1	1
Summer Cover									
Cover Type	**1**	**2**	**3A**	**3B**	**3C**	**4A**	**4B**	**4C**	**5**
Ponderosa Pine	0	0	0	0	0	0.2	0.5	1	1
Winter Feeding									
Cover Type	**1**	**2**	**3A**	**3B**	**3C**	**4A**	**4B**	**4C**	**5**
Gambel Oak	0	0	0.2	0.5	0.5	0.5	1	1	0.5
Pinyon-Juniper	0	0	0	0	0	0.5	0.5	0.5	0.5
Ponderosa Pine	0	0	0.2	0.2	0.5	0.5	1	1	1
Winter Cover									
Cover Type	**1**	**2**	**3A**	**3B**	**3C**	**4A**	**4B**	**4C**	**5**
Ponderosa Pine	0	0	0	0	0	0.2	0.5	1	1

HCI values of 1 represent optimal habitat, HCI values of 0.5 represent marginal habitat, and HCI values near 0 represent low quality habitat.

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

The Abert's squirrel has a Natural Heritage Program ranking of G5. It is demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery. It is also considered secure nationally and within the state of Colorado, and is no longer tracked by the Colorado Natural Heritage Program. The Abert's squirrel has no federal legal protection and is not considered rare or threatened. The Forest considers the squirrel to be a Management Indicator Species, although there is no Regional status. The state of Colorado manages the Abert's squirrel under their Small Game Hunting Regulations.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

The Abert's squirrel is considered a small game species in Colorado and is protected against "take", except as prescribed by Colorado's Small Game Hunting Regulations. The Abert's squirrel hunting season dates are from November 15 through January 15 each year, and hunting is allowed statewide to people with a valid small game hunting license. The daily bag limit is 2 squirrels, and the possession limit is 4. Legal methods of take include small caliber rifles or pistols (less than .23 caliber), shotgun (no larger than 10 gauge), hand-held bow and arrow, and hawking or falconry. Harvest within the Forest appears to be very low (see page 16 under Population Information section).

There are no developed management plans or conservation strategies for the Abert's squirrel. The Abert's squirrel is identified as a Management Indicator Species for the Forest (Table II-15 and II-16, pages II-42, II-43). The Land and Resource Management Plan includes standards and guidelines for management of habitat for the Abert's squirrel, which are summarized in Table 5 below.

Table 5. 1991 Land and Resource Management Plan standards and guidelines for the Abert's squirrel.

Management Activities	**General Direction**	**Standards and Guidelines**
Aquatic and Terrestrial Habitat Management	Manage for habitat needs of indicator species	g. Abert's Squirrel Leave at least two 12-20'' dbh trees per 5 acres for nesting and feeding.
	Maintain habitat for viable populations of all existing vertebrate wildlife species	a. Maintain habitat capability at a level at least 40% of potential capability[1]

1 This standard and guideline varies with specific Management Area direction.

The Standards and Guidelines listed in the 1991 Amended Land and Resource Management Plan for the Abert's squirrel may not adequate to maintain high quality squirrel habitat. Management considerations identified in this Assessment should be considered in the revised Forest Plan.

Biology and Ecology

The Abert's squirrel, commonly known as the 'tassel-eared' squirrel, is a management indicator species for late succession ponderosa pine (*Pinus ponderosa*) forests on the Forest. Abert's squirrels are capable of traveling through and living for short time periods in habitat types other than ponderosa pine, but the species is ecologically dependent on ponderosa pine for food, cover, and nest sites (Mckee 1941, Keith 1965, Dodd et al. 1998, Bissell and Davis 1990, Keith 2003).

The Abert's squirrel is found primarily in ponderosa pine forests on the Colorado Plateau, and in the southern Rocky Mountains of Colorado, Utah, Arizona, and New Mexico in the United States, and the Sierra Madre Occidental of Chihuahua and Durango in Mexico (Keith 1965). In Wyoming, Abert's squirrels only occur in the extreme southern portion of the state where ponderosa pine is present, and they occupy a small portion of southeast Utah (Bissell and Davis 1990). Abert's squirrels are widely distributed in Arizona and New Mexico (Bissell and Davis 1990). They do not inhabit coastal and northern stands of ponderosa pine (Keith 2003).

Abert's squirrels are large tree squirrels with ear tuffs being a distinctive feature. Ear tuffs can be lacking from July through September (Keith 1965). In Colorado, the coat pelage can be black, brown or gray with a white belly separated by a thin black line, variable rusty band down the back, and a white undertail.

Abert's squirrels are diurnal, with most of their activity taking place after sunrise and returning to their nests before sunset or early evening (Keith 1965, Halloran and Bekoff 1994). These squirrels are active every day year-round, in all weather conditions, although inclimate weather can reduce daily activities (Keith 1965). The majority of the day is spent foraging both on the ground and in trees (Keith 2003). Hall (1981) found that peak activity periods were early in the day and late afternoon. During the day, they may return to their nests to rest during inclement weather (Golightly and Ohmart 1978, Hall 1981, Halloran and Bekoff 1994). Halloran (1993) concluded that the squirrels tended to travel more and rest less during the fall and exhibited more social interaction during the spring than other seasons. Overall social interaction only accounted for 4% of their activities.

Persistent snow depths have been correlated to Abert's squirrel survival. Stephenson and Brown (1980) recorded 66 percent mortality for Abert's squirrels during a winter where snow of 3.9 inches (10 cm) or greater covered the ground for 85 days. Dodd et al. (1998) also recorded higher morality rates during a winter where snow depth was greater than 3.9 inches (10 cm) for 61 to 73 days across several study sites. Possible hypotheses for higher mortality rates correlated to increased snow depths include a higher visibility of Abert's squirrels to predators, and increased energy expenditure associated with activity in deeper snow. Abert's squirrels likely expend more energy during winter then other tree squirrels since Abert's squirrels do not cache food, rather they forage daily leading to higher energy costs and increased exposure to predators.

Age of sexual maturity is unknown. The proportion of the population that breeds each year is also unknown (Keith 2003). In Arizona, during the drought of 2000, 153 out of 160 monitored females failed to breed at all (Dodd in prep.). Based on other small mammal species, particularly other tree squirrels, time of first breeding has been estimated to occur at 10-12 months of age (Flyger and Gates 1982). Peak breeding activity is usually May but has been documented from mid-February to early June (Keith 1965, Stephenson 1975, Hakkoran 1993). Female Abert's squirrels usually bear only one litter per year. In southern Arizona, Abert's squirrels may have two reproductive cycles per year (Pogany and Allred 1995, Pogany et al. 1998). The female is in estrus less than 18 hours (Brown 1984), within which she may mate with several males. Gestation is 40 – 46 days (Farentinos 1975, Keith 1965). Litter size ranges from 2.9 – 3.4 and the young remain in the nest for 7 – 9 weeks, emerging in August (Keith 1965). Mushrooms and bark have been added to their diet at this time. Females move their young to different nests every few days while they are small (Hall 1981, Lair 1985, Halloran 1993). By ten weeks the juveniles are weaned and forage on their

own. Mature size is reached by 15 to 16 weeks (Keith 1965, Farentinos 1972). The young remain with their mother until the fall dispersal in November (Keith 1965).

Nests are built out of clipped pine twigs and most have a bolus shape averaging 10 – 18 inches in diameter. Use of tree dens is rare (Patton 1975, Halloran and Bekoff 1994). Farentinos (1972), Pollock (1981), and Garnett (2001) reported that in northern Arizona and Colorado, dwarf mistletoe-induced witches' brooms were used as nests. The nests are lined with frayed grass and/or bark when the young are present (Keith 1965). The nest is usually in the upper third of the canopy against the trunk with an east to south aspect (Keith 1965, Farentinos 1972, Halloran 1993, Halloran and Bekoff 1994). However, a greater use of north to northwest facing nests was observed in winter on a Colorado study (Halloran and Bekoff 1994). Nests are occasionally in an isolated tree but most are built within a group of trees of similar size (Patton 1975). Multiple nests are built, maintained, and used year-round within a squirrel's home range (Patton 1975). Halloran and Bekoff (1994) observed an average of 3.1 nests per adult used annually, based on 17 squirrels, and was not correlated to home range size. Pregnant or lactating females were observed building nests from May through August. In contrast, Dodd (per. comm. 2002) has observed dispersing juveniles constructing 'weak' nests. Halloran and Bekoff (1994) found that nest sites, in part, are selected for structural stability and accessibility. Both males and females perform nest maintenance. Besides a mother with young, squirrels rarely share nests (Halloran and Bekoff 1994, Lema et al. 1999).

Home range use by Abert's squirrels has varied between studies depending on season and habitat quality. Hall (1981) found that in pristine stands of ponderosa pine home ranges were relatively small, consisting of 10.8 acres (4.4 ha) for males, and 6.2 acres (2.5 ha) for females. Home ranges across studies were 9.8 – 51.9 acres (4-21 ha) for males and 9.8 – 42 acres (4-17 ha) for females (Patton 1975, Farentinos 1979, Hall 1981, Halloran 1993), with winter ranges less than summer (Fitzgerald et al. 1994). In poorer habitat home ranges tend to be larger (Lema 2001). Abert's squirrels are generally not territorial (Frye 2004), although females will defend nests with young (Halloran 1993, Lema 2001). Juvenile dispersal during the fall has been documented at 0.5, 0.54, 0.8 and 0.89 miles (840, 870, 1290 and 1440 m) (Farentinos 1972). Resident squirrels do not travel long distances but males have been reported moving 0.9 miles (1.5 km) to locate estrous females (Farentinos 1979, Keith 2003).

Foods used by Abert's squirrels vary with availability, season, habitat, and years (Keith 2003). Ponderosa pine seeds and hypogeous fungi (false truffles) are preferred foods (highest in protein) with apical buds and inner bark of pine twigs used when other foods are unavailable (Keith 1965, Pederson et al.1987), particularly during the winter. Cones and pine seeds are accessed by clipping the bough ends usually 0.25 - 0.50 inches (0.6-1.27 cm) in diameter (Dodd per. comm. 2002). Mushrooms, staminate cones and assorted matter on the ground contribute additional items to Abert's squirrel diets (Keith 1965, Stephenson 1975, Hall 1981, Pederson et al. 1987, States et al. 1988, Austin 1990). In some areas where Gambel oak (*Quercis* gambelii) is scattered through ponderosa pine stands, acorns are an additional food source (Stephenson 1975). Abert's squirrels do not cache food (Bailey 1932, Keith 1965, Halloran 1993).

Importantly, foods from ponderosa pine and fleshy fungi are consumed in large quantitative amounts (Keith 1965, Frye 2004). From May to November, seeds in ponderosa pine cones constitute the major food item in the Abert's squirrel diet (Frye 2004). The best cone producers are ponderosa pine trees over 20 inches in dbh, but, when present in high densities, smaller trees may provide numerous cones (Larson and Schubert 1970, Frye 2004). While seeds of ovulate cones are a nutritious food source, cone availability varies from year to year (Hall 1981) with cone crop production occurring every 3 to 6 years for mature ponderosa pine (Hoover and Wills 1984). Fleshy fungi are a major part of the total food consumed annually by volume and frequency of occurrence (Stephenson 1975). Stephenson (1975) discovered that fungi composed as much as 92 percent of the diet during the summer, although fungi were eaten throughout the year. During winter, when the preferred foods may be unavailable, Abert's squirrels eat the inner bark (phloem) and apical buds of pine twigs that occur at the extremities of trees (Keith 1965). These foods are of poor nutritional value, but they are always available (Frye 2004). However, a diet solely of inner bark, in the absence of supplemental foods, could affect survival during adverse weather (Patton 1974).

Species-Habitat Relationships

Abert's squirrels predominately inhabit cool, dry ponderosa pine forests with minimal understory (Keith 2003), but have been documented using pinyon-juniper woodlands, mixed ponderosa pine, Douglas-fir and spruce-fir forests (Reynolds 1966, Reynolds et al. 1970, Ferner 1974, Finley et al. 1975, Hoffmeister 1986, Hutton et al. 2003). Hutton et al. (2003) documented foraging, feeding, mating chases and nest building by Abert's squirrels in mixed conifer and spruce-fir forests. Natural range expansion has been documented through spruce-fir forests, above timberline and crossing up to 35.4 miles (57 km) through habitats lacking ponderosa pine (Cooper 1987, Davis and Brown 1989, Hutton et al. 2003). Although Abert's squirrels are capable of dispersing through habitats lacking ponderosa pine, they depend primarily on montane ponderosa pine forests to meet their life history requirements.

The literature reports that ponderosa pine occurs at elevations ranging from 6,000 to 9,500 feet (Hoover and Wills 1984), with local geographic variations. On the Forest, the ponderosa pine cover type ranges from 6,571 ft to 11,172 feet (based on average elevation within ponderosa pine cover type polygons from R2-Veg data), with 93 percent (103,206 acres) occurring between 7,200 and 9,200 feet. Approximately 6,911 acres of the ponderosa pine cover type occurs above 9,200 feet, with 98 percent (6,774 acres) found within the Gunnison Basin Geographic area. The remaining two percent occurs on the Uncompahgre Plateau. These high elevation ponderosa pine stands in the Gunnison Basin have been documented supporting populations of Abert's squirrels (L. Spicer, pers. obser.).

Ponderosa pine stands provide cover, nesting sites, and the majority of food items used by Abert's squirrels. Several studies have examined both physical and chemical characteristics of nest trees and feed trees chosen by Abert's squirrels. Research indicated that nest sites, in part, are selected for structural stability and accessibility (Halloran and Bekoff 1994). The chemical content of nest trees has been found to be different from non-nest trees (Snyder and Linhart 1994). Chemical analysis of trees selected for feeding verses trees not chosen has varied among studies from no preference to indicated preferences (Farentinos et al. 1981, Pederson and Welch 1985). One study indicated that feed trees were larger with an average dbh of 12.2 inches (31 cm) (Allred and Gaud 1994).

Abert's squirrels have a narrow range of habitat requirements. Specific ponderosa pine stand characteristics that are most beneficial for Abert's squirrels have been documented extensively in the literature. Patton (1975) and Pederson et al. (1987) report that high quality habitat is comprised of open, uneven age class forests containing 150-250 trees per acre of various sizes, mostly greater than 11.8 inches (30 cm) dbh, with clusters of even age class trees. These patches of high quality habitat are within the overall stand of ponderosa pine. For every 1,235.5 acres (500 ha) of habitat, 35-40 percent must be of good to high quality for recruitment to occur. Stands containing less than 35 percent will have declining populations of Abert's squirrels (Dodd pers. comm. 2002). On each acre there should be clusters of trees 15.7 inches (40cm) dbh with interlocking crowns to provide nest trees (Patton 1975). Patton (1975) found that woody and herbaceous debris was conspicuously absent from nest sites, but he considers ground litter of at least 80 percent to be optimal. In addition, canopy cover was greater than 80 percent and slope was 10 percent or less at nest sites within Patton's study area. Trees with a dbh of 9.8 – 29.5 inches (25-75 cm) should be in high abundance to provide a source of inner bark for food, with a compliment of scattered larger trees 23.6 – 35.4 inches (60-90 cm) to provide cones and seeds (Larson and Schubert 1970, Allred and Gaud 1994). Corridors with interlocking canopies must be maintained between clusters to aid in movement, avoid predation, and overuse of trees near nests (Keith 2003). Interlocking crowns have been strongly correlated with squirrel recruitment (Dodd et al. 1998). States et al. (1988) concluded that Abert's squirrels would use most trees within a heterogeneous stand for one life requirement or another.

Abert's squirrel nest sites have been studied extensively within their range, and several relationships have been described for the cover requirements for nesting (Frye 2004). Patton and Green (1970) and Patton (1975, 1977) concluded that the most important components of nest cover were tree density, diameter, and a grouped distribution of trees. On the Coconino National Forest, Patton (1975) discovered that squirrels tend to select nest trees in stands averaging 11 to 13 inches in dbh, particularly in basal areas of 150 to 200 ft^2 per acre. Patton did not find any nests in stands with less than 50 ft^2 per acre. More than 80 percent of the cover sites were in stands averaging 11 – 16 inches in diameter. Trees in this diameter class generally have a denser crown and provide more protection from weather than large, older trees (Frye 2004). Trees selected for nests were usually larger than the average stand dbh.

In a study conducted by Patton (1975), Abert's squirrel nests were 25 – 50 ft above the ground. Patton concluded that Abert's squirrels preferred dense stands, with a canopy cover greater than 60 percent for nest tree sites. Nest trees typically had a crown comprising 35 – 55 percent of the total tree height. Woody and herbaceous understory vegetation was conspicuously absent from the nest sites. Litter comprised in excess of 81 percent of the ground cover, giving the forest floor a clean appearance. The lack of grasses, forbs, and shrubs associated with high tree density and canopy coverage inhibits herbaceous growth (Frye 2004).

In a study conducted at the Grand Canyon National Park, Hall (1981) recorded nest trees ranging in dbh from 12 – 30 inches. Keith (1965) collected data on 97 squirrel nests in ponderosa pine trees and found nest trees varied from 12 – 41 inches in dbh. Pederson et al. (1987) determined that on the Manti-La Sal National Forest in Utah, nest tree sizes ranged from 9 – 46 inches in dbh, with a mean of 18.9. Of the total, 89.5 percent fell between 11 and 25 inches, with the 17 to 19 inch intervals holding the largest percentage, 25.8 percent of the total.

On the Mancos-Dolores Ranger District of the San Juan National Forest in Colorado, nest tree dbh ranged from 9 – 28 inches, with 62 percent in the 17 – 23 inch diameter class. Basal area at the nest trees varied from 60 to 320 ft^2 per acre. Basal areas of 80 – 200 comprised 88 percent of the total, and the 100 – 160 basal area range included 58 percent of the total nest sites (Frye 2004).

Abert's squirrel nest trees are typically in a group of trees with inter-locking crowns. Seventy-five percent of nest trees inventoried on the Coconino National Forest in Arizona had three or more interlocking crowns (Keith 1965). Tree dominance strongly influences a squirrel's choice within a group (Frye 2003). Seventy-five percent of the trees selected for nesting were co-dominants or intermediates, indicating a preference for a crowded tree within a group for cover (Patton 1975). A nest tree located in a group of trees, with crowns interlocking or only a few feet apart, offers protection and alternate escape routes from predators, as opposed to a nest tree in a less dense stand (Frye 2004).

In a study near Boulder, Colorado, Halloran and Bekoff (1994) concluded that Abert's squirrels select nest site locations to maximize accessibility and structural stability. They also found that nest trees were significantly taller (62 vs. 44 ft) and dbh larger (15 vs. 11in) than non-nest trees. Nest trees contained a base crown height of 40 feet. Non-nest trees contained a base crown height of only 29 feet. Squirrels generally built nests in trees that were subdominant and were in the interior of the stand. They concluded that squirrels selected tree types in which to build their nests, rather than build nests in trees chosen at random.

The majority of ponderosa pine within the Gunnison Basin Geographic area occurs on Bureau of Land Management (BLM) and private lands. In the Gunnison Basin, thirty squirrel observations have been documented south of U.S. Highway 50 on Forest, BLM, and private lands. Sixty-three nests have been located south of U.S. Highway 50 on BLM (n = 23) and FS (n = 40) lands from 2001-2004. As of 2004 no squirrels have been located north of U.S. Highway 50. All squirrel sightings and nests have been located within ponderosa pine stands, based on ground verification of habitat within the vicinity of observations and nest sites. Sixty-two nests were found in ponderosa pine trees and one was found in a Douglas-fir tree. Nest tree data was collected at 59 of the nest sites. Nest tree dbh ranged from 9 – 25 inches, with a mean of 15.7 inches (39.87 cm). Seventy-three percent (n = 43) ranged from 12 – 18 inches in dbh. Fifty-three percent of the nest trees (n=31) had at least one interlocking crown. Average nest tree height and nest height was 67 feet (20.44 m) (range 33-132 ft) and 47.96 feet (14.96 m) (range 20-93 ft), respectively. Sixty-one percent of the nests (n = 36) were against the trunk of the tree. Seventy-six percent of the nests (n=45) had a SW-SE aspect. Available habitat for the Abert's squirrel is limited within the Gunnison Basin Geographic area, primarily due to habitat isolation and a lack of optimal habitat conditions. An important component of optimal habitat for Abert's squirrels, particularly nesting habitat, is uneven age classes containing pockets of even-age classes with interlocking crowns. Forty-seven percent (n = 27) of known nest trees within the Gunnison Basin Geographic area do not contain interlocking crowns, although 15 of those nest trees are within jumping distance (1.5 m apart) of adjacent crown cover. A lack of interlocking crowns may result in reduced canopy travel corridors for squirrels, perhaps causing Abert's squirrels to be more vulnerable to predation.

Based on Abert's squirrel habitat requirements defined in the literature, Abert's squirrels will utilize habitat structural stages 3A – 4C/5 in ponderosa pine to fulfill their cover, forage, and nesting requirements. Mature stands containing habitat structural stages 4A, 4B, and 4C/5 would most likely contain trees needed for nesting, seed and cone production, and cover if sufficient basal area and uneven age classes exist. Very limited activity may occur within the 4A habitat structural stage because 4A stands comprise less basal area, less distribution of uneven age classes, and less cone production compared to structural stages 4B and 4C. Sapling stands (3A-3C) may provide movement corridors and cover, food from ground litter, and fungi.

Fungi are known to form mycorrihizal associations with pine roots and are primarily associated with young ponderosa pine with high canopy densities (States et al. 1988). Tree densities that prevent herbaceous growth accumulate large amounts of tree litter (Frye 2004). As this material decomposes, it creates a favorable condition for certain fungi (Patton 1975). A complex interdependency between squirrels, pines, and fungi appears to have evolved (Capretta and Farentinos 1979). Pines rely on fungi for nutrients, squirrels on the pines and fungi for food, and the fungi on the squirrels for spore dispersal (Frye 2004).

Available Habitat and Local Distribution

Approximately four percent (147,574 acres) of the Forest comprised habitat for Abert's squirrel, which includes ponderosa pine, Gambel oak, pinyon-juniper, and Douglas-fir cover types in habitat structural stages 3A, 3B, 3C, 4A, 4B, 4C, and 5. The majority of this habitat includes 111,183 acres of ponderosa pine (3 % of the Forest). Importantly, ponderosa pine distribution on the Forest, especially the Gunnison Basin Geographic area, is underrepresented based on the R2-Veg database; consequently, potentially available habitat for the Abert's squirrel may also be under represented.

Based on the habitat model described by Towry (1984), habitat structural stages of 4B, 4C, and 5 would be the most optimal habitat for Abert's squirrels. For summer and winter foraging, Habcap provides optimal values (1.0) for 4B and 4C Gambel oak that is associated with ponderosa pine. Across the Forest, optimal habitat for forage and cover encompasses 45,067 acres, or 41 percent of the total ponderosa pine cover type. Ponderosa pine in habitat structural stages 4B, 4C, and 5 comprised of multiple canopy layers further refines optimal habitat, encompassing 32,719 acres, or 29 percent of the ponderosa pine cover type. Low quality to marginal habitat consists of 102,507 acres and includes the Gambel oak, pinyon-juniper, and Douglas-fir cover types where they are associated or intermixed with ponderosa pine, in addition to habitat structural stages 3A, 3B, 3C, and 4A from the ponderosa pine cover type. Suitable Abert's squirrel habitat acres on the Forest is summarized in Table 6.

Table 6. Potentially suitable Abert's squirrel habitat[1] based on dominant vegetation and habitat structural stage.

Cover Type		Unsuitable Habitat		Low Quality to Marginal Habitat				Optimal Habitat		Total Acres (3A to 4C/5 only)	% of Overall Habitat[3]	% of Forested Habitat[4]	% of GMUG[5]
		2S[2]	2T[2]	3A	3B	3C	4A	4B	4C/5				
Optimal Habitat	Ponderosa Pine	0.00	251	10,530	13,060	94	42,180	44,102	965	110,931	75.17	5.34	3.33
Low Quality to Marginal Habitat	Gambel Oak	64,180	0.00	82	0.00	0.00	387	0.00	0.00	468	0.32	0.02	0.01
	Pinyon-Juniper	0.00	0.00	5,731	12,197	505	2,475	3,383	356	24,646	16.70	1.19	0.74
	Douglas-Fir	0.00	0.00	701	1,368	353	2,744	4,207	2,156	11,528	7.81	0.56	0.35
Total Acres		64,180	251	17,043	26,625	951	47,786	51,693	3,476	**147,574**	100.00	7.11	4.43
Optimal Habitat								44,102	965	**45,067**	30.54	2.17	1.35
Low Quality to Marginal Habitat		64,180	251	17,043	26,625	951	47,786	7,590	2,511	**102,507**	69.46	4.94	3.07

1 Potentially suitable habitat derived from literature reviews and Habcap modeling based on Hoover and Wills, 1984.

2 2S and 2T habitat structural stages contain a coefficient value of 0.0 in Habcap, and are not considered potential Abert's squirrel habitat; thus these acres are not included in the total acres and percentage summaries.

3 Overall habitat includes the habitat cover types that have been documented to be utilized by Abert's squirrels based on literature review and known Abert's squirrel distribution on the Forest. The Gambel oak, pinyon-juniper, and Douglas-fir cover types include only the portions of those cover types that are associated with ponderosa pine.

4 Percent of all forested habitat on the GMUG National Forest includes all forest and woodland cover types (2,076,920 acres).

5 Grand Mesa, Uncompahgre, and Gunnison National Forests R2-Veg CVU Total Acres: 3,334,709 acres (includes approximately 381,210 acres that fall outside the Forest boundary)

Optimal habitat comprises 31 percent of the total habitat available to Abert's squirrels. Low quality to marginal habitat encompasses 69 percent of the total habitat available. Optimal habitat can be described as source areas (Pulliam 1988), exhibiting stable density and consistent recruitment of Abert's squirrels (Dodd 2003). Low quality to marginal habitat may display characteristics of sink habitats (Pulliam 1988), exhibiting large seasonal fluctuations in nonresident (immigrant) squirrel density and poor recruitment (Dodd et al. 1998, 2003; Dodd 2003). Abert's squirrel habitat on the Forest in the Gunnison Basin Geographic Area contains primarily sink habitat characteristics, containing only seven percent (3,118 acres) of the total optimal habitat. Approximately 93 percent (41,949 acres) of optimal habitat occurs within the Uncompahgre Plateau Geographic Area.

Estimated Abert's squirrel distribution on and adjacent to the Forest is presented in Figure 4. Areas known to support Abert's occur primarily on the Uncompahgre Plateau, the Naturita Division and the foothill areas of the Gunnison Basin Geographic Area. Within the Gunnison Basin Geographic Area, there have been 63 documented Abert's squirrel nest sites and 30 squirrel detections associated with survey transects and nest checks. All documented occurrences of Abert's squirrels (nests and squirrel observations) were in ponderosa pine dominated stands. Ponderosa pine has a limited distribution within the Gunnison Basin Geographic Area. Many stands are small, isolated patches that were not typed out as ponderosa pine within the R2-Veg database. Consequently, habitat mapping utilizing R2-Veg may underrepresent Abert's squirrel habitat in the Gunnison Basin Geographic Area. Abert's squirrel nest site distribution based on the R2-Veg database is summarized in Table 7 below. Table 8 displays habitat conditions for Abert's squirrel nests on BLM lands adjacent to National Forest within the Gunnison Basin Geographic Area. Two nest sites were on either state or private land and are not included below.

Table 7. Distribution of Abert's squirrel nest sites by cover type and habitat structural stage on the Gunnison Ranger District.

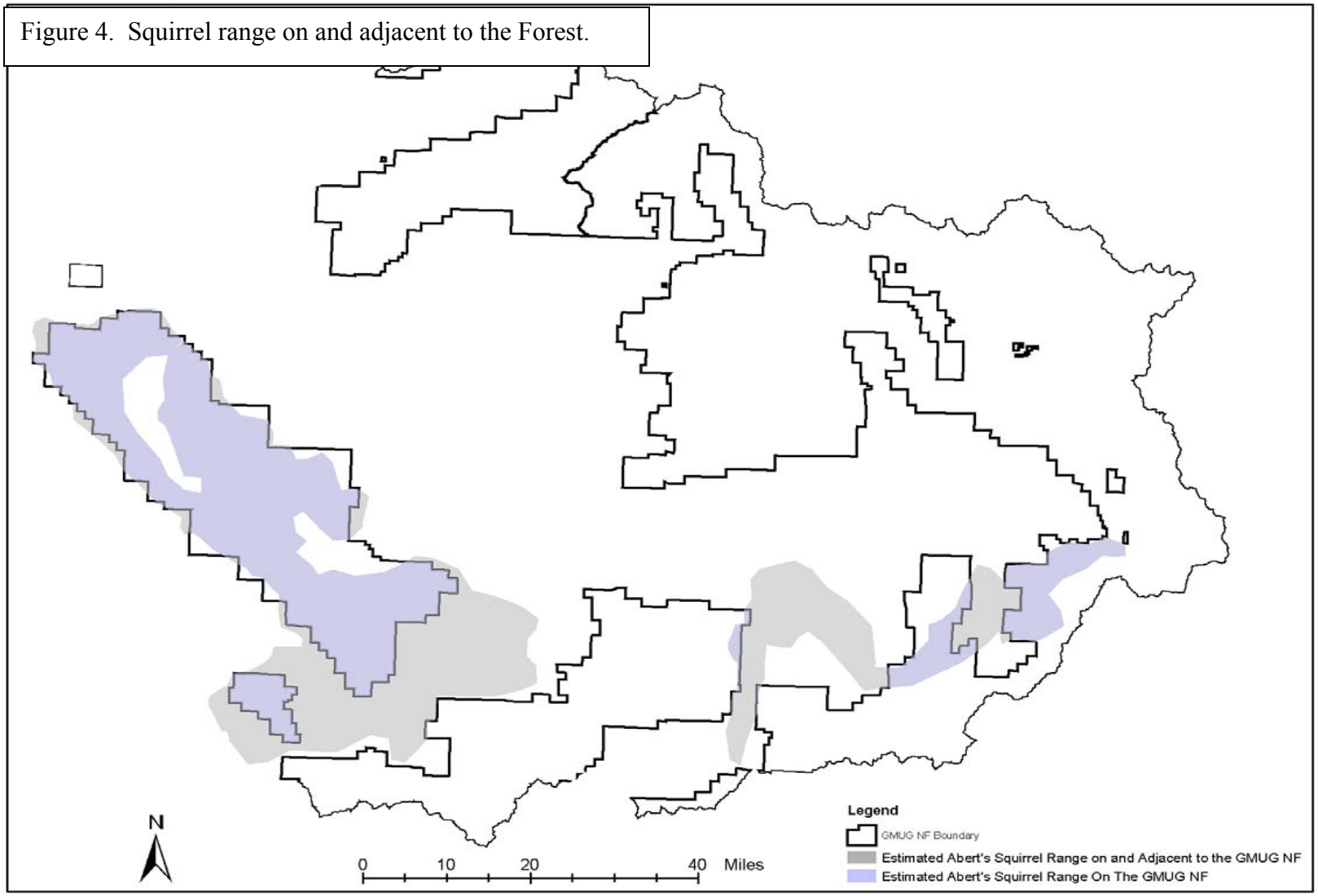
Cover Type	1	2	3A	3B	3C	4A	4B	4C	Total
GRA	3								3
TAA				3			1		4
TBC						8			8
TDF							3		3
TLP							3		3
TSF						1			1
TPP				1		8	9		18
Total	**3**			**4**		**17**	**16**		**40**

Table 8. Distribution of Abert's squirrel nest sites by cover type, tree size class, and crown closure on BLM Lands within the Gunnison Basin Geographic Area

Cover Type	0-9% crown closure	1.0-4.9 inch dbh/10-39% crown closure	5.0-8.9 inch dbh/10-39% crown closure	5.0-8.9 inch dbh/40-69% crown closure	Total
Ponderosa Pine			10	3	13
Douglas-fir		2		1	3
Non-forested	5				5
Total	**5**	**2**	**10**	**4**	**21**

Thirty nest sites occurred in habitat other than ponderosa pine. However, field verification determined that all known nest sites were dominated by ponderosa pine. On the Gunnison Ranger District, ponderosa pine stands containing nest sites may have been inclusions of ponderosa pine occupying an area less than 5 acres. These ponderosa pine inclusions may have been surrounded by other forested or non-forested cover types that dominated vegetation polygons designated by aerial photo interpretation.

Figure 4. Squirrel range on and adjacent to the Forest.



Population Information

The Abert's squirrel currently has no federal legal status. The Global Heritage Ranking is G5; demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery (InfoNatura 2005). The Forest is on the periphery of their range in Colorado (Figure 3).

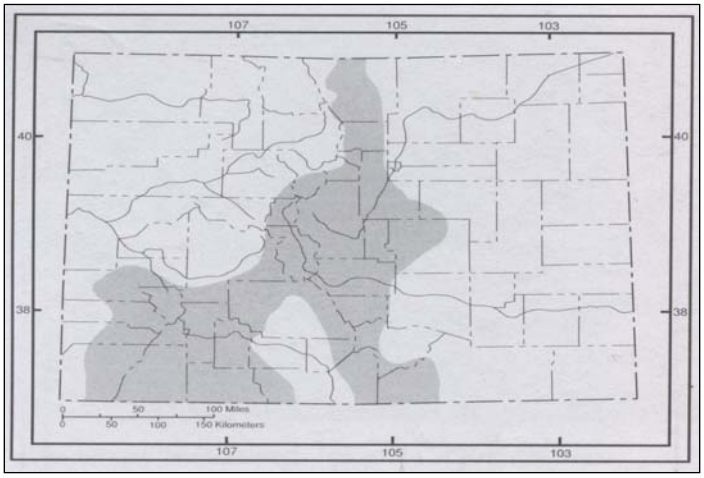


Figure 3. Abert's squirrel range distribution in Colorado (Fitzgerald 1994).

Abert's squirrels are classified as small game animals in Colorado, Arizona, and New Mexico, but are protected in Utah and Wyoming. The Colorado Abert's squirrel hunting season was established in 1977. Currently the Colorado Division of Wildlife considers their status as secure and persistent enough to support a hunting season. Table 9 and Figure 4 reflect Abert's squirrel harvest estimates for the state of Colorado from 1999 to 2004.

Table 9. Abert's squirrel state harvest data, 1999 – 2004 (CDOW 2005)

Year[1]	Number of Hunters	Number of Harvested Squirrels	Days Hunted
1999/2000	539 ± 135	857 ± 26	1,819 ± 63
2000/2001	858 ± 511	1,312 ± 44	3,523 ± 110
2001/2002	368 ± 225	727 ± 23	1,649 ± 45
2002/2003	183 ± 49	605 ± 21	1,617 ± 364
2003/2004	334 ± 65	548 ± 25	1,599 ± 118

1 Colorado small game hunting season begins on November 15 and ends on January 15.

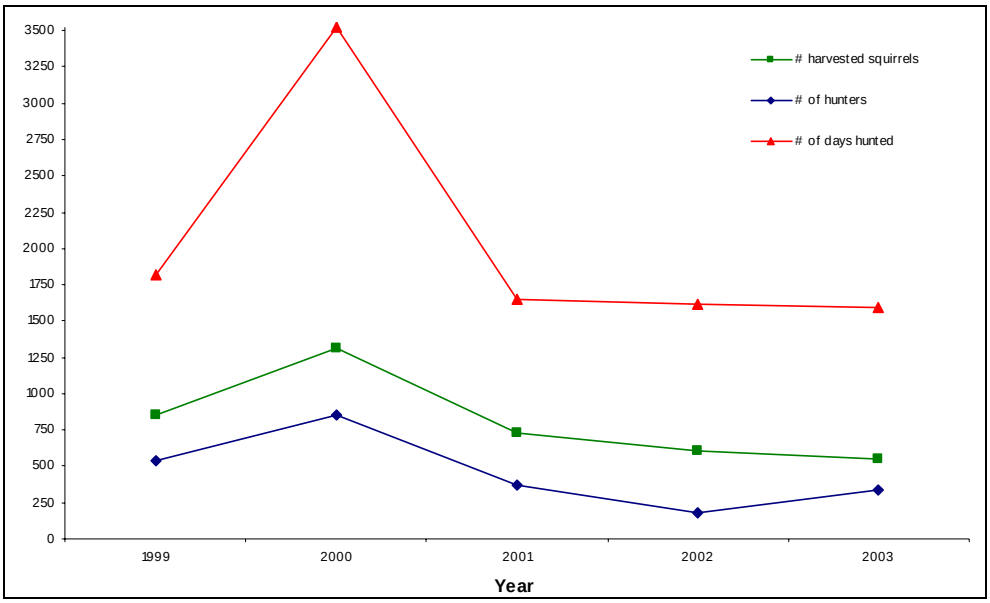


Figure 4. Statewide trends in harvested Abert's squirrels as influenced by number of hunters and days hunted.

Keith (2003) reports Abert's squirrel viability does not appear to be threatened, nor is the species in danger of extinction at a landscape or Forest level anywhere in Colorado. Abert's squirrel populations have fluctuated widely over the last 100 years. Squirrel abundance may vary greatly and frequently, as influenced by weather conditions and food supplies. Importantly, populations are influenced by forest management practices that alter squirrel habitat condition. On the Forest, Abert's squirrel populations exist at the periphery of their northwest distribution in Colorado and may be more dynamic compared to interior areas of their distribution.

Survey methods used for Abert's squirrel within the Gunnison Basin Geographic Area have focused primarily on presence/absence, distribution, habitat inventory, and monitoring. These survey methods have identified nest sites, feeding sign, and documented locations of squirrel observations. From 2001 to 2004, the majority of ponderosa pine stands on National Forest and BLM lands within the Gunnison Basin Geographic Area was surveyed and the overall distribution of Abert's squirrels identified. Grid surveys were conducted in ponderosa pine stands with transects spaced 300 ft apart, accommodating a sight distance of 150 ft for each side of a transect. Nest site data was obtained including nest tree dbh, percent slope, site aspect, canopy cover at the nest tree using a spherical densiometer, nest tree height and nest height, nest aspect, nest location in the tree, nest activity status (active or inactive), ground litter beneath the canopy of nest trees, elevation and UTM coordinates. Abert's squirrel detection information included number of individuals, age (juvenile or adult), squirrel behavior and activity, habitat description, elevation and UTM coordinates. Nest site characteristics are summarized above in the Species Habitat-Relationships section of this document. From 2001 to 2004, twelve nests were active. Table 10 summarizes Abert's squirrel nest status. An estimated 30 Abert's squirrel territories were identified within the Gunnison Basin Geographic Area. Territory identification is based on known Abert's squirrel distribution on the Gunnison Ranger District and BLM land adjacent to the Gunnison Ranger District. Table 11 summarizes Abert's squirrel detections by year for the Gunnison Basin Geographic Area.

Table 10. Abert's squirrel nest status from 2001 to 2004.

Year	Active	Inactive	Unknown	Total
2001	6	8	18	32
2002	3	5	7	15
2003	3	7	4	14
2004	--	--	2	2
Total	**12**	**20**	**31**	**63**

Table 11. Abert's squirrel detections from 2001 to 2004.

	Number of Detections			
Year[1]	Adults	Juveniles	Unknown	Total
2001	16	1	2	19
2002	6	--	--	6
2003	1	--	2	3
2004	2	--	--	2
Total	**25**	**1**	**4**	**30**

1 The majority of survey efforts took place from 2001-2003. Surveys in 2004 were conducted at known nest sites.

Approximately 73% (8,342 acres) of ponderosa pine on Forest within the Gunnison Basin Geographic Area is classified as low quality or marginal Abert's squirrel habitat, comprised of low basal area, low canopy closure, and a lack of interlocking canopy trees. In addition, small, isolated ponderosa pine stands occur north of Highway 50 where no Abert's squirrels have been documented as of 2004 based on surveys documented above. Abert's squirrels are at the periphery of their distribution within the Gunnison Basin Geographic Area and may represent "sink" populations, exhibiting large seasonal fluctuations in nonresident (immigrant) squirrel density and poor recruitment (Dodd et al. 1998, 2003; Dodd 2003). In 2002 and 2003, anecdotal evidence (decline in squirrel observations, active nest sites, and feeding sign) indicated a decline in Abert's squirrels in the Gunnison Basin, which may have been due to low fungi production as a result of drought conditions. Feeding sign was found during the summer periods that included feeding on the inner bark of twigs, which typically only occurs during the winter months or when preferred food sources are unavailable. Within the Gunnison Basin Geographic Area, squirrel populations appear to be small and fragmented. However, the Abert's squirrel has demonstrated an ability to thrive in sparse populations and to emigrate considerable distances, successfully establishing new stable populations (Davis and Brown 1989, Keith 2003).

Survey protocols used for the Abert's squirrel within the Uncompahgre Plateau Geographic Area were based on the Combined Feeding Index sampling method as described by Dodd et al. (1998). Suitable habitat consisting of 6,569 acres was surveyed in the spring of 2004 on the south end of the Uncompahgre Plateau. Abert's squirrels were detected in all but one site, which consisted of a 4A ponderosa pine stand with no vertical diversity or understory oak. Estimated squirrel densities ranged from 0.20 to 0.69 squirrels per acre, with variation in estimated densities dependent on habitat conditions. Lowest squirrel densities were in 4A ponderosa pine stands, and higher densities were in 4B - 4C ponderosa pine stands. Evidence of Abert's squirrels was typically found in ponderosa pine stands with clumps of mature trees containing interlocking crowns.

It is important to note that the Combined Feeding Index sampling method described by Dodd et al. (1998) was developed in Arizona. Habitat conditions and squirrel populations on the Forest likely differ to some degree from those in Arizona, especially since the Forest lies at the periphery of the Abert's squirrel range distribution. For this reason the estimated squirrel densities above should be considered as an index of relative abundance, rather than as an index of precise squirrel densities. From these abundance estimates, population trends over time may be obtained, meeting the requirement for MIS monitoring.

Abert's squirrel populations likely fluctuate dynamically on the Forest, particularly within the Gunnison Basin Geographic Area. Areas of low quality or marginal habitat may support high squirrel densities during periods of high cone availability and fungi production. Van Horne (1983) hypothesized that high animal densities in lower-quality habitat may be a function of juvenile, subadult, or yearling immigration into "sinks" where social interactions are limited. Without strong social, density-limiting interactions, dispersing animals from source areas may build to high densities in sinks (Dodd et al. 1998). Sink areas may contain primarily non-resident squirrels that are absent under poor conditions, such as drought periods that limit food supply. Van Horne (1983) described higher-quality habitats as those where densities are lower but stable and reproduction is more dependable even under poor conditions.

The majority of well-connected, high quality Abert's squirrel habitat (41,949 acres) occurs within the Uncompahgre Plateau Geographic Area; this area likely supports stable populations of Abert's squirrels. Keith (2003) reports that the best available evidence indicates the overall, average abundance and the range of the Abert's squirrel are not decreasing in Colorado. The squirrel has expanded its range in the state and even crossed into the extreme southern portion of Wyoming during the last half of the 1900s. Abert's squirrel populations on the Forest were first documented in the literature by Davis and Bissell (1989) and were determined to be new locations of Abert's squirrels occurring after 1972. Abert's squirrels possibly existed on the Forest prior to 1972, but may have gone unreported.

Prior to 1977, Abert's squirrels were protected in Colorado. Since 1977, hunting has been allowed by permit only. Hunting is not expected to have a significant impact on Abert's squirrel populations, although small, isolated populations could be adversely affected during high harvest years, especially on the Forest where Abert's squirrels are at the periphery of their distribution. Hunter harvest data for each Game Management Unit (GMU) that occurs on or adjacent to the Forest are displayed in Tables 12 and 13. Refer to Appendix A for locations of Game Management Units that occur on or adjacent to the Forest. Interestingly, in 2001/2002, 15 Abert's squirrels were harvested from unit 55, north of Highway 50 within the Gunnison Basin Geographic Area. Evidence of Abert's squirrels (observations, feeding sign, or nest sites) were not found from USFS survey efforts of ponderosa pine stands north of Highway 50, including unit 55 following the 2001/2002 hunting season.

Table 12. Abert's squirrel harvest data by GMU, 1999 to 2004, GMUG NF

Year	GMU	Hunters	Days Hunted	Harvest
1999/2000	61	20	53	20
	70	8	23	23
2000/2001	61	9	24	11
	62	4	26	0
2001/2002	54	3	6	0
	55	6	27	15
	61	4	13	9
	62	7	10	0
	63	3	3	0
2002/2003	53	4	23	15
	70	5	27	0
	551	5	11	0
2003/2004	62	4	11	0

Table 13. Abert's squirrel harvest data summary for all GMUs that occurs on the Forest, 1999-2004

Year	Hunters	Days Hunted	Harvest
1999/2000	28	76	43
2000/2001	13	50	11
2001/2002	23	59	24
2002/2003	14	61	15
2003/2004	4	11	0
Total	**82**	**257**	**93**

Survey protocols implemented for Abert's squirrels on the Forest have provided population estimates, distribution information and insight on general habitat characteristics and habitat quality. To obtain an accurate estimate of Forest-wide squirrel populations and population trends over time, index techniques should be utilized based on methodologies established by Dodd et al. (1998), such as the Combined Feeding Index technique used on the Uncompahgre Plateau. The combined feeding technique should also be applied to areas of suitable habitat within the Gunnison Basin Geographic Area. Based on available information, we can assess habitat suitability for relatively large forest landscapes using generalized species-habitat relationships and stand level vegetation inventory to calculate approximate population size by assuming linear habitat-population relationships. From this information we can determine if there is

sufficient habitat available to support viable populations of Abert's squirrels on the Forest. In addition, we can assess whether or not habitat is distributed in a way to provide interaction within the current distribution of squirrels.

Towry (1984) estimated the minimum number of individuals necessary to maintain a viable population of Abert's squirrels is 30 individuals within a minimum optimal habitat area of 429 acres (219 acres required for feeding, 210 acres required for cover), or one individual per 14.3 acres. There are approximately 45,067 acres of optimal Abert's squirrel habitat on the Forest. Optimal habitat variables used for this analysis are 4B and 4C ponderosa pine. The approximate population size that optimal Abert's squirrel habitat is capable of supporting is calculated below for the Forest:

45,067 acres optimal habitat ÷ 429 acres/population = 105 populations, or 3,152 individuals*

* Assuming 30 individuals per minimum viable population

Approximately 93% (41,949 acres) of optimal habitat occurs within the Uncompahgre Plateau Geographic Area, which is capable of supporting 98 populations, or 2,934 individuals. In addition, optimal habitat within this Geographic Area is well distributed and intermixed with marginal Abert's squirrel habitat, providing the opportunity for dispersal and for individuals to interact with others. However, the Uncompahgre Plateau Geographic Area is relatively isolated and disjunct from suitable habitat that exists to the south of the Forest on the San Juan National Forest (Grother 2003).

The Gunnison Basin Geographic Area comprises only 7% (3,118 acres) of the total optimal habitat, which is capable of supporting 7 populations, or 218 individuals. This habitat is not well distributed and lacks connectivity between adjacent habitats in terms of ponderosa pine cover. However, Abert's squirrels are capable of traveling through, and living for short time periods, on forested habitat other than ponderosa pine. There are also greater amounts of ponderosa pine habitat on BLM land adjacent to the Forest within the Gunnison Basin Geographic Area.

Patton (1984) developed a model to evaluate Abert's squirrel habitat in uneven-aged ponderosa pine (Table 14). He ranked habitat quality based on average tree diameter, average tree density, and tree dispersion pattern (evenly spaced, grouped, etc.). Habitat capability in terms of squirrels per acre was determined for 5 quality classes (poor to optimum; Table 15) by using an exponential regression model. Data for the model came from 9 trap plots of 23 acres each located on the Kaibab, Coconino, and Apache National Forests in Arizona. Patton's model is based on three premises:

1) Over time, habitat quality is a major density independent factor controlling squirrel populations.
2) Habitat quality is a function of kinds, amounts, and distributions of food and cover.
3) Categories of habitat quality can be defined that will reflect the capability of a habitat to maintain a squirrel population.

Table 14. Habitat quality (1 = poor, 5 = optimum) associated with average dbh and average density of trees in a stand of uneven-aged ponderosa pine (Patton 1984).

Average density (trees/acre)	Average diameter (dbh)						
	≤8	9	10	11	12	13-15	16-19
≤40	1	1	1	1	1	1	1
41-80	1	1	1	1	1	1[a]	2[a]
81-120	1	1	1	1	2	2[a]	3[a]
121-160	1	1	1	2	3	3	4
161-200	1	1	2	3	4	4	4
≥200	1	2	3	4	5	5	5

[a] Add 1 if trees are in groups of 4 to 5 (increase habitat quality)

Table 15. Habitat capability (squirrels per acre) by habitat quality class (Patton 1984).

Quality Class	Capability Squirrels/acre
1 Poor	0.02
2 Fair	0.05
3 Good	0.14
4 Very good	0.37
5 Optimum	0.99

Using Patton's (1984) model, we can estimate the habitat capability for Abert's squirrels on the Forest for low quality, marginal, and optimum ponderosa pine habitat based on the assumption that there is a positive correlation between tree density, dbh, and tree dispersion pattern in relation to attributes derived from R2-Veg. R2-Veg attributes that might correlate with Patton's habitat quality classes include habitat structural

stage and patchiness (clumped or continuous tree distribution). There are approximately 23,590 acres of low quality habitat comprised of habitat structural stages 3A and 3B ponderosa pine; marginal habitat consists of 42,274 acres of 3C and 4A ponderosa pine; and optimal habitat includes 45,067 acres of 4B and 4C ponderosa pine on the Forest. Approximate population size based on potential ponderosa pine habitat capability is calculated below:

Low quality (poor) = 23,590 acres x 0.02 = 471.8 individuals

Marginal (Fair to Very Good) = 42,274 acres x 0.14 = 5,918.36 individuals

Optimum = 45,067 acres x 0.99 = 44,616.33 individuals

Habitat capability is expressed as potential because high quality habitat may exist where squirrel populations are low due to weather (Stephenson and Brown 1980), predators (Reynolds 1963, Farentinos 1972), disease, accidents, or geographic barriers to immigration (Patton 1984). In addition, further analysis and field verification is required to determine if Patton's model is applicable to the Forest by relating tree density, dbh, and tree dispersion patterns to habitat structural stage and patchiness. If applicable, this model can be useful to land managers in assessing the effects of management activities on Abert's squirrel habitat.

CONSERVATION

Threats

The primary limiting factor to Abert's squirrel populations in Colorado appears to be the condition of their habitat (Keith 2003). In particular, forest management practices have altered squirrel habitat conditions, primarily through timber harvest, thinning, and fuels reduction. Current forest conditions across Colorado are not sustainable (Keith 2003). However, habitat requirements of squirrels can be accommodated through forest management decisions. Undoubtedly, the future condition of Abert's squirrel habitat in Colorado will depend primarily on management decisions. Abert's squirrel abundance can be maintained and even increased by using available knowledge of squirrel habitat requirements (Keith 2003). As knowledge is now available of forest structure that is beneficial to squirrels, forest managers should integrate Abert's squirrel habitat requirements into their objectives and activities (Keith 2003). It is possible to provide specific habitat requirements for Abert's squirrels, while at the same time meeting multiple-use management objectives.

Primary factors influencing Abert's squirrel mortality and population viability include a combination of forest management activities and natural events. Timber harvesting and prescribed fire, without implementing design criteria to maintain or enhance Abert's squirrel habitat, leads to a decrease in the availability of high quality foods (Keith 1965, Patton et al. 1985, Pederson et al. 1987, Keith 2003) and may reduce the number of interlocking canopy trees. Persistent snow cover (Stephenson and Brown 1980, Brown 1984, Keith 2003) can also cause reduced food availability (Hall 1981, States et al. 1988, Keith 2003) resulting in a lower nutritional state (Patton 1974, Brown 1984, Austin 1990, Keith 2003) that can cause shock disease (Keith 1965, 2003) and/or death (Keith 2003). Drought periods decrease food availability and likely result in poor recruitment (Dodd et al. 2003). Increased road densities or intensity of road use may result in increased mortalities from vehicle collisions. Hunting may adversely affect Abert's squirrels if hunter harvest occurs on areas where squirrel populations are at the periphery of their range and are isolated and small due to low habitat quality, but is not expected to have a substantial affect on forest-wide populations. Predation (Lema 2001, Sieg 2002), particularly by northern goshawks (Reynolds 1963, Reynolds et al. 1992), has also been shown to be a factor causing Abert's squirrel mortality (Keith 2003).

Activities that most severely influenced the habitat quality of the Abert's squirrel, resulting in the existing forest conditions we see today, include logging, grazing and wildfires (Keith 2003) that occurred during the 1800s. Logging, especially in Arizona, seriously degraded or eliminated Abert's squirrel habitats (Keith 2003). Fire suppression and continued logging and grazing during the last 20 years of the 20th century reduced the incident of slow-burning ground fires and encouraged the development of thick stands of even-aged pine regeneration (Keith 2003), creating conditions highly susceptible to catastrophic wildfire. Within

the last century replacement forests have developed that are often homogenous in structure and are not high quality squirrel habitat (Keith 2003).

Specific Threats Identified on the Forest

The prevailing restoration emphasis for ponderosa pine currently used on the Forest is thinning to replicate pre-settlement forest tree density and structure. Ponderosa pine stands are thinned to a basal area of approximately 60-80 ft^2 per acre and then underburned to reduce susceptibility to bark beetles and stand replacing wildfires. Dodd et al. (2003) recommended a basal area greater than 153 ft^2 for High quality Abert's squirrel habitat. Such restoration can exacerbate the effects of past even-aged management by further reducing stand density, structure, and diversity (Grother 2003). If the prevailing restoration emphasis continues on the Forest, there will likely be fewer larger diameter trees and a lower productivity of trees resulting in smaller cone crops, lower tree densities, lower productivity of hypogeous fungi, and possibly fewer chemically suitable feed trees.

Management Considerations

Keith (2003) asserts that timber harvest has caused the greatest disturbance and deterioration to the quality of squirrel habitat. During the last several decades, ponderosa pine management in Colorado has stressed stand improvement and fuel reduction over rather small areas (Keith 2003). Since 1980, the Forest has managed ponderosa pine using a variety of methods including clearcuts (patch, strip, and overstory removal), even-aged shelterwood cuts, selection cuts of various ages and group sizes, improvement cuts (thinning and mistletoe), salvage cuts, precommercial thinning, and prescribed fire. The prevailing restoration emphasis is on thinning to replicate forest tree densities existing ca. 1870, prior to European settlement (Covington et al. 1997, Fulé et al. 1997, Mast et al. 1999, Dodd et al. 2003). To benefit Abert's squirrel populations, forest management practices should be directed to ensure that forest structure enhances the availability of young vigorous trees for inner bark feeding, maintains large cone-producing trees, and provides blackjack clusters with high canopy to enhance fungi production and protection for travel (Keith 2003). This becomes especially important in areas of low or marginal habitat quality where management should be directed at reestablishing conditions that would increase habitat quality for the Abert's squirrel. Dodd et al. (1998, 2003) has provided management options and recommendations based on extensive research on Abert's squirrels in Arizona.

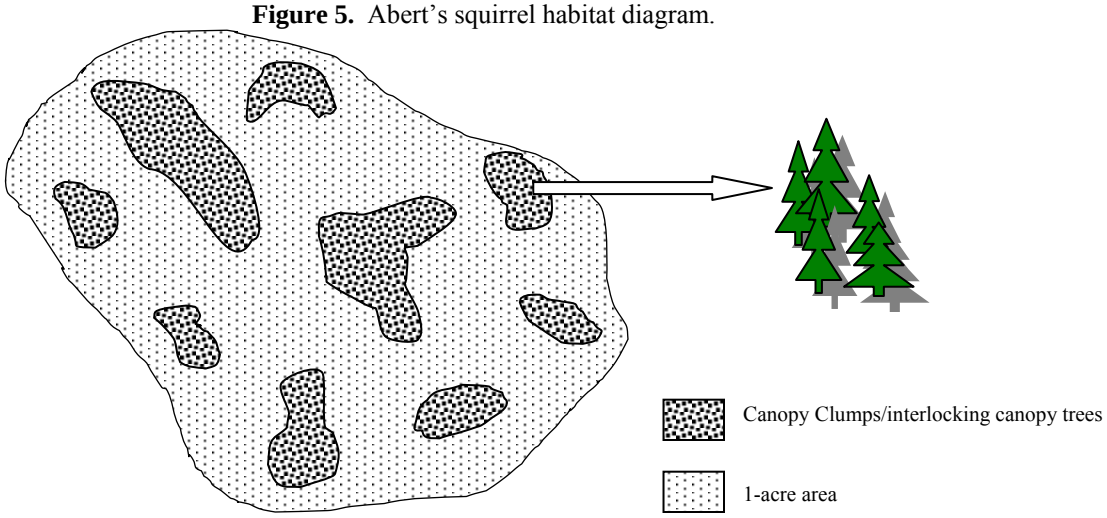
Dodd et al. (2003) emphasized the importance of integrating Abert's squirrel habitat needs of interlocking canopies, hypogeous fungi, and structural diversity in ponderosa pine forest management to benefit squirrel populations. Squirrel populations and hypogeous fungi may be adversely impacted by wide-scale forest restoration when restoration prescriptions substantially reduce the number of interlocking canopy trees and basal area (Dodd et al. 2003). Reductions in interlocking canopy trees diminishes squirrel recruitment (Dodd et al. 2003). Restoration prescriptions that reduce basal area diminishes fungal production (States and Gaud 1997), affecting both squirrel recruitment and survival (Dodd et al 2003). In addition, extensive forest restoration with no regard to Abert's squirrel habitat needs could substantially reduce remaining high quality squirrel habitats (Dodd et al. 2003).

Ponderosa pine restoration that creates a mosaic of structural habitat conditions and patch sizes, as described by Patton (1992), has been found to potentially benefit Abert's squirrels (Dodd et al. 2003). Dodd et al. (2003) found that high quality squirrel habitat exhibited a basal area > 153 ft^2 per acre and > 8 trees per acre with a dbh ≥ 18 inches. A minimum of 9 patches per acre containing > 5 interlocking canopy trees per patch should be maintained. Dodd et al. (2003) recommends an application of variable thinning prescriptions that retain a patchy character, promote canopy clumpiness, and maintain interlocking canopy trees. Management recommendations for Abert's squirrel habitat, based on Dodd et al. (2003, 1998), are summarized below at the stand-scale:

1) Where possible, maintain areas exhibiting high tree basal area (> 153 ft^2/ac), especially where larger trees are present (dbh 12-24 inches). In forest treatment areas, apply variable thinning prescriptions that retain basal area diversity (i. e. avoid even-aged management) within and between treatment areas.

2) If treatment prescriptions include thinning of overstory trees in areas of canopy clumpiness and interlocking crowns, retain those characteristics where possible. If treatment occurs where those characteristics do not exist, ponderosa pine management should accommodate enhancement of canopy clumpiness and interlocking canopy trees to improve Abert's squirrel habitat. Clumps of > 5 interlocking canopy trees > 6 in dbh with ≤ 5 ft between canopies should be interspersed throughout stands. To maintain Abert's squirrel recruitment and avoid creating low quality habitat that might lead to declining populations of squirrels, maintain a minimum of 9 clumps per acre (Figure 5).

Figure 5. Abert's squirrel habitat diagram.



3) To enhance Abert's squirrel populations, retain > 8 trees per acre with an 18-24 inch dbh and maintain > 50 stems per acre with a 12-18 inch dbh.

Forest management activities must consider landscape-scale habitat relationships in addition to stand-scale habitat needs of Abert's squirrels (Dodd et al. 1998). High quality source habitats are limited in distribution and abundance. Source areas will exhibit the characteristics described above and, where they occur, should be maintained or enhanced. In areas of low quality or marginal habitat, the above characteristics should be the desired future condition. Ponderosa pine ecosystems vary depending on geographic location; due to this inherent variability no single prescription or model should be applied in ponderosa pine restoration (Mast 2003). Allen et al. (2002) and Chambers and Germaine (2003) recommended prescriptions that achieve incremental forest restoration under multiple harvest entries to minimize short-term impact and preserve critical processes (Dodd et al. 1998). Importantly, ponderosa pine management on the Forest should avoid reducing the mature tree forest component, clumpiness, and patch size, while striving to prevent forest homogeneity and fragmentation. Failure to incorporate the above design criteria may contribute to declines in Abert's squirrel populations (Dodd et al. 1998).

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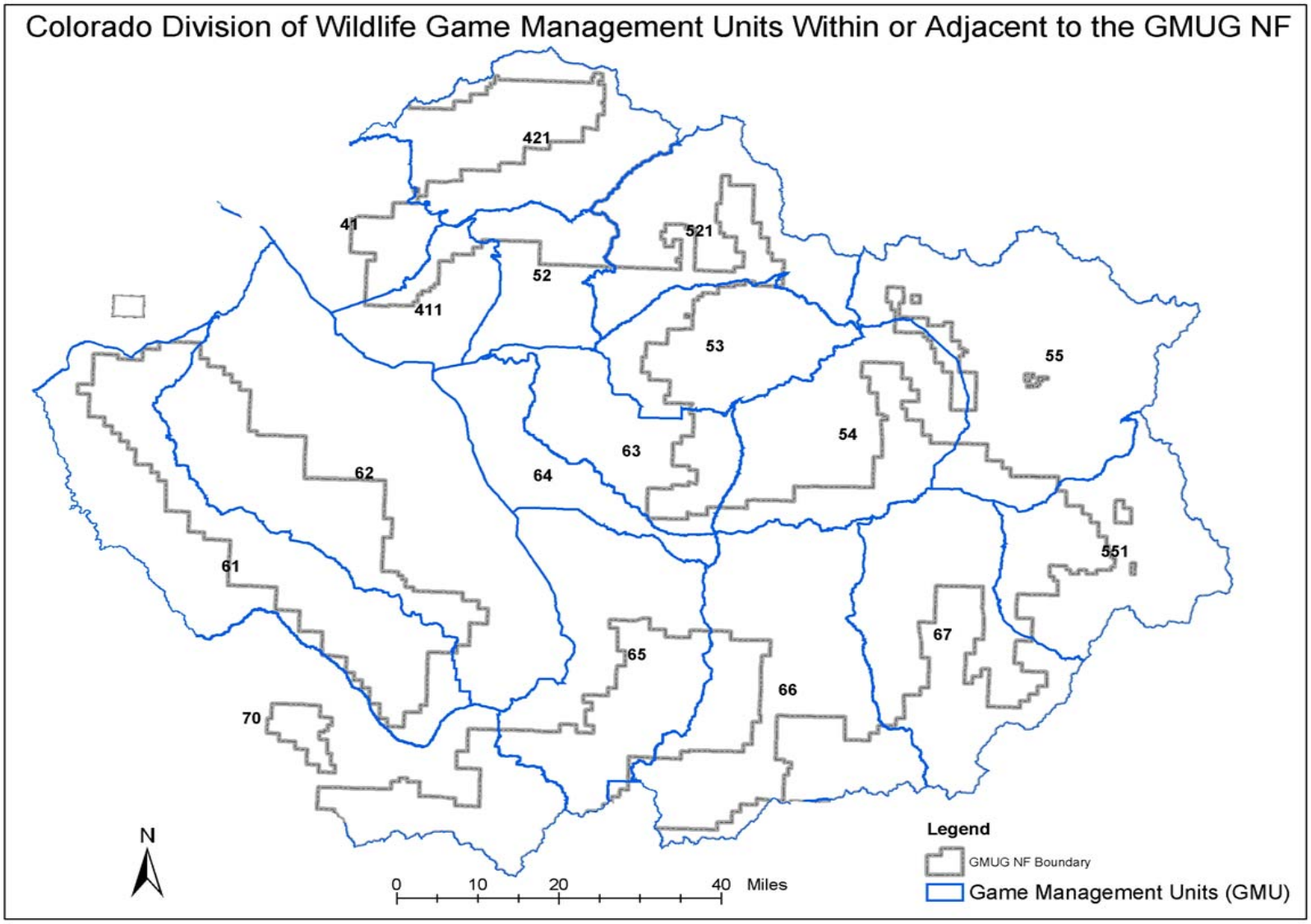
Appendix A.


Colorado Division of Wildlife Game Management Units Within or Adjacent to the GMUG NF
421
41
521
52
411
53
55
54
63
62
64
61
551
67
65
66
70
N
0 10 20 40 Miles
Legend
GMUG NF Boundary
Game Management Units (GMU)