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Conservation Assessment of the Pygmy Nuthatch in the Black Hills National Forest, South Dakota and Wyoming

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INTRODUCTION

The pygmy nuthatch (*Sitta pygmaea*) is a common resident of western yellow pine forests in the United States, principally Ponderosa Pine (*Pinus ponderosa*). The geographic distribution of the species ranges from southern interior British Columbia, northern Idaho, western Montana, central Wyoming, and southwestern South Dakota south to northern Baja California (Kingery and Ghalambor 2001). Several subspecies occur throughout this range. A sister species to the brown-headed nuthatch (*Sitta pusilla*) of pine forests in the southeastern United States, the pygmy nuthatch is a small (less than 10 grams), highly social, and gregarious species that during the non-breeding season forms noisy and conspicuous flocks (Kingery and Ghalambor 2001). The pygmy nuthatch breeds in nest cavities it usually excavates in snags and is peculiar among North America's songbirds in that it often breeds cooperatively (Norris 1958). Because they rely on cavities for roosting and for breeding, pygmy nuthatches typically reach their highest population densities in mature pine forests little affected by disturbance and with a large number of standing dead trees (Kingery and Ghalambor 2001). In fact the pygmy nuthatch often serves as an indicator of unmanaged mature ponderosa pine forests (Kingery and Ghalambor 2001).

The goal of this assessment is to provide the Black Hills National Forest and the public a thorough discussion of the biology and overall conservation status of the pygmy nuthatch. The information presented here is based on published literature and is an attempt to synthesize the most current knowledge available for this species. The desired outcome of this assessment is to identify and rank key risk factors for the pygmy nuthatch and to suggest some components of a practical and affordable monitoring plan for the species.

In comparison to many other songbirds in North America, many aspects of the pygmy nuthatch's biology are well known (see Norris 1958; Harrap and Quinn 1996; Kingery and Ghalambor 2001). However, most of our current knowledge regarding the biology and ecology of pygmy nuthatches is based on work done in California and Arizona. Very little research has been conducted on pygmy nuthatch populations within the Black Hills, thus the scope of this assessment draws heavily from data collected outside the Black Hills region. Nevertheless, an attempt is made here to relate information gathered from other parts of the pygmy nuthatch's range to populations occurring within the Black Hills.

Effective conservation strategies must be based on a solid understanding of the biology of the target species. Yet, accurately predicting how a particular population will respond to changes in its environment remains a challenging prospect for even the most well studied of species. In this assessment, the most current and applicable information available on pygmy nuthatches is reviewed with these specific questions in mind: 1) What are the most important habitat characteristics required by a "healthy and sustainable" population of pygmy nuthatches? 2) How do pygmy nuthatch populations respond to changes in these habitat characteristics caused by natural and human activities? and 3) Do pygmy nuthatches have any peculiar habits or requirements that may require special management considerations? Based on our current level of understanding we can answer many aspects of these questions, however, these answers are subject to a degree of uncertainty. For example, small differences among subspecies and their associations with the forests they inhabit could lead to variation in how different populations respond to the same type of disturbance. This type of uncertainty is of obvious concern, given that most research on pygmy nuthatch populations has been done in ponderosa pine forests of the southwestern United States. Yet, upon reviewing the existing literature there is no indication that different subspecies or populations differ significantly in any aspect of their biology; i.e. the habitat requirements, breeding behavior, and ecological interactions appear to apply uniformly throughout the species range. Therefore, this assessment assumes that any well executed study demonstrating a specific need or identifying a specific risk factor for the pygmy nuthatch, regardless of locality, to be applicable to the species as a whole. The assessment also clearly states areas where no information is available and when existing information available is based on minimal or potentially flawed data.

CURRENT MANAGEMENT SITUATION

Management Status

The pygmy nuthatch is not currently listed as a threatened or endangered species by the U.S. Fish and Wildlife Service. However, it is listed as a “sensitive” species in the Rocky Mountain Region (R2) of the U.S. Forest Service. Sensitive species are those for which population viability is a concern as evidenced by: a) significant current or predicted downward trends in population numbers or density; or b) significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution. The justification for the sensitive status of the pygmy nuthatch is based on its close association with unmanaged mature ponderosa pine forests, a habitat type that has substantially declined in recent years (e.g. Hutto 1989; Wisdom et al. 2000). The pygmy nuthatch also serves as a Management Indicator Species (MIS) within the Rocky Mountain Region (R2) and on many National Forests within the Southwestern Region (R3) (e.g. Coconino and Prescott National Forests, AZ and Cibola National Forest, NM). The indicator species designation exists because numerous lines of evidence suggest that negative changes in the population status of pygmy nuthatches within managed ponderosa pine forests may reflect adverse changes to the community as a whole (see also Diem and Zeveloff 1980). Within the Pacific Northwest Region (R6), the pygmy nuthatch was selected along with 39 other bird species to be the “focus” of a broad scale analysis of source habitats in the interior Columbia basin (Wisdom et al. 2000). The criteria for selecting the pygmy nuthatch as a focal species was based on a petition filed by the Natural Resources Defense Council with the Regional Forester of the Pacific Northwest Region (Wisdom et al. 2000).

At the state level, Arizona, Colorado, Idaho, Oregon, and Wyoming list the pygmy nuthatch as a species of special concern based on its status as an indicator species (Clark et al. 1989, Luce et al. 1997, Webb 1985). However, within each state different organizations take different positions on the status of the species, for example the Colorado Natural Heritage Program classifies it as “very common, demonstrably secure” (Kingery and Ghalambor 2001) and it is only ranked as being a species of “moderate concern" in Arizona by Arizona Partners in Flight (Hall et al. 1997).

Existing Management Plans, Assessments, Or Conservation Strategies

No existing management plan or conservation assessment has been written specifically for the pygmy nuthatch. A review of monitoring updates and annual reports to existing Forest Plans for National Forests neighboring the Black Hills also revealed no specific assessments, plans, or conservation strategies for the pygmy nuthatch (e.g. in Colorado: Routt, Arapaho, and Roosevelt National Forests; in Montana: Custer, Lolo, and Gallatin National Forests; and in Wyoming: Medicine Bow, Shoshone, and Bighorn National Forests;). With the listing of the pygmy nuthatch as a sensitive species within Region 2, it is anticipated that updates and annual monitoring reports to existing Forest Plans within the Region will increasingly address the monitoring and management of this species. At a more local level, the Forest Ecosystem Management Plan for the City of Boulder, CO identifies a number of cavity-nesting species, including the pygmy nuthatch, as species of special concern. The Boulder Forest Plan proposes to monitor and maintain or increase the existing number of all sensitive species, through the maintenance and creation of large snags (see below).

Currently, conservation strategies proposed for cavity-nesting species as a whole benefit the pygmy nuthatch. Such strategies have largely focused on the management and retention of snags within managed ponderosa pine forests. Because snag availability is influenced by a number of human and natural activities, proposed management strategies have the objective of increasing or maintaining the number of large standing dead trees, particularly within "old growth" forests and in burned areas. Suggestions for the minimum number of snags per hectare for cavity-nesters and the pygmy nuthatch have ranged from as few as 5-6/ha (Diem and Zeveloff 1980), to 6.4/ha (Scott 1979), and 6.7/ha (Balda 1975), up to as many as 7.4-12.3/ha (Clark et al. 1989). In addition, it has been proposed that snags should be of relatively large diameter (48.3 cm dbh; Clark et al. 1989) and relatively soft to accommodate the weak excavating abilities of species like the pygmy nuthatch (DeGraaf et al. 1991; Raphael 1980). Various methods have been suggested for creating snags, including: girdling of trees, burning individual trees, injection of heart rot fungus into live trees, prescribed burning, topping trees, and the erection of nest boxes. The Forest Plan for the City of Boulder, Colorado, for example, uses all these methods to create snags as needed for cavity-nesting birds.

REVIEW OF TECHNICAL KNOWLEDGE

Systematics

The pygmy nuthatch is considered to be a sister species to the brown-headed nuthatch (*Sitta pusilla*) based on morphology, ecology, ethology, and genetic differences (Norris 1958; Sibley and Monroe 1990; Monroe and Sibley 1993; Harrap and Quinn 1996; American Ornithologists' Union 1998). Currently, the American Ornithologists' Union (1998) recognizes six subspecies. Differences among subspecies depend on subtle differences in size and proportions, and very subtle differences in coloration (Harrap and Quinn 1996; Kingery and Ghalambor 2001). The subspecies within the Black Hills is

Sitta pygmaea melanotis. Below is a description of this and other subspecies (see also Harrap and Quinn 1996; Kingery and Ghalambor 2001).

S. p. melanotis has the largest and most discontinuous range of all the subspecies. It occurs from southern interior British Columbia east to the Black Hills, South Dakota. Its southern range extends from the San Bernardino Mountains in southern California to northwestern Zacatecas, northern Jalisco, and northern Coahuila in Mexico. It occurs in isolated mountain ranges throughout the Great Basin, Arizona, New Mexico, and Mexico. The spotty distribution of this subspecies follows the likewise spotty distribution pattern of ponderosa pine and other yellow pines used by this species. Two subspecies described by Van Rossem (1929, 1931), *S. p. chihuahuae* and *S. p. canescens*, are subsumed into this subspecies by Phillips (1986; see Kingery and Ghalambor 2001). *S. p. melanotis* is distinguished from other subspecies by its strongly contrasting eye-stripe and a broader post-ocular line that is dusky or nearly black. The top of the head and nape are less brownish than other subspecies (Phillips 1986). *S. p. melanotis* is slightly larger than *S. p. pygmaea*, but there appears to be a latitudinal gradient in size, with birds from the north being smaller compared to birds in the south (Kingery and Ghalambor 2001). The wing is long in relation to the tarsus (Phillips 1986): tarsus/wing ratio 22.0-23.8%, based on 27 populations and "remarkably constant" (Norris 1958).

S. p. pygmaea occurs only in Coastal California. It occurs in long-needled yellow pines from Mendocino to San Luis Obispo Counties (Van Rossem 1929, Norris 1958, Phillips 1986). It is the smallest of the subspecies and has a short wing relative to its tarsus (Phillips 1986): ratio 23.6-25.8% (average 24.4%). In fresh plumage, its crown is the grayest of the subspecies and its eye-stripe is a poorly defined dusky color that strongly contrasts with the crown (Phillips 1986, Harrap and Quinn 1996).

S. p. leuconucha occurs from the Laguna Mountains, San Diego County, CA, south to the San Pedro Mártir Mountains in northern Baja California (Van Rossem 1929, Norris 1958). Birds from the nearby San Jacinto Mountains, Riverside County, CA, were originally described as *S. p. leuconucha* but appear to be intergrading with the more common *S. p. melanotis* (Van Rossem 1929, Norris 1958). Further research is needed on the populations that occur in the several mountain ranges between the Lagunas and San Jacintos to find the exact boundary and zone of intergradation between the two subspecies (Kingery and Ghalambor 2001). *S. p. leuconucha* is larger and paler than *pygmaea* and *melanotis* and ventrally dull like *pygmaea*. Also, in comparison to *pygmaea* and *melanotis* the wing, tail, and tarsus are significantly longer (Phillips 1986), and the bill is longer and heavier (Norris 1958, Phillips 1986).

S. p. flavinucha occurs in the mountains south and east of Mexico City (Van Rossem 1939). Norris (1958) described this race as having questionable heterogeneity, and split *brunnescens* from it, which left three isolated populations with distinguishable measurements. *S. p. flavinucha* is relatively large compared to other subspecies, with long wings and a short bill (Norris 1958).

S. p. brunnescens occurs in the mountains of south and west Jalisco, and east to southwest Michoacan, Mexico, and possibly northeast Nayarit (Norris 1958). The wing and tail are fairly long and the bill is broader than either *flavinucha* or *melanotis.* Norris (1958) noted a yellowish-buff suffusion on the nuchal patch. It is brownest on the crown and buffiest on the nape with a inconspicuous eye-stripe (Phillips 1986).

S. p. elii is resident in southwestern Nuevo Leon and southeastern Coahuila. This subspecies represents an isolated population split from *flavinucha* by Phillips (1986). This is the largest subspecies. It is similar to the longer, heavier-billed individuals of *melanotis* but larger, and its back is slightly paler. Ventrally, it is dull and pale like *leuconucha* but with a smaller bill (Phillips 1986).

Distribution And Abundance

Distribution Recognized In Primary Literature

The pygmy nuthatch is resident in ponderosa and similar pines from south central British Columbia and the mountains of the western United States to central Mexico. With respect to the Black Hills National Forest, the pygmy nuthatch is resident in the Black Hills region from northeastern Wyoming into western South Dakota (Luce et al. 1997, Peterson 1995). One breeding record and one juvenile male specimen also exist from nearby northwestern Nebraska (Sioux County; Ford 1959, Rosche 1972). The patchy distribution of pines in western North America dictates the patchy distribution of the pygmy nuthatch throughout its range. Little or no information exists on the historic range, but it is unlikely to differ significantly from the current distribution, which is closely tied to the distribution of these pines. The reliance on pines distinguishes pygmy nuthatches from other western nuthatches such as the red-breasted and white breasted, which are associated with fir/spruce and deciduous forests respectively (Ghalambor and Martin 1999). The following is a review of the distribution of populations in the United States, Canada, and Mexico (based on Kingery and Ghalambor 2001).

Populations Within The United States And Canada

The pygmy nuthatch occurs in southern interior British Columbia, particularly in Okanagan and Similkameen valleys and adjacent plateaus (Campbell et al. 1997) south into the Okanagan Highlands and the northeast Cascades of Washington. It is scattered along the eastern slope of the Cascades from central Washington (Jewett et al. 1953, Smith et al. 1997) into Oregon and in the Blue Mountains in southwest Washington (Garfield County only; Smith et al. 1997) but widespread in Oregon along the west slope of the Cascades (Gabrielson and Jewett 1940, Jewett et al. 1953, Gilligan et al. 1994). It ranges south from the Cascades in Oregon into northern California and south into the Sierra Nevadas and nearby mountains of Nevada (Brown 1978). In the southern Sierra Nevadas it is found on the east and west side of the range in the Mono Craters and Glass Mountain region (Gaines 1988, Shuford and Metropulos 1996) and in the White Mountains of Nevada and California (Norris 1958, Brown 1978, Shuford and Metropulos 1996). It is also found throughout the mountain ranges of southern California, including the Sierra Madres in Santa Barbara County, the Mt. Pinos area (Kern and Ventura Counties), the San Gabriel and San Bernardino Mountains in Los Angeles and San Bernardino Counties (Norris 1958, B. Carlson, K. Garrett pers. comm.), the San Jacinto and Santa Rosa Mountains in Riverside County (Norris 1958, B. Carlson pers. comm.), and in the Laguna and Cuyamaca Mountains, as well as Mt. Palomar, Volcan and Hot Springs Mountains of San Diego County (San Diego County Breeding Bird Atlas preliminary data, B. Carlson, P. Unitt pers. comm.). The range extends south into the Sierra Juarez and Sierra San Pedro Mártir Mountains in Baja California Norte, Mexico (Grinnell 1928, Norris 1958, A. Sada pers. comm.).

In eastern Washington, the pygmy nuthatch is common in the pine forests of Spokane County (Jewett et al. 1953, Smith et al. 1997) and adjacent Kootenai County, ID (Burleigh 10 1972). Only scattered records exist for the rest of Idaho's mountains (Burleigh 1972, Stephens and Sturts 1991) but pygmy nuthatches are well distributed in the Rocky Mountains of far western Montana (Montana Bird Distribution Committee 1996). It is generally absent from southwestern Montana, northwestern and west-central Wyoming, and southern Idaho. It is present in north-central Wyoming (Big Horn Mtns. and nearby; Downing 1990) and probably immediately north in Montana (Montana Bird Distribution Committee 1996). It is possibly breeding in southwestern Wyoming (Luce et al. 1997) and resident from the Snowy Range in south-central Wyoming (Luce et al. 1997) south through the Colorado Front Range (Jones 1998) and into New Mexico's Sangre de Cristo Range (Santa Fe and San Miguel Counties, Norris 1958, S. Williams pers. comm.). The pygmy nuthatch is also found in the Uinta Range of northeastern Utah (Norris 1958), Douglas Mountains of northwestern Colorado (Jones 1998), and San Juan Mountains of southwestern Colorado (Jones 1998) and north-central New Mexico. The pygmy nuthatch occurs in at least 3 desert ranges (Spring, Sheep, and Snake) from Las Vegas to Baker, NV (Brown 1978) and across southern Utah in the Pine Valley Mountains, Zion National Park, Bryce Canyon National Park, and portions of the Dixie National Forest between Cedar City, Panguitch, and Bryce Canyon, (Norris 1958, S. Hedges pers. comm.). It is scattered throughout Arizona's mountains where ponderosa pines grow, particularly from Flagstaff to the White Mountains (see Arizona Breeding Bird Atlas). It's spotty distribution continues into New Mexico's Mogollon Mountains and Black Range, as well as other mountains in New Mexico high enough to have ponderosa woodlands (e.g. Chuska, Zuni, Jemez, Sandia, San Mateo, Gallinas, Jicarilla, Sacramento Mountains, and Animas Range). It's range within the Guadalupe Mountains of New Mexico extends south into Texas, and it also occurs in the Davis Mountains in Texas. Breeding has been documented in the Sierra Grande Mountains, Union County, NM, close to the Oklahoma panhandle. (Norris 1958, G. Lasley, S. Williams pers. comm.), but no confirmed reports of breeding exist for Oklahoma itself. The pygmy nuthatch occurs in the "coastal fog belt" of California (Burridge 1995) within 25 km of the coast, in the coast ranges containing coastal pine groves from Mendocino County to Cambria in northern San Luis Obispo County (Norris 1958, Roberson 1993, Shuford 1993, Burridge 1995, Kingery and Ghalambor 2001). It is also found in some "islands" of ponderosa and Jeffrey pines that grow in isolated mountain ranges (e.g., central Montana, Wyoming, Nevada, and Utah; Critchfield and Little 1966). Explorations of some of these "island" ranges might turn up more pygmy nuthatch populations.

Populations Within Mainland Mexico

The distribution of pygmy nuthatches within Mexico is probably not continuous but fragmented as in the southwestern United States. This may reflect a general pattern throughout the southwest (e.g. Russell and Monson 1998), or simply be due to a lack of field observations in Mexican forests. In the interior ranges and adjacent slopes, there are apparently isolated populations that occupy mountain pine forests. It is found in the San

Jose Mountains in northern Sonora and Sierra del Carmen in northwestern Coahuila. Pygmy nuthatch populations confirmed in the Sierra Madre Occidental include areas in southern Sonora, eastern Chihuahua, southwestern Chihuahua, west-central Durango, northwestern Zacatecas, east-central Sinaloa, southwestern Durango, northern Nayarit, northern Jalisco, southern Jalisco, Colima, and Michoacán (Kingery and Ghalambor 2001). Populations in the Sierra Madre Oriental include areas in Cerro Potosí in southwestern Nuevo León and southeastern Coahuila, Distrito Federal, Morelos, western Puebla (Cerro San Miguel, Volcán Ajusco, La Cima, Popocatépetl), and Pico Orizaba in Veracruz (Cox 1895, Miller et al. 1957, Norris 1958, Ely 1962, Phillips 1986, Wilson and Ceballos-Lascurain 1993, Russell and Monson 1998, G. Lasley and A. Sada pers. comm.).

Additional Information From Federal, State, And Other Records

A Forest Service review by Baylor et al. (1972) recorded the presence of the pygmy nuthatch in the Black Hills. In recent years there have been two Forest Service publications testing habitat capability models for birds of the Black Hills (e.g. Mills et al. 1996, 2000; Rumble et al. 1999), however, these studies did not address the distribution or abundance of the pygmy nuthatch.

Estimates Of Local Abundance

No good estimates of pygmy nuthatch populations are available within the Black Hills, SD. Mills et al. (1996) and Rumble et al. (1999) report results from bird counts on the Nemo, Pactola, and Spearfish Ranger Districts of the Black Hills National Forest from 1992-1993, but neither study reports the presence of pygmy nuthatches. It appears that pygmy nuthatches were simply not present at many of these sites, or were present in such small numbers that they precluded any analysis (R. Hoelscher pers. comm.). The description of the vegetation on at least some of these study sites suggests potentially good habitat for pygmy nuthatches (i.e. mature ponderosa pine) making their absence even more surprising. Breeding Bird Survey (BBS) routes in the vicinity of the Black Hills lack adequate sample size to be currently useful. Likewise, Christmas Bird Count (CBC) data does not have adequate resolution to provide meaningful estimates for the Black Hills region.

Nationwide, BBS results show the highest numbers of pygmy nuthatches on routes in Arizona and southern California (Price et al. 1995). Christmas Bird Count data show highest counts from Spokane, Washington, Mt. Charleston, Nevada, and the Front Range foothills of the Colorado Rockies from Boulder south to Pikes Peak. The Colorado Breeding Bird Atlas shows the highest numbers in the Front Range foothills (Fort Collins to Pikes Peak) and in southwestern Colorado (Kingery 1998).

Intensive monitoring of pygmy nuthatch populations report different breeding densities depending upon habitat type, habitat quality, local conditions, and available nest sites. The following population estimates are for the number of breeding pairs/40 ha of *S. p. melanotis* in ponderosa pine forests in Arizona:

1.5 - 18.0 pairs (Szaro and Balda 1979)

0.0 - 53.0 pairs (Overturf 1979)

7.6 - 22.3 pairs (Scott 1979)

1.0 - 42 pairs (Cunningham et al. 1980)

0.0 - 23.7 pairs (Brawn and Balda 1988a)

14.2 - 26.2 pairs (Horton and Mannan 1988)

7.7 - 16.0 pairs (Siegel 1989)

Population numbers tend to increase following the breeding season and stay high through the winter, without a decline until breeding begins in the spring (McEllin 1979a). For example, a breeding density of 10.3 birds/40.47 ha, doubled after breeding to 29.8 birds/40.47 ha (October- December), then dropped to 19.6 birds/40.47 ha (April-May; Stallcup 1968). In the longest breeding bird census (21 intermittent years, 1956-1995, in Boulder Co., Colorado) densities averaged 20.1 pairs/40 ha, but varied from none (3 consecutive years) to 49 pairs/40 ha (Kingery and Ghalambor 2001).

Most of the above data were collected in ponderosa pine forests in Arizona. No estimates exist for populations closer to the Black Hills. It is difficult to assess whether these estimates of local abundance are likely to be similar in the Black Hills. However, given the high variability of these estimates, it is unlikely that population numbers within the Black Hills would lie outside this range of variability.

Population Trend

Survey-wide estimates of all BBS routes suggest pygmy nuthatch populations are stable (Sauer et al. 2000). However, these estimates are based on small samples that do not provide a reliable population trend nor reliable trends for any states or physiographic regions, due to too few routes, too few birds, or high variability (Sauer et al. 2000). The lack of reliable data is particularly the case in the Black Hills, where there are too few data to perform even the most basic trend analysis (Sauer et al. 2000). Where long-term data are available for particular populations, natural fluctuations in population numbers have been documented. For example, a constant-effort nest-finding study in Arizona recorded a major population crash. On this site between 1991-1996 the number of nests found each year varied from 23-65 (mean = 50.2), whereas in the same site from 1997-1999, only 2-5 nests were found each year (Kingery and Ghalambor 2001). Likewise, Scott's (1979) study also portrays a pygmy nuthatch population swing, but no clear factor has been identified as being responsible for rapid changes in population numbers (see also Population Trend above). No definitive explanation currently exists for why some pygmy nuthatch populations may be prone to large fluctuations, but it is suspected that an intolerance to cold winter temperatures (see Communal Roosting below), and or a poor cone crop may play a role.

Broad Scale Movement Patterns

Pygmy nuthatches are sedentary and resident throughout their range; they do not migrate. No broad scale movements have been observed in any population to date. Vagrants have been reported spending winter in such uncharacteristic locations as Fargo, North Dakota

(Williams 1997); Des Moines, Iowa (photographed; Dinsmore et al. 1984); Wichita, Kansas (flock of 10; Thompson and Ely 1992); Big Bend National Park, Texas (Kingery and Ghalambor 2001); and Albuquerque and Las Cruces, New Mexico. Vagrants have also been observed away from coniferous mountain habitats in coastal British Columbia (Campbell et al. 1997), coastal Santa Barbara County, California (Lehman 1994), southern Idaho (Stephens and Sturts 1991), eastern Montana (Montana Bird Distribution Committee 1996), southeastern Wyoming (Luce et al. 1997), northeastern Colorado plains (Andrews and Righter 1992), and desert sites throughout New Mexico including Portales (Kingery and Ghalambor 2001). Specimens also exist from Kansas (Thompson and Ely 1992), Dallas County, Texas (G. Lasley pers. comm.), and Cimarron County, Oklahoma, with irregular sight records there in December and May (Sutton 1967). Despite these records on vagrants, populations by and large are very sedentary and show little broad scale movements. The sedentary nature of this species may be related to its highly social behavior, given that families form post-breeding flocks and young males often stay on the parental territory to assist the parents in breeding (see Breeding Biology below). The majority of these vagrant observations appear to be individuals from the *S. p. melanotis* subspecies, the subspecies from the Black Hills. However, this is unlikely to reflect a propensity for movement in *S. p. melanotis*, instead it is more likely a reflection of the large discontinuous range of this subspecies. There is currently not enough information available to assess the degree to which pygmy nuthatch populations are isolated from other populations for any region, but given the unique “island” qualities of the Black Hills it is unlikely that there is much opportunity for the exchange of individuals with other localities.

Habitat Characteristics

Pygmy nuthatches show a strong and almost exclusive preference for yellow pine forests. Their geographic range is almost co-extensive with that of ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*Pinus jeffrey*), and similar species (Kingery and Ghalambor 2001). Among all breeding birds within ponderosa pine forests, the density of pygmy nuthatches is most strongly correlated with the abundance of ponderosa pine trees (Balda 1969). In Colorado 93% of breeding bird atlas observations occurred in coniferous forests, 70% of those in ponderosa pines. Indeed the distribution of pygmy nuthatches in Colorado coincides with that of ponderosa pine woodlands in the state (Jones 1998).

Several studies identify the pygmy nuthatch as the most abundant or one of the most abundant species in ponderosa forests (e.g. Mt. Charleston, NV, Arizona’s mountains and plateaus, New Mexico, Colorado statewide, and Baja California, see Reassumes 1941; Brandt 1951; Norris 1958; Stallcup 1968; Balda 1969; Farris 1985; Travis 1992; Kingery 1998) as well as in other yellow long-needled pines such as those of coastal California and Popocatépetl, Mexico (Norris 1958, Paynter 1962).

In California’s mountains, it favors open park-like forests of ponderosa and Jeffrey pines in the Sierra Nevada Mountains (Gaines 1988) but also ranges to 3050 m in open stands of large lodgepole pine in the White Mountains of California (Shuford and Metropulos 1996). In the Mogollon Rim region of central Arizona, it breeds and feeds in vast expanses of ponderosa pine that extend throughout the Colorado plateau, and, is also common in shallow snow-melt ravines that course through the pine forests. These snow-melt drainages contain white fir (*Abies concolor*), Douglas-fir (*Pseudotsuga menziesii*), Arizona white pine (*Pinus strobiformis*), quaking aspen (*Populus tremuloides),* and an understory of maples (*Acer* sp.; Kingery and Ghalambor 2001).

In New Mexico, it is most common in ponderosa pine, including ponderosa/oak and ponderosa/Douglas-fir forests (Kingery and Ghalambor 2001). In Washington, it uses Douglas-fir zones rarely, and then only those in or near ponderosa pines (Smith et al. 1997). In Summit County, CO, a small group of pygmy nuthatches occupy a small section of lodgepole pine at the edge of an extensive lodgepole forest (Kingery and Ghalambor 2001).

In coastal California (Sonoma, Marin, Monterey, San Luis Obispo Counties) pygmy nuthatches occur in the "coastal fog belt" (Burridge 1995) in Bishop pine (*Pinus muricata*), Coulter pine (*Pinus coulteri*), natural and planted groves of Monterey pine (*Pinus radiata*; Roberson 1993, Shuford 1993), other pine plantations (Burridge 1995), and wherever ponderosa pines grow (e.g., Santa Lucia Mountains, Monterey County; Roberson 1993).

In Mexico, where it occurs in arid pine forests of the highlands, it follows pines to their upper limits at tree line on Mount Popocatépetl (3,800-4,050 m; Paynter 1962) and Pico Orizaba (4,250 m; Cox 1895). In Distrito Federal, it is primarily restricted to coniferous forests above 3,000 m (Wilson and Ceballos-Lascurain 1993). Almost no other contemporary information is available on the habitat preferences of pygmy nuthatches in Mexican mountain ranges (S. Howell, J. Nocedal, A. Sada pers. comm.). It is known to favor pine and pine-oak woodlands, these pine species include ponderosa-type pines: *Pinus engelmanii, P. arizonica, P. montezumae* and non-ponderosa-types *Pinus teocote, P. hartwegii, P. leiophylla*, and *P. cooperi*. Associated Mexican tree species in pygmy nuthatch habitat include oaks (*Quercus rugosa, Q. castanea, Q. durifolia,* and *Q. hartwegii*), madrones (*Arbutus xalapensis* and *A. glandulosa*), and alders (*Alnus firmifolia;* Nocedal 1984, 1994, A. Sada pers. comm.). It also occurs, in small numbers, in fir (*Abies religiosa*) forests (Nocedal 1984, 1994).

Foraging Habitat

The pygmy nuthatch feeds almost exclusively in pines. It explores the whole tree for food, in this respect it is a more generalized feeder than chickadees and other nuthatches. Pygmy nuthatches typically seek static insect food in needle clusters, cones, twigs, branches, and trunks. It climbs over and under branches, from and to the outermost twigs and needles, and both up and down tree trunks (Bent 1948; Stallcup 1968; Bock 1969; Manolis 1977; McEllin 1978, 1979b; Ewell and Cruz 1998). It spends more time in areas with the highest density and greatest cubic feet of foliage (Balda 1967, 1969). Pygmy nuthatches forage higher in trees and farther from the trunk than the white-breasted nuthatch (*Sitta carolinensis*) and mountain chickadee (*Poecile gambeli*), but use various zones of the tree in more equal proportions than those flock associates (McEllin 1979b).

Time spent by pygmy nuthatches foraging in different zones of the tree remains relatively similar within the breeding and non-breeding seasons, but differs between seasons. Four studies that quantify time spent in different foraging zones confirm this but differ on the proportionate time spent in the various zones (Stallcup 1968, Larimer County, CO.; Bock

1969, Boulder County, CO.; McEllin 1978, 1979a, Larimer County, CO; Ewell and Cruz 1998, Boulder County, CO.). These studies report that during the breeding season, the percentage of time foraging in different zones of a tree are: trunks 3-35%, large branches 12-15%, small branches, 10-25%, and needles, twigs, and cone clusters, 34-74%. Foraging during the non-breeding season then shifts primarily to the cone clusters: trunks 1-23%; large branches, 7-16%; small branches, 22-34%; needles, twigs, and cone clusters, 34-71%. This shift reflects the greater reliance on pine seeds during the non-breeding season.

In Larimer County, CO, the time spent in foraging zones does not differ with respect to foraging height, tree diameter, or location within the tree, and, more time is spent at each foraging location in the non-breeding season than in the breeding season (McEllin 1978). In addition, the pygmy nuthatch uses a greater amount of a tree's vertical height during the nonbreeding season (foraging height averages 9.51 m " .051 SE in the breeding season and 10.40 " .056 SE in the non-breeding season; McEllin 1979b).

In Boulder County, CO, non-breeding birds spent 92.0% of their foraging time in ponderosa pines, 5.3% in Douglas firs, 1.4% in dead brush, and 1.1% on the ground. When in the pines, they spent 34.6% of their feeding time on the trunk, 25.4% on branches, and 22.0% on needles and twigs (Bock 1969). Some foraging on fallen pinecones during the non-breeding and breeding season has also been reported (Stallcup 1968).

Food Items Consumed

The pygmy nuthatch diet varies seasonally and by location. The winter diet is primarily seeds in some populations and mostly insects in others. During the breeding season the diet mainly consists of insects and spiders. Beal (1907) reported that 31 pygmy nuthatch stomachs contained 83% animal matter and 17% vegetable matter. These individuals were collected in Monterey County, CA during the summer and contained the following arthropods: Hymenoptera (mostly wasps with a few ants) 38%, Hemiptera (mainly Cercropidae) 23%, Coleoptera (mainly weevils, plus some coccinellids) 12%, also caterpillars 8% and spiders 1%. The vegetable matter consisted entirely of seeds, mainly from conifers.

In contrast, Norris (1958), using year-round samples from Marin County, CA, found a diet, by weight, of 65% vegetable matter. He examined 73 stomachs collected in 9 different months. Vegetable food (all seeds of Bishop pine) exceeded 85% of diet from October to January. In late spring the proportion dropped to 39% in April 2% in May, 65% in June and July, and 42% in September. Insect food, most important in spring and fall, consisted of beetles (in 51% of the stomachs), mainly snout weevils (Curculionidae), leaf beetles (Chrysomelidae), bark beetles (Scolytidae), and wood- or bark-infesting larvae, but no Hymenoptera as in Beal's (1907) sample. Nestlings received food from most of the above groups, plus coccinellids. The oldest nestlings also received pine seeds with the hard integument removed. The stomachs of six fledglings had 0-98% pine seeds (average 45%) in them. Eight stomach samples collected in December from Napa County, CA, showed a much lower proportion of ponderosa seeds (range 0-65%, mean 39%; Norris 1958).

During the breeding season, pygmy nuthatches appear to select only a few insect taxa among the many available. In Oregon, the pygmy nuthatch breeding diet (by volume) consists of 45% weevils, 37% leaf beetles, and varying amounts of ants and bark-dwelling insects. Weevils disappear from the post-breeding diet, which consists of 59% leaf beetles, 3% weevils, and 38% other insects. Winter diet switches to only 12% leaf beetles, 25% weevils, 12% Hemiptera, 50% other insects, and only 4% vegetable matter (seeds). The winter diet also includes twice as many bark-dwelling insects (7% cf. 3%) as in the post-breeding diet (Anderson 1976).

The amount of food in the stomach reaches its maximum in winter and spring: 0.18-0.20 g (wet weight) in November-May, compared with 0.13-0.15 g in June-September (Norris 1958).

Nesting Habitat

Because the pygmy nuthatch nests primarily in dead pines and live trees with dead sections, it prefers mature and undisturbed forests that contain a number of large snags (Szaro and Balda 1982). Pygmy nuthatch abundance correlates directly with snag density and foliage volume of the forest, but inversely with trunk volume, implying that it needs heterogeneous stands with a mixture of well spaced, old pines and vigorous trees of intermediate age (Balda et al. 1983). Scott (1979) illustrated the importance of snags for pygmy nuthatch populations by comparing two plots that had been harvested for trees, but differed in that snags were removed in one plot and left in the other. Pygmy populations decreased by half on the plot where snags had been removed (16.3 pairs/ ha to 7.6 pairs/ ha), whereas populations slightly increased on the plot where snags were left (18.7 pairs/ ha to 22.6 pairs/ ha ; Scott 1979). This reliance on ponderosa pine forests with high amounts of foliage volume and numerous snags has led some authors to regard the pygmy nuthatch as one of best indicator species for overall "health" of bird communities in mature ponderosa pine forests (e.g. Szaro and Balda 1982).

Nest Tree

Pygmy nuthatches most often use ponderosa pine and other yellow longneedled pines for nesting. It less often uses other conifers and quaking aspen, but this appears to depend on the habitat. The Black Hills subspecies, *S. p. melanotis* nests almost exclusively in areas dominated by conifers (McEllin 1979a, Brawn and Balda 1988a). In British Columbia, of 153 cavity nests, 74% were in ponderosa pines, 6% in aspen, 5% in Douglas-firs, and 7% in fence posts (Campbell et al. 1997). In Los Alamos County, NM, 7 of 8 nests were in ponderosa pines, the other in a cottonwood snag (Travis 1992). In Missoula County, MT, 8 of 9 nests were in ponderosa, and one was in an aspen (Storer 1977). In California, of 33 nests found, all were in unspecified pines (Grinnell and Linsdale 1936). On the Mogollon Rim in central Arizona, a site with numerous large aspen snags, pygmy nuthatches built 64% of their nests in aspen, 23% in fir, and 5% in pine (*n* = 294; T. Martin pers. comm.). No nest tree information is available for populations in the Black Hills. Limited data is available for other subspecies. *S. p. pygmaea* in Marin County, CA, nests almost exclusively in Bishop pine, but occasionally nests in broadleaved oaks (Shuford 1993). In Golden Gate Park, San Francisco, CA, 2 nests were found in eucalyptus trees and 4 were in horizontal branches or between splinters of broken branches of Monterey pines (Löhrl 1988).

Characteristics Of Nest Tree

The pygmy nuthatch nests in cavities, in dead trees or dead sections on live trees. It is capable of excavating its own cavities, but will also use existing holes and occasionally nest boxes. The nest cavities are usually in the trunk of trees and less commonly in the branches (Hay and Güntert 1983). In central Arizona, 51.7% of pygmy nuthatch nest cavities were in dead trees and 48.3% in live trees (*n* = 294 nests; T. Martin pers. comm.). In Missoula, MT, of 9 cavities used for breeding, 5 were in dead pines and 4 were in live pines (Storer 1977). Nest cavities are often situated under or near existing or broken off branches (Bent 1948, Kingery and Ghalambor 2001). Of 26 nests in Larimer County, CO, 23 had limbs below the entrance and 3 had limbs beside the entrance (McEllin 1979a).

Where habitat becomes progressively more open with fewer live and dead trees, as when forests are clear-cut, pygmy nuthatches have shown a propensity to increase their use of nest boxes (Brawn 1988). Of 213 nests found in British Columbia, 73% were in cavities and 24% were in nest boxes (Campbell et al. 1997). Below are specific characteristics of trees used for nesting (see also Table 1 for summary).

Table 1. Summary of nest tree characteristics used by pygmy nuthatches.

(N/A denotes cases where the information is not available).

Tree characteristic	Mean (•SE/SD)	Range	Location	Reference
Tree Height	16.15 m (1.01SE)	5.09-25.54	Colorado	McEllin (1979a)
	9.40 m (N/A)	1.70-25.00	Montana	Storer (1977)
	9.80 m (5.8 SD)	N/A	Arizona	Hay and Güntert (1983)
	62.00 ft (N/A)	(30 -102)	Arizona	Scott et al. (1980)
	23.80 m	N/A	Arizona	Cunningham et al. (1980)
Diameter of Nest Tree	42.6 cm (0.78SE)	13-100	Arizona	Li and Martin (1991)[1]
	23.0 in (N/A)	11-37	Arizona	Scott et al. (1980)
	67.8 cm (14.0SD)	42-96	Arizona	Cunningham et al. (1980)
Height of Nest Cavity	10.79 m (0.73SE)	3.54-17.22	Colorado	McEllin (1979a)
	3.30 m (N/A)	0.90-6.5	Montana	Storer (1977)
	5.60 m (2.2SD)	N/A	Arizona	Hay and Güntert (1983)
	43.00 ft (N/A)	8-80	Arizona	Scott et al. (1980)
	18.90 m (N/A)	N/A	Arizona	Cunningham et al. (1980)
	15.90 m (4.78SE)	N/A	Arizona	Li and Martin (1991)[1]

[1] information is also based on unpublished sources.

Tree Height

The mean height of nest trees for *S. p. melanotis* populations nesting in Colorado, Montana, and Arizona is 16.03 m (" 2.89 SE). See Table 1 for more information.

Diameter Of Nest Tree

The mean diameter at breast height (dbh) of nest trees for *S. p. melanotis* populations nesting in Arizona is 47.83 cm " 10.35 SE. See Table 1 for more information.

Height Of Nest Cavity In The Tree

The mean height of the nest cavity for *S. p. melanotis* populations nesting in Colorado, Montana, and Arizona is 10.57 m (" 2.83 SE). See Table 1 for more information. Cavity height also varies by tree species: ponderosa pine, 1-21.3 m, mean 7.6 m (*n* = 78); Jeffrey pine, 2.4-7.6 m, mean 5.6 m. (*n* = 7); Bishop pine 3.4-15 m, mean 10.1 (*n* = 22); Douglas-fir 9-23 m, mean 14.8 (*n* = 7); quaking aspen, 9-23 m, mean 5.7 (*n* = 8).

Habitat Surrounding Nest Tree

In a comparison of habitat characteristics surrounding the nest tree, Li and Martin (1991) compared an 11.3 radius circular plot around the nest to a random plot centered on a similar sized tree of the same tree species used for nesting. They found that the circular plots surrounding the nest trees had significantly more aspen and conifer snags, more conifers of greater than 15 cm (dbh), and fewer deciduous trees of greater than 15 cm (dbh) in comparison to the randomly selected plots (Li and Martin 1991).

Condition Of Nest Tree:

In central Arizona, pygmy nuthatches placed 78% of their nests in completely dead snags, 11% in the dead portions of live trees, and 11% in completely live trees (*n* = 18 nests; Li and Martin 1991).

Communal Roost Cavities

In addition to using cavities for breeding, pygmy nuthatches also rely on cavities as year-round roost sites. Thus, unlike the majority of birds that roost on branches in trees and shrubs, pygmy nuthatches are dependent on tree cavities for nightly shelter. During the breeding season, pairs, and when present helpers, roost in the nest cavity together (Norris 1958; Kingery and Ghalambor 2001). In winter, family groups or larger aggregations will share a single roost each night, and this communal roosting behavior has been shown to significantly reduce heat loss during cold winter temperatures (See Complex Interactions below). No records exist of pygmy nuthatches roosting alone (Norris 1958), and they are not known to roost outside a cavity except in aviaries (Hay 1983).

The selection of communal roost cavities is affected by weather and by characteristics of the cavity (such as type of wood, thickness of bole, size of entrance, and depth of cavity) that afford protection from outside ambient temperature (Hay 1983). The presence of snow is the best predictor of how many individuals use a cavity (26% of the variability in roost numbers is explained by the amount of snow). Temperature, barometric pressure, and day in the winter cycle collectively explain only a small amount of the same variation

(Hay and Güntert 1983). Pygmy nuthatches exhibit clear seasonal cavity preferences that are related to thermal insulation and ventilation. Over the course of an entire year, they use roost sites that are significantly higher than cavities used for nesting, and they pick spring/fall roost sites that are significantly higher than summer roost sites (Hay and Güntert 1983). The diameter of cavity entrance holes used in the winter is smaller than those used during summer and fall/spring roosts. Non-breeding cavities that are used exclusively for roosting (fall/spring and winter) are more typically in the trunks of trees, while summer roost sites tend to be in or near branches (Hay and Güntert 1983). On warm summer nights they use cavities with large entrance holes, often with additional cracks and openings, while in the winter they seek cavities in trees with large trunk diameters, large volumes in order to hold more birds, and relatively small entrance holes (Güntert et al. 1989). Smaller groups of pygmy nuthatches select smaller cavities than larger groups, regardless of climate or season (Hay 1983).

Over one winter in Arizona, 170 individuals used 136 different cavities as nests or roosts, and inspected 7 others. Flocks of pygmy nuthatches repeatedly made communal inspections of up to 5 different cavities prior to roosting (Hay 1983). Usually groups roost within their territory, but when they form multiple family roost groups some of these groups may leave their territory 30 minutes before their usual roosting time (Güntert et al. 1989).

Near Colorado Springs, CO, Knorr (1957) documented 150 pygmy nuthatches entering several holes in a large, hollow ponderosa snag to roost for the night. Of the 150 birds, at least 100 were estimated to be roosting in a single cavity (Knorr 1957). At the bottom of 2 cavities inspected near Boulder, CO, 9 dead birds were found (possibly suffocated) in one cavity, and an additional 13 were found in another (Knorr 1957). Another notable roost site was 23.9 m high in a dying ponderosa in Coconino County, AZ, which Sydeman and Güntert (1983) documented as a major roost site in one winter even though it had substantially less use in previous winters. Sydeman and Güntert (1983) monitored this roost from 14 January- 9 April 1983 ($n = 33$ evening counts), where they observed the snag hosting a large number of roosting pygmy nuthatches that varied from 27 individuals (10 March) to 167 individuals (19 February). The number of pygmy nuthatch groups ranged from 2-15 and the flocks moved from as far away as 1.682 km to visit the roost tree. These data suggest that groups, not individual birds, decide where to roost (Sydeman and Güntert 1983).

Landscape Context Review

There is no information on the spatial context of habitat requirements for pygmy nuthatches.

Movements

Pygmy nuthatches are year-round residents in the Black Hills and are non-migratory. The most significant movements appear to occur during post-breeding dispersal and winter wandering, when a few individuals have been observed moving into atypical habitats, including krumholtz at timberline and into other conifers at lower elevations (Bent 1948; Kingery and Ghalambor 2001). For example, in Colorado and New Mexico pygmy nuthatches have been observed as high as timberline and as low as valleys and cities along the edge of mountains (Kingery and Ghalambor 2001). In California, they have been observed in non-pine coastal locations such as in Santa Barbara Co. (Lehman 1994) and San Diego County (Unitt 1984). In Oregon, they have been observed in desert-like habitat (Malheur National Wildlife Refuge) as well as on the coast (Gilligan et al. 1994). In Arizona, post-breeding movements have also been documented at high elevations in spruce/fir forest and down to desert scrub (Davis and Russell 1979).

Breeding Biology

The pygmy nuthatch is one of the few cooperatively breeding passerines in North America. Typically one third of all breeding pairs have one to three male helpers, usually progeny or other relatives (Kingery and Ghalambor 2001). The helpers feed incubating females, feed nestlings and fledglings, and participate in defense of the nest site. Most of our information on the breeding biology of this species comes from work done in California (Norris 1958) and Arizona (e.g. Hay 1983; Sydeman et al. 1988). No information exists on the breeding biology of pygmy nuthatches within the Black Hills.

Phenology Of Courtship And Breeding

No data is available on the exact time of year when pairs form. However, pair bonds appear to be permanent and are maintained throughout the year (Norris 1958). Cavity excavation for breeding has been recorded from mid-March to mid-June. Excavation of nests starts in mid- March in coastal California, New Mexico, and Spokane County, WA, late March in Colorado, and early April in Oregon. Excavation has been recorded through April in Marin County, CA, May-June at Lassen Peak, CA, and March-June in Colorado (Norris 1958, Roberson 1993, Jones 1998). Excavation can take 3-6 weeks, but the time can vary because of weather, hardness of wood, a change in nest site preference, and the birds' "internal state" (Norris 1958). Unlike woodpeckers that do not build a nest within the cavities they excavate, nuthatches build a nest inside the cavity following completion. Dates for the timing of nest building for *S. p. pygmaea* are 25 March -11 May (*n* = 5) and for *S. p. melanotis*, 26 April-18 May (*n* = 5; Kingery and Ghalambor 2001). In Colorado, nest building begins 7 May-12 June (*n* = 4; Jones 1998). In Los Alamos County, NM, nest building occurs from 4 April-11 May (*n* = 3; Travis 1992). (See also Clutch Initiation And Size below).

Courtship Characteristics

Males frequently feed females before and after copulation (Norris 1958, Löhrl 1988, Kingery and Ghalambor 2001). The female initiates copulation. Courtship begins with the male and female perched next to each other on a horizontal branch. The female faces the male with an open bill and utters a drawn-out high-pitched call. The call is a string of high-pitched chirr-chirrchirr notes (Kingery and Ghalambor 2001). The female then holds her tail stiffly erect and holds her wings away from her sides and shakes them vigorously. The trembling female then begins to swing (this swinging motion is typical of many nuthatch species, and invites the male to mate). The male sitting behind the female also begins to swing and quiver his wings and copulation soon follows. The male mounts the female and may peck at the back her head. Both continue swinging, and the female continues to call. Copulations last less than 5 seconds and both then fly off (Storer 1977, Löhrl 1988, Kingery and Ghalambor 2001).

The relationship of six breeding males and females provided some limited evidence of long-term pair bonds (Norris 1958). Of the six pairs, five pairs nested together in the second year, one male mated with a new female (his previous mate had not been seen since previous fall), and a helper male mated with an unbanded female (Norris 1958). Extra-pair copulations have not been reported. Because pair bonds appear to be long term and nest cavities are often excavated, there is little evidence suggesting that intra-specific competition for partners or nest sites is unusually high.

Nest Site Characteristics

Males appear to take the lead in selecting the nest site, but data supporting this observation are lacking (Norris 1958). Pygmy nuthatches most often use ponderosa pine and other yellow longneedled pines throughout their range, but do occasionally use other conifers and quaking aspen (see Nesting Habitat above). The pygmy nuthatch is both a primary and secondary cavity nester. It typically excavates its own cavity, but will use and modify old woodpecker holes and natural cavities (Bent 1948, Norris 1958). In central Arizona, 73% of all nests were new excavations, 23% were in old cavities excavated in the previous years, and 4% were in natural cavities (*n* = 237 nests; T. Martin pers. comm.). Both sexes, and sometimes helpers, excavate the cavity and later bring material to the build the nest with (Norris 1958). Both sexes share in excavation equally and the average excavation bouts last 9.2 and 9.9 min for males and females respectively (Storer 1977). The excavating individual can be readily observed swinging back and forth, delivering several blows at the hole, then pausing motionless for a few seconds, before resuming excavation. Birds working inside and outside the cavity make a noise similar to an excavating woodpecker, but typically not as loud. One bird excavating inside the hole exited 3 times in 10 minutes to flip chips and sawdust into wind with its bill (Grinnell et al. 1930). The adults more typically make 3-15 blows per session (but up to 25 at a time), and average 6-7. Norris (1958) describes this behavior in detail. Birds may spend up to 63% of their entire day excavating (Norris 1958).

Pygmy nuthatches start to bring nest material into cavity during the last few days of nest excavation and continue over the “next few weeks” into the incubation period. The delivery rate of nest material can vary from 2-3 bits/hour to 10-12/hour. Males and females both deliver nest material at an equal rate and helpers deliver material until the onset of incubation (Storer 1977).

The nest cup is built of bark shreds, fine moss, grass, plant down, fur, cocoons, and other soft fibrous material. Most nests also incorporate feathers into the nest lining (Bent 1948; Norris 1958, Gabrielson and Jewett 1967, Campbell et al. 1997). The pair will continue to line the nest well into the egg-laying period (Norris 1958). Of 38 nests in California, feathers of 6 bird species were reported in 92% of the nests, while bark shreds or fibers were in 45%, moss was in 32%, fur and hair were in 26%, wool was in 21%, and snake skin was found in 18% (Norris 1958). Other less common materials found in nests include parts of sagebrush in 10% of nests, plant down in 10%, cotton or cotton-like substances in 10%, string in 10%, grass blades in 8%, bits of cloth, lichen, cocoon fibers, papery material from wasp nests, and various other soft materials such as decayed wood in less than 5% (Norris 1958). Of 206 nests in British Columbia, 67% had hair, 32% moss, and 21% grass (Campbell et al. 1997). Nests were never observed to include conifer seed wings, despite being the most common constituent in nests of the closely related brown-headed nuthatch (Norris 1958). Brandt (1951) reported that one excavating bird threw wood chips out of the cavity entrance, then picked them up again to use as lining. Parents may steal nesting material from cavity nests of other species, and males sometimes remove nest material that mates bring into the cavity (Kingery and Ghalambor 2001). The nest cup covers the bottom of the nest 2-4 cm deep (Storer 1977). Pygmy nuthatches will use nest material, such as hair and feathers, to "caulk" cracks in the cavity walls, thus weather-proofing the nest (Harrison 1979, Löhrl 1988).

Cavity Dimensions

Cavity entrances are irregular in shape and tend to be elliptical in outline (Brandt 1951, Bent 1948). Cavity shapes can vary considerably, but are often an irregular gourd shape (Storer 1977). Below is a summary of cavity dimensions from populations nesting in central Arizona (Ghalambor and Martin, unpublished data) :

- cavity entrance height ranges from 2.75-5.0 cm (mean 3.83 cm " 0.63 SD, *n* = 14)
- cavity entrance width ranges from 2.5-4.5 cm (mean 3.43 cm " 0.75 SD, *n* = 14)
- cavity depth ranges from 12.5-32.5 cm (mean 19.03 cm " 5.87 SD, *n* = 9).
- inner cavity width ranges from 3.75-13.75 cm (mean 7.88 cm " 3.31 SD, *n* = 9)
- distance from back of cavity to the outer entrance ranges from 2.0-10.18 cm (mean 4.41 cm " 2.31 SD, *n* = 13)
- width of the front wall can range from 0.75-17.5 cm (mean 5.48 cm " 4.06 SD, *n* = 13).

Other miscellaneous measurements of the cavity dimensions can be found in Kingery and Ghalambor (2001). No information on measurements of nest built inside the cavity.

Cavity Microclimate

The microclimatic conditions experienced inside nesting and roosting cavities appear to be very important determinants of cavity selection. Work by Hay (1983), Hay and Güntert (1983), and Güntert et al. (1989) all suggest pygmy nuthatches are very sensitive to extreme cold temperatures (Communal Roosting above and Torpor And Communal Roosting below). In Larimer County, CO, cavity openings always face southward and eastward, away from the prevailing winds (McEllin 1979a). In central Arizona, nest temperatures measured 2 cm above the incubating female inside of cavity over a 24-h period, ranged from 15.5-27.6o C (mean 19.8o C, *n* = 4 nests; Kingery and Ghalambor 2001).

Maintenance Or Reuse Of Nests, Alternate Nests

Pygmy nuthatches may use the same cavity year-round and in successive years (Shuford 1993).

Clutch Initiation And Size

No data on clutch initiation and size are available for the Black Hills region. *S. p. pygmaea* populations on the California coast appear to breed earlier than the interior populations of *S. p. melanotis* (Kingery and Ghalambor 2001). For *S. p. pygmaea* in Monterey County, CA, nests were occupied from 12 March and had young (*n* = 3) from 3 May-12 July (the latest dates come from pairs breeding at higher elevations; see Roberson 1993). The median egg date for *S. p. pygmaea* is 9 May (Table 2; *n* = 38; Norris 1958). The median egg date for *S. p. melanotis* populations breeding at lower elevations is 28 May (ranges from 4 May-20 May; Kingery and Ghalambor 2001), and for populations breeding at high elevations in California and the Rocky Mountains the median egg date is 28 May (ranges from 4 May-20 June, n = 29; Norris 1958). See Table 2 for more median clutch initiation dates. Nests with young have been observed from 29 April-26 July (n = 84). In British Columbia nests with young have been observed from 1 May-1 September (53% occur 27 May- 18 June; n = 156; Campbell et al. 1997). In Spokane County, WA, nests with young have been observed from 29 Apr-3 July (n = 5). In Missoula County, MT, nests with young were observed from 14 May-11 Jun (n = 4). In Colorado, nests with young have been observed from 3 June-22 July (n = 19; Jones 1998). In New Mexico, nests with young have been observed from 19 May- 13 July (n = 39; Travis 1992).

Table 2. Dates and locations for clutch initiation of different subspecies of the pygmy nuthatch.

Data from Kingeryand Ghalambor (2001). (N/A denotes cases where the information is not available).

Subspecies	Location	Median Date	Date Range
S.p. melanotis	British Columbia, Canada	7 April	21 April -14 July
	Missoula, MT	N/A	8 May - 24 May
	Oregon/Utah	N/A	12 June - 20 June
	Colorado	N/A	24 May - 1 July
	New Mexico	24 April	N/A
	Arizona	10 May	6 May - 18 May
S.p. pygmaea	California	9 May	23 April - 18 June

Egg Shape

Eggs are short and subelliptical or short-oval in shape (Harrison 1979). See Table 3 for egg dimensions and dry eggshell weights of different subspecies. The mass of fresh eggs ranges from 1.00 to 1.35 g. For 8 newly laid eggs in Marin County, CA, the mean egg weight was 1.16 g (Norris 1958). In San Bernardino County, CA, the mean egg weight of 6 newly laid eggs was 1.27 g (Hanna 1924). The overall mean egg weight is 1.20 g (Norris 1958).

Table 3. Dimensions of egg shape in different subspecies of the pygmy nuthatch.

Data primarily provided by the Western Foundation of Vertebrate Zoology (see also Kingery and Ghalambor 2001). Weight determined from an empty egg shell.

Subspecies	Length x Width	Range	Weight	Range
S.p. pygmaea	15.76 x 12.21mm	14.37-17.42 x 11.23-13.34	0.073 g	0.053-0.089
S. p. melanotis	15.57 x 12.00mm	14.35-16.83 x 11.29-12.60	0.065 g	0.054-0.076
S.p. leuconucha	15.84 x 12.19	13.86-17.17 x 10.84-12.86	0.071 g	0.053-0.089

Clutch Size

Typically, clutch size ranges from 5-9 eggs. The modal clutch is 7.0, but has been observed to be as high as 12. See Table 4 for more clutch size information.

Table 4. Clutch size data for different subspecies of the pygmy nuthatch.

Data extracted from Kingery and Ghalambor 2001). Weight determined from an empty eggshell.

Subspecies	Clutch Size	Location	Source
S. p. melanotis	7.2 eggs	Oregon, Arizona, California	Norris (1958)
	7.3 eggs	Montana	Storer (1977)
	6.9 eggs	Arizona	Martin (unpublished data)
	6-7 eggs	British Columbia	Campbell et al. (1997)
S.p. pygmaea	6.9 eggs	California	Norris (1958)

Parental Care

Incubation

Incubation is initiated after clutch completion, although the female will often reenter the nest cavity during the egg-laying period (Norris 1958, Kingery and Ghalambor 2001). No information is available on the female's behavior once inside cavity, but she is presumably covering the eggs with nest material to conceal their presence (see below). The female has a single vascularized brood patch that develops by late April when the pair initiates breeding. The patch remains vascularized and filled with fluid at least until the young are feathered. The maximum width of the brood patch ranges from 17-20 mm across breast. Re-feathering of the brood patch occurs in early July (Norris 1958). The start of incubation is difficult to detect due to egg-covering during the egg-laying period. At one nest, the time from laying the last egg to the time of hatching of the last egg was 15 days and 18 hours (Norris 1958). The length of incubation ranges from 13.5-16 days in Missoula County, MT, and is more typically 14.5-15 days (n = 7; Storer 1977). Incubation can take longer in the Okanagan Valley, British Columbia, where incubation has been observed to range from 12-17 days (mean 14.3, n = 4; Cannings et al. 1987). Only the female incubates. The male and any helpers roost with the female inside the nest cavity overnight. The male and any helpers regularly feed the female on and off the nest during the incubation period (incubation feeding). During incubation-feeding visits, the male often calls in flight when approaching the nest cavity and typically flies with food in his bill straight to the cavity entrance and perches. The female will often begin food solicitation calls while the male is in flight to the cavity, otherwise she vocalizes when the male perches at the cavity entrance. When the male arrives with food, the female opens her bill, faces him, and issues a drawn-out high-pitched call. She then will hold her wings out slightly away from her body and quiver them, in a manner that is similar to fledglings soliciting food from the parents. During feeding by the male, the female continues to spread and quiver her wings, while stretching her head and neck upwards and towards the male (Ghalambor 1998). The male occasionally will also quiver his wings in response to the female. The incubation feeding displays between males and females are similar to the copulation display (Storer 1977), and the display of nestlings or fledglings when being fed (Ghalambor 1998). After receiving the food, the female resumes the display for a number of seconds. If a helper is present, all three will display. During early incubation, the male will continue to carry small bits of nest material. The female occasionally responds to the male with a display that is similar to when she is being fed, grabs the material from male, and tries to eat it (Storer 1977). The incubation behavior of pygmy nuthatches is highly correlated with both time of day and ambient temperature. Female nest attentiveness (i.e. the percentage of time spent of the nest incubating) and male incubation feeding are highest early morning and when temperatures are cool (Ghalambor 1998). Incubation bouts on the nest last from 8-69 minutes in Marin County, CA (Norris 1958) and 6-73 minutes in Missoula County, MT (Storer 1977). The mean duration of incubation bouts in Marin County, CA is 24.5 minutes (Norris 1958), 30.2 minutes in Missoula County, MT (Storer 1977), and 31.0 minutes in central Arizona (Ghalambor 1998). Although the length of time during bouts off the nest are shorter in the morning, the actual coverage of the eggs is 2% greater in the afternoons (Norris 1958). Nest attentiveness (i.e. percent of time, min/hr, the female spends on the nest) averages 80.6% in Marin County, CA (Norris 1958), 80.7% in Missoula County, MT (Storer 1977), and 86% in central Arizona (Ghalambor 1998).

Brooding

Only the female broods the young. Brooding is intermittent, with the greatest attentiveness during the first 2-3 hours after sunrise. Brooding bouts last about 60% as long as incubation bouts (Norris 1958). During the first 3 days of the nestling period, the female spends about 75% of daytime hours brooding young (mean bout length 12.7 minutes). Ambient temperature affects female attentiveness, in that colder morning temperatures result in greater brooding time. The amount of time the female spends brooding becomes progressively less as the young grow, but remains appreciable until the young reach 3 weeks old (Norris 1958). Both parents and any helpers also spend the night in cavity with the young (Norris 1958, Kingery and Ghalambor 2001). Males feed the brooding female on the nest and provision young when the female is off the nest.

Feeding Nestlings

Both parents and helpers feed the young. Parents may forage together or separately when collecting food for the young. Immediately after hatching, adults go into the nest cavity with food. As the young grow and space within the cavity becomes limited, the adults feed from a vertical position outside the cavity (Gignoux 1924, Kingery and Ghalambor 2001). Adults feed the young at the nest and leave quickly (Gignoux 1924). Parents arriving with food often give chattering notes from their last perch before flying to the nest tree. Occasionally, both parents arrive simultaneously at the cavity entrance with food and enter the cavity together (Kilham 1975, Kingery and Ghalambor 2001). If one parent arrives when the other is occupying the hole, it waits before entering, or occasionally will pass food to the adult in the cavity, who then delivers the food to the young (Law 1929). Sometimes the female will eat the food delivered to the nest by the male, in which case she gives feeding cries and quivers her wings. The young beg for and receive food at the cavity entrance in the final days of nestling period. The parents occasionally push past the topmost young to feed young towards the bottom of the cavity (Norris 1958). The young are only fed adult and larval insects and spiders, but well-developed nestlings sometimes are fed pine seeds with the hard integument removed (Norris 1958). The intervals between feedings become shorter with increasing age of young. Size of food items brought by parents increases with age of nestlings (Norris 1958), but size of food brought by helpers does not bear a relationship to nestling age (Sydeman 1989).

The rate at which parents feed their young increases with the number and age of the nestlings (Sydeman 1989). On the day young hatched, adults (a pair without helpers) delivered food 17 times to the nest in 2.5 hours (mean of 6.8 trips/hour), whereas six days later they delivered food 28 times in 2.5 hours (mean 11.2/hour ; Wheelock 1905). Norris (1958) recorded even higher rates, but his sample included nests that had helpers; 8.4 times/hour on hatch day, 28.2/hour on days 10-17, and 45.1/hour on days 18-21. The longest interval between feeding visits was 8 minutes and the shortest was less than a minute (Norris 1958). Sydeman (1989) reported a morning feeding every 2-minute, and sometimes every minute—this is considered a very high energetic expenditure by the adults. The parents will forage between 15-25 meters up in pine foliage when collecting food for the young, and, they fly approximately 75 meters one-way from their foraging sites to the nest (Gignoux 1924). Norris (1958) recorded travel distances that ranged from 25-400m (mean 170 meters, n = 157 trips).

Nest Sanitation

For the first 1-2 days adults will eat the fecal sacs of the young in the cavity. At 2-3 days, the male (and the helper if present) will remove the sacs from the nest. As the young age and the female spends less time brooding, she removes fecal sacs in equal proportion to the male. The size of the fecal sacs and the removal rate increase with the age of the young (Norris 1958). The frequency that parents remove fecal sacs from the nest increases from 1.1/hour when the young are between 0-3 days old, 2.2/hour at 4-9 days old, and 4.6/hour at 10-21 days old (Norris 1958). The older nestlings deposit their fecal sacs directly into their parent's bill (Sydeman 1989). The parents do not drop the sacs below the nest, but more typically deposit them on a high limb (they often use the same limb repeatedly), then wipe and rap their beak vigorously on the limb (Law 1929).

Demography

Life History Characteristics

The estimated average life span of pygmy nuthatches is 1.7 years (the maximum is 6 years, n = 122; Kingery and Ghalambor 2001). However, this estimate is based on a relatively small number of birds and is not corrected for variation in the probability of re-sighting an individual. A larger sample of birds may yield a significantly higher estimate for life span (see Survival And Reproduction below). The pygmy nuthatch has a lower life expectancy than the very closely related brown-headed nuthatch, presumably due to its having larger broods, denser populations, a more "vigorous" way of life (manifested by vocal tempo, rate of feeding female and nestlings, and foraging activity generally), and living in a cooler climate (Norris 1958). The maximum recorded life span, based on recaptures of banded birds is 8 years and 2 months (Klimkiewicz et al. 1983, Klimkiewicz 1997).

Males and females are capable of breeding in their first year, however, first year males commonly assist parents as helpers before breeding on their own in their second year. In contrast, most females are likely to breed in their first year (Norris 1958). At the population level, approximately one third of all nests have between 1 and 3 helpers (Norris 1958; Sydeman et al. 1988).

No information is available on the proportion of the population that are non-breeders, although non-breeders are more likely to be males (Norris 1958). Because young birds are more likely to disperse from their parent's home range, estimating non-breeders is difficult.

Survival And Reproduction

Survival

The estimated annual adult survival rate is 65.0%, a high rate for a passerine bird (Martin 1995), and in stark contrast to the short estimated life span of 1.7 years (see above). Over 3 years in Marin County, CA, an average of 38% of color-banded birds remained alive in 1 of the 2 following breeding seasons (Norris 1958). First year birds have a 27% annual survival rate (Norris 1958). Sydeman et al. (1988) reported a higher survival rate for first-year birds of 44% (21 of 48), but also found an unclear pattern of autumn dispersal. Because first-year birds move and establish breeding sites that are 4 times farther away from their birthplaces compared to the distance adults move between breeding sites, first-year birds are less likely to use a discrete study area making it difficult to separate dispersal from mortality (Norris 1958). Norris (1958) reported as many yearlings in relation to adults in spring and summer as in fall and winter; the ratio of adults to sub-adults in spring and summer (probably including some dependent fledglings) is 1:1.46, while in the fall and early winter it is 1:1.30. Norris (1958) suggested that this indicates similar mortalities for yearlings and adults, but more information is needed to verify this claim.

Reproduction

Pygmy nuthatches produce one brood per year, and rarely produce a second replacement clutch (Kingery and Ghalambor 2001). It has the highest nest success, 86.8% (nests that successfully fledged at least one young), of 114 passerine species examined in North America (Martin 1995). The presence of helpers increases the production of offspring (Sydeman et al. 1988). Habitat quality also affects nest success; in good quality habitat, 64 breeding units fledged an average of 5.5 young, whereas in poorer habitat 77 units fledged an average of only 4.4 young (See also Limiting Factors below for more information on habitat features associated with breeding productivity). In central Arizona, nesting success is 80% (% of nests that successfully fledge > 1 young, n = 416 nests). This estimate of nest success breaks down by stages in the following way: 89% of nests survive through egg-laying, 85% survive through incubation period, and 80% survive through nestling period (T. Martin pers. comm.; see also Li and Martin 1991). In the Okanagan Valley, British Columbia, nest success of pygmy nuthatches is 81.9% for birds using nest boxes and using natural cavities. By stage, nest success breaks down as 89.7% of eggs hatching and 91.3% of nestlings fledging (n = 204 eggs, 183 young hatched, 167 fledglings; Cannings et al. 1987). In British Columbia, the number of young fledged per successful clutch ranges from 2-12 young in 66 (Campbell et al. 1997).

No information is available on lifetime breeding success. The number of broods normally reared per season is almost always only one (Norris 1958, Kingery and Ghalambor 2001). Second broods are likely to be rare because of the long period from egg-laying to full independence (72-78 d; Norris 1958). However, near Flagstaff, AZ two breeding units had two successful broods in one season (n = 147; Sydeman et al. 1988). Also, second broods are known to occasionally occur in the Okanagan Valley, British Columbia (Cannings et al. 1987). Second attempts at re-nesting after nest failure are also unusual. Two instances of re-nesting were reported by Norris (1958) and four instances (3 successful; n = 141) by Sydeman et al. (1988).

Factors Influencing Species Density

Breeding Season

Pygmy nuthatch pairs have foraging territories that usually include the nest site. The pair occupies a foraging territory year-round, but active defense occurs only during the breeding season. Territories sometimes overlap, although the overlap is not as pronounced as in the brown-headed nuthatch (Kingery and Ghalambor 2001). Territory size and shape do not appear to change over the course of the breeding season.

Sometimes, if a potential territory with good food resources lacks a nest site, pygmy nuthatches will select a nest site outside the foraging territory. For example, one pair nested in a Douglas-fir 150 m from their ponderosa pine foraging area (Thatcher 1953). Other examples of the nest site being separate from the foraging territory include, a nest tree surrounded by chaparral vegetation (Norris 1958), and one case of nesting in a snag that was above water (Wheelock 1905). During breeding, pairs usually defend the nest and its immediate vicinity (Norris 1958, McEllin 1978, 1979a). Intra-specific aggression away from immediate vicinity of nest occurs infrequently. As a result, pairs may nest in close proximity to each other (McEllin 1979a).

Territory size appears to vary as a function of the density of pines, cavity availability, and the presence or absence of helpers. Estimates of territory size from different habitats vary from 0.54 to 8.15 hectares (Norris 1958, Balda 1967, Storer 1977). In Marin County, CA, Norris (1958) observed that pairs with helpers held larger territories (mean = 1.28 ha) than pairs without helpers (mean = 0.94 ha). In nearby Napa County, CA, a pair held a relatively large territory of 1.48 hectares, but it contained substantially fewer pines than territories on the Marin site, suggesting a relationship between territory size and the number of pine trees (Norris 1958). Similarly, Sydeman et al. (1988), found that territory size is smaller and reproductive output is higher in undisturbed mature forests compared to forests that are continually cut for firewood and had been selectively cut in the past.

Territorial encounters and trespassing on neighboring territories occur rarely, as most individuals forage within the boundaries of their own territory (Storer 1977). The male is the primary defender of the territory, both intra- and inter-specifically against other hole-nesting species.

Active nest-site defense is limited mainly to counter-singing/calling and wing fluttering between occupants of adjacent territories, (Löhrl 1988, Kingery and Ghalambor 2001). Family flocks defend foraging areas by using “intense vocalizations” (mainly “song” Norris 1958) interspersed with feeding bouts. Confrontations between family flocks last up to 10 minutes and end when one flock, led by an adult, moves off (Denson 1981). Pygmy nuthatches rarely use fighting and chasing when defending territory boundaries, although some mid-air clashes have been reported (Norris 1958).

Non-Breeding Season

When fledglings become mobile, territorial boundaries between breeding units become less defined and flocks may invade neighboring territories (Norris 1958). During the non-breeding season, pygmy nuthatches maintain foraging areas from which they try to exclude non-members of the flock (Norris 1958). In ponderosa pine forests near Flagstaff, AZ, Güntert et al. (1989) observed that in a mild winter, 130 individuals spent winter in 13 territorial groups, whereas in the following harsher winter 170 individuals wintered in 16 territorial groups.

Local Density Estimates

See Estimates Of Local Abundance under Distribution And Abundance above.

Limiting Factors

There is good evidence for at least two main limiting factors in pygmy nuthatch populations: 1) the availability of snags for nesting and roosting, and 2) sufficient numbers of large cone-producing trees for food.

Nest Site Availability

Pygmy nuthatches depend on snags for nesting and roosting. In all cases where timber harvesting has reduced the number of available snags, the number of breeding pairs declines (McEllin 1979a; Brawn 1987, Brawn and Balda 1988a, Bock and Fleck 1995.). Experimental evidence on the role of nest sites in limiting population numbers comes from nest box addition studies. The addition of nest boxes increases breeding pairs by 67-200% and this increase is greater in selectively cut and clear-cut forests with reduced snag availability (Brawn 1987, Brawn and Balda 1988a, Bock and Fleck 1995). These experiments do not address use of boxes during the non-breeding season and the effect upon winter survival, but boxes are seldom used for roosting during non-breeding season (R. Balda pers. comm.). Further evidence that snag availability plays a role in limiting population numbers comes from estimates of population density on logged sites with and without nest boxes added. Addition of nest boxes increases the density of pygmy nuthatches on “severely thinned” and “moderately thinned” plots respectively, from 3 pairs/40ha to 10 pairs/40 ha and from 15/40ha to 25 pairs/40 ha (Brawn and Balda 1988a). Similarly, a comparison of unlogged, moderately thinned, and severely thinned plots showed that pygmy nuthatches will use natural and self-excavated cavities in unlogged forest (15 of 16 nests), but switch to nest boxes in moderately thinned (15 of 16 nests) and heavily thinned (10 of 10 nests) forests where snag availability has been reduced (Brawn 1988). See also Risk Factors Below.

Roost Site Availability

Pygmy nuthatches choosing roost sites during the non-breeding use a different set of characteristics compared to nest sites (see Communal Roost Sites above). In a heavily harvested forest near Flagstaff, AZ, birds chose atypical cavities with poorer thermal properties compared to adjacent unlogged forests (Hay and Güntert 1983). This suggests that a considerable reduction in snag densities may affect overwinter survivorship and possibly reproduction by forcing pygmy nuthatches to use cavities in snags they would normally avoid (Hay and Güntert 1983, Matthysen 1998). More research on the differences among snags is clearly needed in order to distinguish those factors that make some snags more desirable than others.

Availability Of Foraging Substrate

Pygmy nuthatches differ from other nuthatches in that they prefer to forage amongst the foliage of trees rather than simply on the bark (see Foraging Habitat above). A number of lines of evidence suggest that because pygmy nuthatches rely heavily on pine seeds during the non-breeding season and preferentially feed in dense foliage, they are particularly sensitive to significant habitat alterations. For example, in a comparison of open forests that have been severely thinned of all snags and have a 75% reduction in pine foliage and forests that were only “moderately thinned”, Brawn and Balda (1988a) found that even with the addition of nest boxes, pygmy nuthatch densities were significantly higher on the moderately thinned plot. These results suggest that foliage volume and food resources can influence pygmy nuthatch densities independent of cavity availability. In a comparison of “clear-cut”, “heavy cut”, “medium cut”, “light cut”, and “uncut” forests, Szaro and Balda (1986) similarly found that pygmy nuthatches and other species that select dense foliage became less abundant as the habitat became more “modified”. Rosenstock (1996) concluded that pygmy nuthatches and other species that prefer to forage in more dense foliage decline in forests that have low canopy density, high canopy patchiness, and reduced vertical vegetation density, as commonly occur as a result of timber harvesting. Furthermore, there is also a general positive correlation between pygmy nuthatches and the diameter (dbh) of pine trees (Rosenstock 1996). Finally, Sydeman et al. (1988) report that pygmy nuthatches achieve higher breeding success in “undisturbed mature” forests compared to forests that were selectively cut in the past and were being continually cut for fuelwood. The “undisturbed forests” had not been disturbed for over 70 years and had a greater basal area of ponderosa pine (13.97 vs. 10.46 m2/hectare, fewer but larger ponderosa pines per hectare (50.65 vs. 40.37 cm dbh), and taller ponderosa pines (18.82 vs. 15.36 m) compared to the disturbed site (Sydeman et al. 1988). The undisturbed site also contained more junipers and oaks per hectare, and significantly more snags per hectare (112 vs. 24) than the disturbed site (Sydeman et al. 1988).

Patterns Of Dispersal

Initial Dispersal From Natal Site

Only limited detailed information is available from Norris (1958) on initial dispersal of young from the natal site. One male established a territory 165 meters from his birthplace. No information is available for females, but it is presumed to be farther than males (Norris 1958). First-year birds established breeding sites that were over 4 times as far from their birthplaces than the average distance adults move between breeding territories (Norris 1958). Young birds move a mean of 286.5 meters (range from 0.6 meters for a bird that remained in the same snag, to 533 meters). The two shortest distances moved away from the natal territory involved yearling males that acted as helpers to their parents, all other moves exceeded 150 meters (Norris 1958). Young can be observed leaving the natal territory in the summer and fall, and, immigrating young from nearby territories eventually replace locally produced offspring (Güntert et al. 1989).

Dispersal From Breeding Site

Following the breeding season, local post-breeding populations increase in particular sites and remain at levels well above breeding density until spring, then the population declines rapidly as family flocks break up and disperse (McEllin 1978). Post-breeding adults in coastal California moved a mean distance of 67 meters (range, 0- 335 meters). Females that were unsuccessful in breeding moved a significantly farther distance than females of pairs that successfully bred (Norris 1958). Post-breeding movements are irregular with respect to habitat and geography, and birds have been observed to move into both lower and higher elevations (Norris 1958, Roberson 1993, Kingery and Ghalambor 2001). The irregularity in the pattern of post-breeding dispersal may relate to local failures of ponderosa pine cone crops, but no information is available.

Among eight juvenile birds that were successfully followed, three were observed roosting in their natal nest cavity, one used another cavity in the nest tree, one joined another family, and three relocated to another roost sites (Norris 1958).

Fidelity To Breeding Site

Few data are available, but it appears most birds exhibit a high degree of fidelity to their breeding sites. Males may exhibit greater fidelity to breeding sites than females. Among two males that were observed moving nest sites, one male changed cavities in the same tree, while the other moved 39 meters (Norris 1958). No information is available for females. Pygmy nuthatches were observed to use the same cavity for three consecutive years in San Bernardino County, CA, although it was not established whether they were the same or different individuals (Kingery and Ghalambor 2001). Of 101 banding recoveries, 100 were recovered in same ten-degree block, also suggesting a high degree of fidelity (Kingery and Ghalambor 2001).

Community Ecology

Predators And Relationships To Habitat Use

Kinds Of Predators

Predation or attempted predation on adult pygmy nuthatches has been documented to occur by the sharp-shinned hawk (*Accipiter striatus*; Norris 1958, Denson 1981), Cooper's hawk (*Accipiter cooperii;* Kingery and Ghalambor 2001), northern pygmy-owl (*Glaucidium gnoma*, Rashid 1999), acorn woodpecker (*Melanerpes formicivorus)* suspected (Sydeman et al. 1988), western scrub-jay (Norris 1958), and Steller's jay (*Cyanocitta stelleri*; Norris 1958, Carothers et al. 1972). Non-avian predators of adults in the nest cavity include chipmunks (*Eutamias* sp.; Sydeman et al. 1988, Cannings et al. 1987), red squirrel (*Tamiasciurus hudsonicus*; Kingery and Ghalambor 2001), and gopher snake (*Pituophis melanoleucus*; Cannings et al. 1987, R. Balda pers. comm.).

Egg and nestling predators include Steller's Jay (Kingery and Ghalambor 2001), house wren (*Troglodytes aedon*, Kingery and Ghalambor 2001), hairy woodpecker (*Picoides villosus*, Norris 1958); red squirrel (Kingery and Ghalambor 2001), gray-necked chipmunk (*Eutamias cinereicollis*), and gopher snake (R. Balda pers. comm.).

Response To Predators

To avoid a perceived avian predator (e.g. Accipiter hawk), the pygmy nuthatch will quickly switch to the opposite side of a tree it is on, position a limb between it and the larger bird, and flattens itself against trunk (Denson 1981). It may exhibit a similar reaction to a human. Denson (1981) theorized that pygmy nuthatches increase flock size during severe weather, which involves low light intensity, for the purpose of predator avoidance. When a sharp-shinned hawk attacked a flock of pygmy nuthatches, the birds were observed to initially scatter, then call incessantly until the hawk left area (Kingery and Ghalambor 2001). During observations of a Cooper's hawk perched on top of tree with a roost hole, 2 pygmy nuthatches ascended to the same level as the hawk and mobbed it until it left (Denson 1981). Pygmy nuthatches will mob sharp-shinned and Cooper's hawks, American kestrel (*Falco sparverius*), northern pygmy-owl, hairy woodpecker, house wren, western scrub-jay, Steller's jay, Clark's nutcracker (*Nucifraga columbiana*), Abert's squirrel (*Sciurus aberti*), and chipmunks (Norris 1958, Denson 1981, Rashid 1999, Kingery and Ghalambor 2001). It repeatedly attacks house wrens, which elicit a very strong response if they approach the nest tree (Kingery and Ghalambor 2001). When they noticed a rattlesnake (*Crotalus viridis*) partially hidden under a rock by a pool, pygmy nuthatches hovered over pool as if inspecting the snake, after inspecting, birds drank from pool (Bryan 1998). In response to red squirrels that frequently climb nest trees, the incubating female jumps out of the nest cavity, perches at the cavity entrance, and begins an anti-predator display (like that of white-breasted and red-breasted nuthatches; Kilham 1968, Ghalambor and Martin 2001), that can be very effective at deterring squirrels. During the anti-predator display, the female faces downward towards the predator and spreads her wings, holds her body in a fixed position and then sways slowly from side to side in a rhythmic movement. In response, the squirrel becomes motionless and fixates on the female for up to 10 seconds and then retreats (Kingery and Ghalambor 2001). When several chipmunks ran under a nest tree with 9 young in the cavity, 4 pygmy nuthatches stopped outside the nest hole and stood motionless on the trunk, and remained that way for < 20 minutes (Bleitz 1951). In response to a red squirrel model placed near the nest during incubation, males reduce the rate at which they feed incubating females and increase the amount of time they spend vigilant (Ghalambor 1998; Ghalambor and Martin 2001; Ghalambor unpublished manuscript). Compared with red-breasted and white-breasted nuthatches, however, the pygmy nuthatch exhibits the smallest reduction in incubation feeding in response to the squirrel model, presumably because of their safe nest sites and lower vulnerability to nest predation (Ghalambor and Martin 2001).

Relationships To Habitat Use

No information exists on specific habitat alterations that have influenced predator-prey relationships involving pygmy nuthatches. However, given that squirrels and chipmunks are the most common nest predators (Ghalambor and Martin 2001), any changes in habitat that increase the numbers of these potential nest predators could have negative consequences on breeding productivity. Likewise, any habitat alteration that increased the number of *Accipiter* hawks could increase predation rates on adult birds. In this respect, management plans designed for other species (e.g. squirrels, hawks, etc..) could have indirect consequences for pygmy nuthatches.

Competition

Intraspecific Competition

Males are dominant over females based on roosting behavior. Dominant males roost at the bottom of the cavity where they derive the highest thermal benefits, whereas the subordinate females are forced to the top of the stack where they receive possibly one-fifth the thermal benefit from communal roosting (Hay 1983). However, birds on the bottom occasionally suffocate, suggesting a more complex cost-benefit strategy during communal roosting (Knorr 1957). Territorial conflicts and trespassing are rare (see Factors Influencing Species Density above), suggesting that there is little intraspecific competition for territories. The lack of intraspecific aggression is not too surprising considering that under normal conditions populations are more or less resident on the same territories year round. No study has examined whether competition for territories, nest sites, or roost sites increases in response to logging or any other activity that might influence habitat quality.

Interspecific Competition

Pygmy nuthatches are aggressive towards other hole-nesting bird species. Pairs and threesomes chase and physically attack other cavity-nesting birds, particularly house wrens (Kingery and Ghalambor 2001). They chase Nuttall's woodpecker (*Picoides nuttallii*), white-breasted nuthatch, and chestnut-backed chickadees (*Poecile rufescens*) from their territory boundaries, and, will also chase violet-green swallows (*Tachycineta thalassina*) and house finches (*Carpodacus mexicanus*) from the vicinity of the nest (Bent 1948). In El Paso County, CO, 7 pygmy nuthatches roosted in a nest box between June 18-24 until house wrens drove them out. The wrens arrived June 21 and for three nights tried to repel nuthatches with "furious attacks". On June 24 the wrens began to carry sticks into the nest box and by 25 June the nuthatches could not penetrate the sticks to roost. The wrens ultimately nested in the box (Jones 1930). Also, chipmunks will compete with pygmy nuthatches for cavities (Brawn 1987). Such behavior and interactions near the nest suggest that pygmy nuthatches may face strong competition from other cavity-nesting species for their nest sites, but further study is needed to quantify the intensity of this competition.

Parasites And Disease

Body Parasites

Of 8 birds collected in Marin County, CA, one had a "fair infection" of *Haemoproteus* spp. (Norris 1958). One of six Colorado birds examined showed *Trypanosoma avium* in the blood marrow, probably acquired by ingesting a hippoboscid fly, *Ornithomyia* sp. (Stabler et al. 1966, Stabler and Kitzmiller 1970). Of nine birds collected at Eagle Lake, CA, three had blood parasites (1 *Trypanosoma* sp., 1 *Haemoproteu*s sp., and 2 *Microfilaria* sp.; Miller et al. 1978). A blue fly (a blood sucker), probably a *Protocalliphora*, was observed around the cavity entrance of pygmy nuthatch nest (Law 1929). *Protocalliphora* fly larvae develop in the nest lining and in the bodies of nestlings. Of approximately 150 birds dissected, three showed infection (swollen and discolored intestinal tracts due to cyst-like structures) caused by an intestinal fluke (*Gyrabascus echinus* or a close relative). Tapeworms have been found in the small intestines of several birds (Norris 1958). Body parasites documented include one tick-like mite and several feather mites (Acarina), and two species of bird lice (*Myrsidea* spp. And *Brüelia* spp.; Norris 1958).

Diseases

No information is available. Observers occasionally see deformed birds, such as one with an upper mandible was twice the normal length and with a very slight down-curve (this bird spent more time at feeder than other pygmy nuthatches; Kingery and Ghalambor 2001).

Other Complex Interactions

Sharing Nest Tree

Pygmy nuthatches often share snags with other species, but such interactions appear to be both agonistic and benign (Kingery and Ghalambor 2001). For example, pygmy nuthatches have been observed nesting in the same tree as the northern saw-whet owl (*Aegolius acadicus*), hairy woodpecker, Williamson's sapsucker (*Sphyrapicus thyroideus*), northern (redshafted) flicker (*Colaptes auratus*; nesting cavities sometimes only a few centimeters apart), tree swallow (*Tachycineta bicolor*), violet-green swallow, purple martin (*Progne subis*), house wren, western bluebird, mountain bluebird, and European starling (*Sturnus vulgaris*). There are no records of pygmy nuthatches sharing a nest tree with other nuthatches, brown creepers (*Certhia americana*), mountain (*Poecile gambeli*), black-capped (*Poecile atricapillus*), or chestnut-backed chickadees (Brandt 1951, Norris 1958, Storer 1977, Pinkowski 1980). Western bluebirds (*Sialia mexicana*), in one instance, temporarily or permanently ousted pygmy nuthatches from their cavity, yet in another case a pair of pygmy nuthatches excavated a hole 0.7 meters below a bluebird nest and the two species nested amicably (Grinnell and Linsdale 1936). Continued harassment of a pygmy nuthatch pair by mountain bluebirds (*Sialia currucoides*) nesting in the same tree and by a pair of Lewis's woodpeckers (*Melanerpes lewis*) nesting 25 m away disrupted excavation activities and thereby extended excavation period (Storer 1977). In Park County, CO, mountain bluebirds nested in an aspen 1.9 meters from the ground, pygmy nuthatches nested 2.4 meters up in same tree. The nuthatch nest eventually failed, in part because the male nuthatch fed the bluebird nestlings and neglected his own young. In 3.5 hours of observation over two days, the bluebird nestlings were fed by the bluebirds 22 times and by the nuthatch 34 times (Pinkowski 1980). No research has been done on why different species share nest trees and what characteristics if any these snags have that set them apart from other snags. It is possible that by nesting close to other cavity-nesting birds, the pygmy nuthatches gain some benefits in terms of protection from predators, while at the same time experience a cost in the form of harassment from the same species.

Torpor And Communal Roosting

The communal roosting strategy used by pygmy nuthatches has been shown to be an adaptive strategy to reduce heat loss in the face of cold ambient temperatures (Hay 1983). Communally roosting birds employ torpor to save energy during cold ambient temperatures and most individuals in this state cannot be awakened at night (Hay 1983).

The intragroup position of the individuals within the cavity affects the thermal savings provided by roosting. Birds at the bottom of the stack realize almost 6 times the metabolic savings of a bird alone at the top of the stack (Hay 1983). Roosts have significantly higher temperatures and higher relative humidity than the outside air (Hay 1983). Roost temperature often exceeds ambient temperature by 9.0E " 4.7 SD (Hay and Güntert 1983). Compared with a single roosting bird, grouped birds have lower cloacal temperatures and consume substantially less oxygen. Some groups remain in the roost all day when snow covers the branches and needle clusters, and some individuals have stayed in the roost cavity up to 42 hours without leaving. Single birds lose significantly more heat through evaporative water loss than do pairs, and pairs lose more heat than groups of four (Hay 1983). Evaporative water loss increases with air temperature, such that a single bird's loss increases linearly with increasing temperature (Hay 1983).

Risk Factors

The following is a prioritized list (beginning with the most important) of risk factors or threats faced by pygmy nuthatches. These risk factors are based on the most current knowledge available and are discussed in the context of the Black Hills.

Snag Availability

Pygmy nuthatches are dependent on snags for nesting and roosting, and reduced snag availability has been shown to have negative effects on populations (see Limiting Factors above). Because pygmy nuthatches nest and roost in excavated tree cavities, the importance of snags is manifested during both the breeding and non-breeding season. During the breeding season, numerous studies have documented a decline in the number of breeding pairs and a reduction in population density on sites where timber harvesting reduced the number of available snags (see Limiting Factors above). During the non-breeding season, studies show that timber harvests that remove the majority of snags, cause communally roosting groups to use atypical cavities with poorer thermal properties (see Limiting Factors above).

On the Black Hills, timber harvesting (including the cutting of standing dead trees for firewood) is likely to be the primary human activity influencing snag availability, and therefore the most important risk factor for pygmy nuthatches (see Management Activities below). However, the type and amount of timber harvesting carried out in forests supporting pygmy nuthatch populations will ultimately determine how important this risk factor may become. Natural threats to snag availability are wind, other weather events, and possibly competition from other species (see Natural Activities below).

Foraging Habitat

Pygmy nuthatch populations rely heavily on the availability of pine seeds and arthropods that live on pines. In comparison to other nuthatches and woodpeckers, pygmy nuthatches forage more amongst the foliage of live trees rather than on the bark. (see Foraging Habitat and Limiting Factors above). The preferred foraging habitat for pygmy nuthatches appears to contain a high canopy density, low canopy patchiness, and increased vertical vegetation density, a common feature of mature undisturbed forests.

Indeed, studies show that pygmy nuthatches occur at lower densities, forage over a larger area (i.e. have larger territories), and have lower reproductive success on harvested plots compared to undisturbed plots (see Limiting Factors above).

On the Black Hills, timber harvesting is likely to be the primary human activity influencing foraging habitat (see Management Activities below). However, as with snag availability, how timber harvesting is carried out will determine the quality of the foraging habitat. Natural events that could negatively influence foraging habitat include large wildfires, insect epidemics, weather events, and other natural events (see Natural Activities below).

Loss Of Continuous Habitat

Pygmy nuthatch populations are very sedentary. Young birds have been observed to only move 286.5 meters from their natal territories. Such limited dispersal reduces the number of individuals that emigrate and immigrate from local populations, which in turn reduces gene flow and demographic stability. Thus, in contrast to the majority of North America's songbirds, movement and dispersal patterns in pygmy nuthatch populations is limited to a relatively small geographic area. Therefore, pygmy nuthatches may need a greater amount of connectivity between suitable habitat potentially in comparison to other resident birds.

On the Black Hills, any event that reduces the total area or the connections between suitable areas has the potential to negatively influence pygmy nuthatch populations by reducing movement between local habitat patches. The Black Hills is a forested "island" within a larger landscape dominated by grasslands, thus pygmy nuthatch populations in the Black Hills may be even more isolated than other populations scattered throughout the western United States. However, almost no information is available on the degree to which populations separated by very large expanses of unsuitable habitat exchange individuals. Nevertheless, special attention should be paid to pygmy nuthatch populations because recruitment of individuals from other populations may be rare. Human activities have the potential to fragment the mature ponderosa pine habitat pygmy nuthatches rely on. Likewise, natural events such as fire, wind events, and insect epidemics also have the potential to break up continuous tracts of forest into fragments that are more difficult to colonize.

Response To Habitat Changes

Management Activities

Timber Harvest

The effects of timber harvesting on bird communities as a whole may have both beneficial and negative effects. Because timber harvesting changes the structure, density, age, and vegetative diversity within forests, the new habitats created following timber harvesting activities may be either suitable or unsuitable to different species of birds. Furthermore, the type of timber harvesting (e.g. clear-cut, partial-cut, strip-cut) may also have differential consequences on the local bird community. No study to date has quantified the effects of timber harvesting on pygmy nuthatches in the Black Hills (but see Dykstra et al. 1997 for other species). Nevertheless, various lines of research suggest that some timber harvesting treatments have negative impacts on pygmy nuthatches (reviewed in Hejl et al. 1995; Finch et al. 1997). Comparisons between uncut mature forests and forests that have been subject to various silvicultural treatments reveal that the density of pygmy nuthatches is significantly reduced on harvested forests (e.g. Franzreb and Ohmart 1978, Brawn 1988, Sydeman et al. 1988), and these reduced numbers are significantly correlated with reduced snag density and the volume of ponderosa pine foliage. For example, Szaro and Balda (1979) report that the average number of breeding pygmy nuthatches over a three year period in uncut mature forests (582.5 ponderosa pines/ha) was 14 pairs / 40 ha, in a strip cut forest (145 ponderosa pines/ha) it was 4.0 pairs /40 ha, in a severely thinned forest (59.7 ponderosa pines/ha) 1.3 pairs /40 ha, and in a selectively cut forest (216.1 ponderosa pines/ha) that only removed some old mature trees 13.5 pairs /40 ha. Pygmy nuthatches were always found to be absent from clear cut forests (Szaro and Balda 1979). Similarly, Balda (1975) reports the number of breeding pairs on three uncut mature ponderosa pine forests to be 26, 15, and 43 pairs per 100 acres, whereas on two plots where all snags were removed the number of pairs dropped to 2 and 3 pairs per 100 acres. Scott (1979, 1983) reports that the before-and-after density of pygmy nuthatches dropped from 16.3 pairs/ 100 ha to 7.6 pairs/ 100 ha on plots where timber harvesting reduced the basal area of live trees from 110 to 64 square feet per acre and also resulted in the removal of all snags. In contrast, on plots where timber harvesting reduced the basal area from 107 to 51 square feet per acre but no snags were removed, the number of breeding pairs increased from 18.7 pairs/ 100 ha to 22.6 pairs/ ha (Scott 1979). During the same time, pygmy nuthatch populations on control plots that had a standing basal area of 102 square feet per acre and were not cut, numbers increased from 13.6 pairs/ ha to 20.4 pairs/ ha (Scott 1979). The pygmy nuthatch was one of four species that showed a significant reduction in population density with a reduction in snags (Scott 1979, 1983). These results illustrate the importance of retaining snags during timber harvests. In addition, work by Balda (1969, 1975), Szaro and Balda (1986), O'Brien (1990) and Rosenstock (1996) all conclude that pygmy nuthatches prefer to forage in dense foliage and populations decline in forests that have low canopy density, high canopy patchiness, and reduced vertical density, which are a common result of timber harvesting activities. For example, even using "coarse" forest survey plot data, O'Brien (1990) found that the number of pygmy nuthatches was significantly correlated with both foliage volume of ponderosa pine and the estimated availability of food in ponderosa pines (computed using average canopy height and canopy closure; see O'Brien 1990 for more details). Furthermore, O'Brien (1990) found that the average number of pygmy nuthatches observed was much higher (6.5 vs. 1.5) and more birds were observed at more locations in a more remote less intensively managed forest than a forest intensively managed for timber. Using a somewhat similar approach, Rosenstock (1996) found a general positive correlation between pygmy nuthatches and the diameter of pine trees.

Dykstra et al. (1997) examined the effects of timber harvesting on birds in ponderosa pine forests in the Black Hills, but did not record the presence of pygmy nuthatches on either harvested or unharvested stands.

Recreation

Recreational activities can negatively impact bird populations through the accidental and purposeful taking of individuals, habitat modification, changes in predation regimes, and disturbance (Knight and Cole 1995; Marzluff 1997). In a recent review of the effects of recreation on songbirds within ponderosa pine forests, Marzluff (1997) hypothesized that "nuthatches" would experience moderate decreases in population abundance and productivity in response to impacts associated with established campsites (although pygmy nuthatch was not specifically identified). Impacts associated with camping that might negatively influence nuthatches include changes in vegetation, disturbance of breeding birds, and increases in the number of potential nest predators (Marzluff 1997). However, other recreational activities associated with resorts and recreational residences might moderately increase nuthatch population abundance and productivity (Marzluff 1997). This positive effect on nuthatch populations is likely to occur through food supplementation, such as bird feeders, that are frequently visited by pygmy nuthatches.

Livestock Grazing

No study to date has considered the effects of livestock grazing on the pygmy nuthatch or any other cavity-nesting bird. In the short-term it is unlikely that grazing would have any negative or positive impacts on the pygmy nuthatch because their foraging is largely confined to foliage in large trees. The long-term effects of grazing in ponderosa pine forests on pygmy nuthatches are difficult to predict. On one hand, grazing can reduce grass cover and plant litter that in turn can enhance survival of pine seedlings and reduce the frequency of low-intensity ground fires. On the other hand, heavy grazing can also change the recruitment dynamics of ponderosa pines and aspens that eventually would be used for breeding, roosting, and foraging and also alter the frequency of high-intensity crown fires. Studies that compare the vegetation characteristics and productivity of pygmy nuthatches in grazed and non-grazed forests could provide important information in this regard.

Mining

No study to date has considered the effects of mining on the pygmy nuthatch or other cavity nesting bird. However, mining or any related activity that resulted in a significant loss of snags or reduced the number of large mature trees could have negative consequences. Mining could also have negative consequences on pygmy nuthatches by disrupting breeding birds.

Prescribed Fire

Because fire is an important natural process in ponderosa pine forests and is an important factor in creating snags, the restoration of natural fire regimes has been proposed as a management tool (e.g. Covington and Moore 1994; Arno et al. 1995; Fule and Covington 1995). In particular, the use of prescribed fires to reduce fuel loads has been suggested as being necessary in order to return fire regimes to more "natural" conditions (e.g. Covington and Moore 1994; Arno et al. 1995). Because frequent, low intensity ground fires play an important role in maintaining the character of natural ponderosa woodlands (Moir et al. 1997), prescribed low intensity ground fires are presumed to have beneficial effects on the pygmy nuthatch. However, little information exists on the short- and long-term benefits of fire on pygmy nuthatches. The short-term effects of large crown fires appears to have negative effects on pygmy nuthatch populations because of a reduction in the sources of food and shelter (Brawn and Balda 1988b). Lowe et al. (1978) examining more long term effects, report that pygmy nuthatches were more common in an unburned plot, rather than on plots that had undergone stand replacing fires at various times in the previous 20 years. However, many of these burned sites may have been salvage logged, making it difficult to distinguish fire effects from logging effects (Finch et al. 1997). Similar problems have plagued other studies (e.g. Overturf 1979; Blake 1982; Aulenbach and O'Shea- Stone 1983) attempting to quantify the effects of fire on pygmy nuthatches and other birds within ponderosa pine forests (see Finch et al. 1997). The importance of experimental design is illustrated by Horton and Mannan (1988) who examined the effects of a prescribed broadcast understory fire on breeding birds in a ponderosa pine forest. They found that pygmy nuthatch densities dropped from 24.4 individuals / 40 ha to 14.2 individuals/ 40 ha following the prescribed fire (Horton and Mannan 1988), however, on non-burned control plots they found a similar decrease of 26.2 individuals / 40 ha to 15.8 individuals / 40 ha (Horton and Mannan 1988). These results suggest that the decrease in pygmy nuthatch numbers on the burned plots may have been unrelated to the prescribed fire. However, although this study incorporated a control plot, there was only a single replicate for the experimental and control treatments. Clearly, more research on the effects of low intensity and high intensity fires on pygmy nuthatch 59 populations is needed.

Thus, the current level of information makes it difficult to accurately predict the effects of fire on pygmy nuthatches. However, it seems reasonable to conclude that low intensity ground fires would have little or no negative effects, whereas high intensity crown fires would have significant negative short-term effects because of the reduction in foraging habitat.

Fire Suppression

Long-term fire suppression can lead to changes in forest structure and composition, and result in the accumulation of fuel levels that can lead to severe crown fires that replace entire stands of trees. Little information is available on populations of pygmy nuthatches prior to fire suppression policies, although evidence from Arizona and New Mexico suggest they were abundant (Scurlock and Finch 1997). Attempts to restore ponderosa pine forests to their pre- European structure and function (i.e. conditions prior to forest suppression) should have positive impacts on pygmy nuthatch populations, but too little information is currently available. Current work by Paul Beier and colleagues at Northern Arizona University is looking at the abundance and diversity of birds in a ponderosa pine forest that is being restored by the Bureau of Land Management to its historic condition. This work should provide some insight into how pygmy nuthatch populations respond to a large-scale effort to restore old-growth ponderosa pine.

Decades of fire suppression also increase the risk of large stand replacing fires. While the effects of fire on pygmy nuthatch populations remains unclear (see above), large crown fires are expected to have negative affects on pygmy nuthatches by reducing or eliminating sources of food and shelter (Brawn and Balda 1988b).

Non-Native Plant Establishment And Control

No study to date has investigated how the establishment or control of non-native plants influences pygmy nuthatches or any other cavity-nesting bird species in ponderosa pine forests. Some techniques employed to control non-native plants such as prescribed fires are expected to have little or no effect as long as these fires are low intensity ground fires. To the extent that establishment of non-native plants alters the recruitment of trees used for foraging or nesting, such as ponderosa pine or quaking aspen, there could be long-term impacts.

Fuelwood Harvest

Fuelwood harvesting occurs at two levels. At a large-scale, forest managers often harvest dead or diseased trees from large areas, particularly after fires, windstorms, and other natural events. The justification for removing dead and diseased trees is to reduce the accumulation of fuelwood that could lead to high-intensity fires. At a smaller-scale, standing dead trees, fallen trees and other downed woody debris are collected for firewood at campsites or other personal uses. Any fuelwood harvesting that removes standing snags is expected to reduce the population density of pygmy nuthatches (see Timber Harvest above). The harvesting of fallen trees and downed woody debris is not expected to have any negative consequences.

Natural Disturbances

Insect Epidemics

Insect populations typically show large fluctuations over time. Within ponderosa pine forests, attention and concern over insect populations is primarily focused on the mountain pine beetle (*Dendroctonus ponderosae*) because of its potential to kill trees that would otherwise be desirable for harvesting. No study to date has investigated how pine beetle outbreaks influence pygmy nuthatch populations. The ultimate effects of insect epidemics may be related to the scale at which outbreaks occur. Small insect outbreaks that only kill small patches of trees may have beneficial effects on pygmy nuthatch populations, because the increase in tree mortality results in more snags for nesting and roosting. However, large-scale epidemics that result in large amounts of tree mortality could have negative consequences on pygmy nuthatches because of they rely heavily on the foliage of live pine trees for foraging. Thus, the ultimate net effect may be related to how extensive the outbreaks are. Clearly, further study in this area would be warranted.

Wildfire

See Prescribed Fire and/or Fire Suppression above.

Wind Events

Wind events have the potential to negatively influence pygmy nuthatch populations by blowing down snags used for nesting and roosting. During the non-breeding season, when large numbers of pygmy nuthatches communally roost in a single cavity (see Other Complex Interactions), severe wind events have the potential to harm large numbers of individuals by blowing down roost trees. During the breeding season, such risks are minimized because individuals are distributed among many snags used for breeding.

Other Weather Events

Cold temperatures, particularly during the winter months, have the potential to reduce pygmy nuthatch populations. Szaro and Balda (1986) report that breeding bird densities (including pygmy nuthatches) were highest following the mildest winter conditions and bird densities were lowest following a winter with the highest winter snowfall on record in their Arizona study sites. Given that pygmy nuthatches have a low tolerance to cold temperatures, as exemplified by their use of torpor and communal roosting, cold winter temperatures may have disproportionately greater effects on their populations.

SUMMARY

The pygmy nuthatch is a year round resident of ponderosa and similar pine forests from southcentral British Columbia and mountains of western United States to central Mexico. The pygmy nuthatch breeds in nest cavities it usually excavates in snags and is peculiar among North America's songbirds in that it breeds cooperatively. During the non-breeding season, breeding units form family flocks that will join with other flocks to communally roost in cavities. The communal roosting behavior has been shown to be an adaptation to cold overnight and winter temperatures and results in a significant thermal savings. The cooperative breeding behavior and the high degree of sociality in this species are facilitated by very local movements and limited dispersal. Females typically breed in their first year and lay a clutch of 7 eggs and only a single brood is reared each year. Adult birds have a relatively high annual adult survival rate of 65% and individual birds have been recorded to live up to 8 years.

The distribution of pygmy nuthatches is limited to the western United States, Canada, and Mexico where it is highly tied to the distribution of ponderosa and related pines. The subspecies of pygmy nuthatch occurring in the Black Hills is *Sitta pygmaea melanotis* and it has the largest and most discontinuous range of the six recognized subspecies. This subspecies ranges from southern interior British Columbia east to the Black Hills, South Dakota; south to the San Bernardino Mountains in southern California and into northwestern Zacatecas, northern Jalisco, and northern Coahuila in Mexico. The spotty distribution of this subspecies closely follows the spotty distribution pattern of ponderosa pine and other yellow pines. Throughout its range, pygmy nuthatch populations reach their highest density in mature undisturbed ponderosa pine forests. Populations have been shown to be limited by the availability of snags, and thus are sensitive to events that reduce snag availability. Breeding density declines in areas where timber harvesting reduces the number of available snags. On sites with limited snag availability, cavities selected for roosting have thermal properties that are poorer than cavities typically selected.

Pygmy nuthatches prefer to forage in the dense foliage of pines and subsist on arthropods and pine seeds for food. This foraging preference makes pygmy nuthatches vulnerable to the removal of large pines on their territories. Populations decline in forests that have low canopy density, high canopy patchiness, few large diameter trees, and reduced vertical density, which are often consequences of timber harvesting. The decline in population size in harvested forests is in part explained by a reduction in the number of available snags, however, a reduction in large trees and associated foliage volume has also been shown to contribute to lower populations of pygmy nuthatches. Finally, reproductive success is also lower on forests subjected to timber harvesting as compared to undisturbed mature forests.

The limited dispersal abilities of pygmy nuthatches may make them potentially vulnerable to the effects of human and natural disturbances that create large expanses of unsuitable habitat because of the reduced likelihood for populations to be "rescued" by individuals from distant populations. At a larger scale, there is very little information available on the effects of dispersal between distant populations, but given that the Black Hills are an isolated island in the plains, the degree of isolation should be given some consideration, perhaps through regional planning.

REVIEW OF CONSERVATION PRACTICES

Management Practices

No specific management practices have been implemented to target pygmy nuthatches, however, numerous standards and guidelines for the protection of snag dependent species are in effect. The most common management practice that applies to pygmy nuthatches is the general policy of retaining snags in harvested areas. No study to date has evaluated whether such management practices are effective for pygmy nuthatches. Although, Ffolliott (1983) found that in Arizona that the suggested Forest Service policies for snag retention were not being met. Current information on snag retention policies in the Black Hills are not available, nor is there more current information on whether practices on Arizona forests have changed. Programs and studies that monitor snag density and other important aspects of pygmy nuthatch habitat should therefore be considered.

Models

Because direct monitoring of populations is usually time intensive, managers often employ a modeling approach to estimate or predict the occurrence of a particular species. These habitat capability models (i.e. HABCAPs) look at the correlation between stand level vegetation data and bird census data with the goal of predicting the consequences of habitat changes on wildlife populations. The models have the potential to identify the extent of available habitat for a given species, however, it would be inappropriate to take a HABCAP approach to a sensitive species like the pygmy nuthatch. Habitat models are only an indirect assessment of population and cannot substitute for actual field surveys and monitoring approaches.

The Black Hills National Forest currently uses a successional-stage HABCAP model to assess habitat quality and to predict the effects of logging on wildlife (Mills et al. 1996; Rumble et al. 1999). The Black Hills HABCAP model performs reasonably well for some species and some cover types but poorly for others (Mills et al. 1996; Rumble et al. 1999). The pygmy nuthatch is currently included in the Black Hills HABCAP model, however, current sample sizes are to small to test how well the model performs. The small sample sizes for pygmy nuthatches is surprising considering that the model has looked at a range of apparently suitable ponderosa pine habitats in the Black Hills (Mills et al. 1996; Rumble et al. 1999). Incorporating the spatial distribution of snags into existing stand data along with focused censussing for the pygmy nuthatch in appropriate habitat types could increase sample sizes, and, allow for evaluating and testing a more focused HABCAP model in the Black Hills. However, it should be stressed again that a modeling approach alone would be a highly inappropriate way to manage for a sensitive species.

Survey And Inventory Approaches

There are three general methods for conducting bird surveys and inventories to determine the presence or absence of a given species (see Ralph et al. 1995; Nichols and Conroy 1996; Sauer 1998): 1) area-specific checklists, 2) count-based indexes, and 3) point counts.

Area-specific checklists provide presence/absence data by having multiple observers visit the same area and generate replicate checklists of all species observed (Nichols and Conroy 1996). This method allows users to estimate such variables as the presence or absence of a particular species and species richness for the area as a whole. The strengths of this approach are that it is relatively simple and with a minimum of five replicate checklists, statistical estimation procedures can be applied to each site (Nichols and Conroy 1996). The weaknesses of this approach are that no estimates of population size can be obtained and because all species have a nonzero probability of being encountered some statistical biases exist (Nichols and Conroy 1996). This approach is relatively cost effective, requiring a minimum of five checklist participants that are of similar ability and that can visit the same site on a single or multiple occasions. Such an approach can be used to obtain data for a large number of areas over a relatively short time.

A second approach to sample bird populations is count-based population indexes (Sauer 1998). Most bird surveys are count-based indexes, in that they provide an index to population numbers that is based on numbers counted rather than actual population sizes (Sauer 1998). This method is widely used in regional surveys, such as the Breeding Bird Survey (BBS) and the Christmas Bird Count (CBC). The method can be useful for detecting population trends over large areas, but these surveys all share the same weakness of collecting general information without a standardized protocol, and this introduces variation that complicates the interpretation of the data (see Barker and Sauer 1995; Sauer et al 1995; Sauer 1998). Depending on the geographic and temporal scale to be covered, such an approach can range from being very cost-effective to fairly expensive.

The third, and most commonly used approach is point counts, in which an observer stands at a predefined location and counts birds with a specific protocol (Sauer 1998). This is the most common method of surveying for birds, and is the standard approach for most monitoring programs, including those used by the Forest Service and its collaborators. Point counts can be used to appropriately estimate species richness for each point and for groups of points, but estimates of relative abundance are somewhat limited in their applicability (Sauer 1998). If the goal of the point count is to obtain information on a single species or group of species, the specific methodology chosen can be modified to increase the probability of detection. Standardized methods and observer training are essential in ensuring some level of comparability of results, but differences among observers in ability will always make such comparisons problematic. However, this approach is still the most reasonable means of indexing change over time, and, in combination with additional vegetation data is the basis for building a better habitat capability model (HABCAP) for the pygmy nuthatch. As with non-standardized counts, the cost and time requirements will depend on the geographic and temporal scale to be covered. Additional time and cost may arise depending on the specific protocol decided upon.

Monitoring Approaches

There are three general approaches to monitoring bird populations, constant effort mist-netting, nest searching, and different modified census methods (reviewed in Ralph et al. 1993). As with any monitoring plan, the choice of methodology will depend on the specific objectives. Ralph et al. (1993) suggest that prior to implementing a monitoring program the following steps should be taken: (1) decide the objectives and goals desired; (2) determine whether monitoring is the way to accomplish these; (3) with the goals firmly in mind, write down the questions being asked, clearly and objectively; (4) determine which monitoring methods most directly answer the questions posed; (5) review the types of data that can be obtained from these methods, and outline exactly how these data will answer the questions; (6) outline the analytical methods that can be employed; (7) determine the cost, logistics, availability of personnel, and probable length of commitment to the project; and (8) write a study plan and have it reviewed by a person competent in research and statistics. This final procedure is vital, because accumulation of a data base does not itself lead to meaningful analyses later (Ralph et al. 1993). Below is a brief description of different approaches and some of their strengths and weaknesses.

Constant effort mist-netting is a methodology where birds are captured and banded using mist nets that are located throughout a given habitat (Ralph et al. 1993). The most common protocol for constant effort mist-netting is the one used by the Institute for Bird Populations called Monitoring Avian Productivity and Survivorship (MAPS). This is a national program with numerous collaborators, including the Forest Service. The advantages of constant effort mist netting is that by handling and banding individual birds information about the various attributes of the population can be gained, for instance, age and sex ratios and physiological condition (Ralph et al. 1993). Although some studies have used mist netting to assay population size, for most species, censuses are the best method for this (see below), as netting provides relatively fewer data points per unit time (Ralph et al. 1993). The disadvantages of constant effort mist-netting are that biases can exist in the probability of capture for some species and in some habitats, and reproductive parameters like fecundity are not collected. Depending on the size of the area to sampled, it is recommended that 4-6 people operate 20 to 30 different mist net stations. The cost of such an approach will vary on the experience level of those employed and the duration of the sampling period, which is usually two to four months depending on the length of the breeding season.

A second approach to monitoring relies on nest searching. Nest searches provide the most direct measurement of nest success in specific habitats and allow for: 1) identification of important habitat features associated with successful nests, 2) insight into detailed habitat requirements, and 3) species coexistence (Ralph et al. 1993). Nest searches have an advantage over constant-effort mist netting, in that the measures of reproductive success are direct and habitat-specific. However, they are more limited as to the area surveyed and do not measure individual survivorship. Mist nets sample birds from a larger area, and the data derived may therefore have wider applicability, but are not habitat specific (Ralph et al. 1993). The most common standardized protocol in nest search studies are those set forth by the Breeding Biology Research and Monitoring Program (BBIRD). BBIRD is a national cooperative program (including the Forest Service) that allows participants to share and compare data and allows examination of large-scale patterns and trends in breeding bird populations. Depending on the number of species being monitored and the size of the habitat being searched for nest, anywhere between 4 and 8 people usually search for nests on sites they visit on alternating days. Again, the cost of such an effort will depend on the experience level of the nest searchers and the length of the breeding season.

A final approach for monitoring populations is censussing. There are four general census methods; point counts, spot-mapping, strip counts and area searches.

Point counts are the best approach for most surveys and have been adopted as the standard method for monitoring most bird populations (Ralph et al. 1993, 1995). The two most suggested types of point counts are 1) extensive point counts which are intended to sample a series of points over a large region, and 2) intensive point counts which are placed within a local area like a mist net plot or nest search plot. The specific goals and objectives of the monitoring scheme will determine which approach is most appropriate. The benefits of standardized point counts are that a much larger area can typically be covered than when using constant effort mistnetting and nest searches and actual estimates of population size can be estimated. The drawbacks of these approaches are that they do not provide any data on the reproductive success of a species or any of the individual level parameters such as age and sex ratios. In both point count methods, observers with good identification skills are needed for a minimum of three to four hours a day depending on the distance between sampling points (Ralph et al. 1993). These considerations will also determine the cost of implementing such a plan.

Strip counts or strip transects are similar to point counts, but the observer records all birds seen or heard while traversing a trail or pre-defined area (Ralph et al 1993). This method is primarily used in very open terrain and not recommended for forested areas (Ralph et al. 1993).

Area searches are described above under inventory approaches. This method can be a particularly cost-effective way of counting birds when a large number of people are involved. For example, if a large number (> 20) of volunteers are available each person can survey all the birds in a given area.

ADDITIONAL INFORMATION NEEDS

In comparison to many of North America's songbirds, much information is known about the biology of the pygmy nuthatch. However, most of this information is based on populations from Arizona and California and very little is known about populations in the

Black Hills. It is well established from this prior work that pygmy nuthatch populations reach their highest densities in forests with high snag densities and high foliage volume. However, the lack of data for the Black Hills makes it difficult to know what the current status of pygmy nuthatch populations are and how they respond to natural and human activities. In addition, because the pygmy nuthatch is considered a sensitive species at the regional level within the Forest Service (i.e. Region 2), any local efforts to develop a conservation strategy would benefit from coordinating efforts at the regional level. Such coordination could provide greater insight into the status of pygmy nuthatch populations at a larger scale. Below are the suggested prioritized additional information needs to develop a scientifically sound conservation strategy for the pygmy nuthatch in the Black Hills.

Estimates Of Local Abundance And Distribution

The first and most important step in establishing a conservation strategy would be to conduct a forest-wide survey to determine the distribution and abundance of pygmy nuthatch populations. A modified point-count method is suggested as the most effective method to census specifically for pygmy nuthatches (or for a group of species that includes the pygmy nuthatch). The sampling area should cover all forest stand types that include ponderosa pine, including but not limited to a range of habitat types from mature undisturbed forest to heavily logged or disturbed sites. Each sampling unit within the entire sampling area should be a minimum of 40 ha to allow for thorough coverage and increased chance of detection. Counts should be conducted in late spring and early summer to coincide with the time of the breeding season, and additional counts can be made in early fall to obtain a non-breeding estimate. Finally, before embarking on any population monitoring/census some attempt should be made to establish statistical power and effect size to ensure the resulting data will provide the necessary inference. Estimates of local abundance and distribution are a particularly important first step, considering that previous censuses in potentially good habitat have not recorded sufficient sample sizes of pygmy nuthatches (e.g. Mills et al. 1996). Supplementing estimates of pygmy nuthatches with information on important habitat features, such as snag availability, could provide insight into the small sample sizes of nuthatches in what appear to be good habitat. Additionally, these data can be incorporated into existing forest stand data in conjunction with already available HABCAP models (Mills et al. 1996; Rumble et al. 2000) to examine habitat associations and amount of potential habitat available. Conducting these censuses is a relatively inexpensive way of assessing baseline estimates of abundance, distribution, and habitat associations. Information obtained from these censuses will allow further investigation into more detailed questions such as snag availability within different landscapes and effects of different management activities.

Habitat Requirements Associated With Reproductive Success

Measures of population abundance alone can be misleading indicators of habitat quality and population health (e.g. Van Horne 1983). In order to accurately assess the population status of pygmy nuthatches in the Black Hills, information is needed on the reproductive success of birds nesting in different habitat types. Of the different protocols available for measuring reproductive success, it is suggested that a BBIRD type methodology be given priority. This method combines nest searching with a vegetation sampling scheme that measures those features of the habitat that are correlated with high reproductive success. Vegetation sampling should be done at different scales that encompass the nest site, the territory, and the landscape matrix. Specific attention should be paid to nest site characteristics such as the diameter of snags used for nesting and the availability of snags within the territory. Comparisons between used and unused snags would also be useful in determining preference. Nest success and vegetation data collected could then be incorporated into a GIS based program to examine the spatial distribution of reproductive success and the habitat features associated with it. This approach could also be combined with management activities such as timber harvesting and prescribed fires to look at before and after effects of different habitat alterations.

Local Movement Patterns

The existing information suggests that pygmy nuthatches have very limited movement patterns, and this lack of movement may make them vulnerable to the effects of habitat fragmentation. Information on local movement patterns can be obtained by following individual birds over the course of a year. Such an approach would provide a number of important data sets. First, either through re-sighting of banded birds, or use of radio-telemetry, individuals can be followed to determine the size of territories and scale of movement on the landscape. Questions that could be addressed include whether particular habitats are avoided, are there important corridors that connect habitats, and what are the vegetation features associated with these areas. Another approach to answering these questions could be to use genetic markers, which would provide information on gene flow and effective population size. Combining this type of genetic data with actual movement patterns of individuals would be a particularly informative project.

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DEFINITIONS

Dispersal - movement by an organism, usually juveniles, to territories away from their site of birth.

Krumholtz - dwarf, wind-sculpted conifers at timberline.

Gene flow- the exchange of genes between distinct populations.