West Virginia Northern Flying Squirrel
(Glaucomys sabrinus fuscus)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
West Virginia Field Office
Elkins, West Virginia

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I. GENERAL INFORMATION

I.A. Methodology used to complete the review: This review has been conducted through the joint efforts of the West Virginia Field Office (WVFO) and the Northeast Regional Office. The squirrel's status was reviewed and threats were assessed in an in-house workshop held on October 29-30, 2003, and an initial draft of the review was prepared in 2003-2004. Additionally, the WVFO initiated two meetings with academic and agency experts to discuss the threats assessment. The new information that has been compiled since listing, combined with the initial draft review, provides the foundation for this 5-year review.

I.B. Reviewers

Lead Regional Office:	Region Five, Hadley, MA; Mary Parkin, 617-876-6173
Lead Field Office:	West Virginia Field Office, Shane Jones, 304-636-6586
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I.C. Background

I.C.1. FR Notice announcing this review: 70 FR 38976 (July 6, 2005)

I.C.2. Species status: Although there have been 10 new capture sites[1] for *Glaucomys sabrinus fuscus* since the year 2000, species status has been reported as "stable" for the past five years. This determination has been based on persistence of *G.s. fuscus* at long-term nest box monitoring sites throughout its range and little or no change in threats from the previous year; however, based on this review, we anticipate upgrading the squirrel's status during the next recovery data call.

I.C.3. Recovery achieved: In the 2004 Recovery Report to Congress, "recovery achieved" was reported as category 3, i.e., between 51-75 percent of the recovery needed to reach delisting criteria (as laid out in the 1990 recovery plan) has been accomplished. This is indicative of the number of recovery actions that have been implemented and the estimated progress toward full recovery based on the successful outcome of implementation efforts. As with the species' status, we anticipate upgrading this measure of progress during the next recovery data call.

[1] The West Virginia Division of Natural Resource (WVDNR) defines a site as a capture location greater than 0.5 mile from another capture location: hence capture sites may contain multiple locations where squirrels were captured. This definition was based on home range estimates available when the surveys began (e.g., Urban 1988).

I.C.4. Listing history:

FR notice: 50 FR 26999
Date listed: July 1, 1985
Entity listed: Subspecies
Classification: Endangered

I.C.5. Associated rulemakings: not applicable

I.C.6. Review history: This review constitutes the first 5-year status review of *G.s fuscus* since its listing. Information that has become available since the 1985 rule has been used to evaluate and assess the current status of the squirrel. In a 1994 letter to the Service, Craig Stihler, endangered species biologist for West Virginia Division of Natural Resources (WVDNR), requested a review of this subspecies' status and recommended that downlisting from endangered to threatened be considered (WVDNR 1994).

I.C.7. Species' current Recovery Priority Number at start of review: *G.s. fuscus* currently has a recovery priority number of 9c, indicating a moderate degree of threat, high recovery potential, and conflict with economic development for this subspecies.

The current ranking was last updated in September 2005. At that time, the ranking took into account the persistence of populations throughout the current range; historical declines in available habitat; and perceived threats from acid deposition, climate change, genetic isolation, habitat fragmentation, and exotic forest pests. Since then, it has been determined that the threats listed above have been abated. Although climate change and acid deposition present more intractable management challenges, they show no evidence at this time of having a detrimental effect on the species. As indicated by the "c" appellation, *G.s. fuscus* conservation may conflict with timber harvest and land development interests in localized parts of the subspecies' range.

I.C.8. Recovery Plan or Outline:

Name of plan: Appalachian Northern Flying Squirrels (*Glaucomys sabrinus fuscus* and *Glaucomys sabrinus coloratus*) Recovery Plan

Date issued: September 29, 1990

Dates of revisions/updates: September 2001, Appendix A of the plan, "Guidelines for Habitat Identification and Management for *G s. fuscus*", was amended in order to promote more effective recovery of the *G.s. fuscus* on Federal lands, primarily the Monongahela National Forest (MNF). The update prescribed that, during Section 7(a)(2) consultation, all areas of suitable habitat should be assumed to be potentially occupied. Assumed presence in suitable habitat is thought to be more appropriate and, in many cases, more protective because the squirrels are less likely to use nest boxes or enter traps in good quality habitat due to the abundance of natural den sites and preferred foods in these areas (USFWS 2001). Because this amendment acknowledges the weakness of conducting live trap surveys or nest box monitoring to prove or disprove presence of the squirrel, its basic intent is to protect *G.s. fuscus* habitat considered suitable without

having to provide such proof. As a result of this plan update, presence/absence surveys are no longer necessary for projects in suitable habitat subject to Section 7(a)(2) consultation. However, if surveys are conducted, negative results from these surveys do not absolve a Federal entity from ESA responsibility.

Recognizing the affirmative conservation responsibilities for the Federal government under Section 7(a)(1) of the ESA and the more limited responsibility of the non-Federal entities to simply avoid unauthorized "take", the recovery plan amendment is specific to Federal projects. However, because assuming presence in suitable habitat is considered more protective of the squirrel, the Service has encouraged non-Federal entities to adopt a similar approach on their properties.

II. REVIEW ANALYSIS

II.A. Application of the 1996 Distinct Population Segment (DPS) policy

II.A.1. Is the species under review listed as a DPS?

____ *Yes*
_x_ *No*

II.A.2. Was the DPS listed prior to 1996? Not Applicable

II.B. Recovery Criteria

II.B.1. Does the species have a final, approved recovery plan containing objective, measurable criteria?

_x_ *Yes* (but see below)
____ *No*

Although the recovery criteria as they apply to *G.s. fuscus* were deemed objective, measurable, and adequate when the plan was approved in 1990 and updated in 2001, they do not meet current standards for adequacy. The updated Appendix A guides implementation of habitat identification and management on the MNF; otherwise, the plan is not actively used to guide recovery for two reasons: first, it was developed over 15 years ago and needs updating, and, second, its recovery criteria and actions are, for the most part, combined and generalized for both *G.s coloratus* and *G.s. fuscus.*

II.B.2. Adequacy of recovery criteria:

II.B.2.a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?

____ *Yes*
_x_ *No*

The 1990 recovery plan does not have up to date recovery criteria that is based on the threats to the species. The plan contains downlisting and delisting criteria that are directed largely toward maintaining populations and protecting habitat within designated Geographic Recovery Areas (GRAs)[2] for the two Appalachian northern flying squirrel subspecies. Recent publications and information assimilated as part of this 5-year review and habitat conservation planning have shed new light on the appropriateness of the GRA nomenclature for *G.s. fuscus*. New information has also become available with reference to the plan's threat-based recovery criteria.

II.B.2.b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or additional threats)?

____ *Yes*
_x__ *No*

II.B.3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information. For threats-related recovery criteria, note which of the 5 listing factors are addressed by that criterion. Also note which, if any, of the 5 listing factors are not relevant to this species.

Downlisting Criteria:

1. Squirrel populations are stable or expanding (based on biennial sampling over a 10-year period) in a minimum of 80% of all Geographic Recovery Areas (GRA) designated for the subspecies;

2. Sufficient ecological data and timber management data have been accumulated to assure future protection and management; and

3. GRAs are managed in perpetuity to ensure: (a) sufficient habitat for population maintenance/expansion and (b) habitat corridors, where appropriate elevations exist, to permit migration among GRAs.

Delisting Criterion:

In addition to all the criteria above:

4. The existence of the high elevation forests on which the squirrels depend is not itself threatened by introduced pests, such as the balsam wooly adelgid, or by environmental pollutants, such as acid precipitation or toxic substance contamination.

Although habitat-related threats are addressed in the delisting criterion and threats abatement can be inferred to some extent from meeting the population- and habitat-based

[2] Unlike Recovery Units, no formal or regulatory distinction is imparted to these areas.

downlisting criteria, the recovery criteria do not specifically address the five listing factors. The recovery plan does not, therefore, provide an explicit reference point for determining the appropriate legal status of *G.s. fuscus* based either on alleviating the specific factors that resulted in its initial listing as an endangered species or on addressing new risk factors that may have emerged since listing. Additionally, the current known range of the species is much more widespread than the GRAs designated in the recovery plan. Therefore, this review focuses on the five-factor analysis that compares current conditions to known conditions at the time of listing.

II.C. Updated Information and Current Species Status

II.C.1. Biology and Habitat

G.s. fuscus is a small, nocturnal, gliding mammal endemic to the Alleghany Highlands of West Virginia and Virginia. This rodent is relatively short-lived with an average life span of about four years. A recent biological opinion for *G.s. fuscus* (USFWS 2006) compiles the best available scientific information for this subspecies, including a habitat quality ranking (Appendix A). This information indicates that *G.s. fuscus* is a genetically distinct Pleistocene relict confined to the montane boreal forests of the central Appalachians (USFWS 1990; Urban 1988; Payne et al. 1989; Stihler et al. 1995; Weigl et al 1999; Sparks 2005; Menzel et al. 2004, 2006a, 2006b;,Arbogast et al. 2005). Within this range, *G.s. fuscus* primarily use spruce, mixed spruce-northern hardwood, and open habitats (Ford et al. 2006). While the squirrel nests mainly in tree cavities, it will utilize drey nests (Hackett and Pagels 2003, Menzel et al 2004 and Menzel et al. 2000). Food habits of *G.s. fuscus* indicate reliance primarily on hypogeal fungi (truffles) and lichens, rather than upon hard mast (Maser et al. 1986, Maser and Maser 1988, Maser et al. 1978, Carey et al. 1999, Loeb et al. 2000 and Mitchell 2001); Loeb and others further observed an associative link of truffles with the roots of red spruce trees rather than with hardwood tress species (Ford et al. 2004). Therefore, the presence of red spruce (Urban 1988, Payne et al. 1989, Weigl et al. 1999, Hackett and Pagels 2003) and the forest structure (Carey 1989, Carey 1991, Carey 1995, Carey et al. 1999, Rosenburg 1990, McDonald 1995, Mowry and Zasada 1982) are deterministic factors for *G.s. fuscus* breeding and feeding habitat.

Overall, available information indicates that forests containing red spruce and old-growth characteristics provide optimal habitat conditions for *G.s. fuscus* in comparison to hardwood forests that are younger and/or degraded, which provide fewer nest cavities and food resources. Despite the preference for mature spruce forests, *G.s. fuscus* has shown the ability to persist in and around remnant patches of red spruce.

II.C.1.a. Abundance, Population Trends:

New population information available since the time of listing includes the following:

- Presence/absence surveys using nest box checks and live-trapping to record squirrel occurrences (1985-present). This includes approximately 30 long-term nest box sites that have been monitored for at least 10 years by the WVDNR and personnel from the MNF (WVDNR 1987-2002).
- Search efforts on private land via live-trap surveys over the past five years have increased in response to an increased awareness of the ESA in conjunction with proposed energy, highway, and private lands projects in potential habitat outside the MNF and across the squirrel's range
- Nest box surveys, live-trapping, and telemetry efforts conducted by academia, e.g., West Virginia University and the Forest Service's Northeastern Research Station (last ten years)

- An 11-year inventory (1985-1996) conducted by the Virginia Department of Game and Inland Fisheries (VDGIF) on private and public lands Virginia, including the Allegheny Highlands of Highland County, Virginia (Reynolds *et al.* 1999).

To date, there have been 1,141 captures (including 78 recaptures) at 105 sites in West Virginia and two sites in Highland County, Virginia. This includes 10 new capture sites since 2000 (see II.C.1.d.). Capture sites may contain multiple locations where squirrels were captured. The number of individual *G.s. fuscus* encountered at a capture site has ranged from one to 59. Forty-two (40 percent) of the capture sites have a single record of presence (likely the result of a project clearance survey), and the other 65 capture sites (60 percent) document *G.s. fuscus* occurrence through time. Although most of the sites with captures over multiple years are nest box monitoring sites, the nest box monitoring program[3] has had only a 2 percent average success rate of squirrel occupancy per box checked. These data confirm the difficulty of capturing squirrels via nest boxes and caution against relying on nest box survey results to determine occupied habitat, i.e., although a captured individual affirms presence, an empty nest box does not necessarily signify absence or unoccupied habitat.

Despite the limitations in nest box monitoring, long-term nest box monitoring data from over 30 sites provides evidence of the continued presence of *G.s. fuscus* in an area over several years or decades. Reproduction has been confirmed at 65 percent of these sites through the capture of nestlings, and juveniles captured at about the same percentage, suggesting recruitment. Since *G.s. fuscus* has a relatively short life span, averaging approximately 4 years, persistence at a single next box site for any amount of time over 5 years indicates successful reproduction and the presence of multiple generations. Appendix B provides additional information for the 105 sites in West Virginia. *G.s. fuscus* presence has continued at all long-term nest box monitoring sites, although the length of documented occurrence is limited by data collection efforts. For example, while *G.s. fuscus* presence at Stuart Knob was first documented in the 1950s and monitoring verifies its continued presence there, *G.s. fuscus* presence at Kumbrabow State Forest was first confirmed in 2001; therefore, the length of documented occurrence at Kumbrabow State Forest is less than five years compared to several decades at Stuart Knob.

II.C.1.b. Genetics, genetic variation:

A microsatellite DNA analysis for *G.s. fuscus* was initiated in the mid-1990s to provide information on genetic diversity and isolation between the population centers; however, the DNA could not be amplified. More recently, a very limited study by Sparks (2005) attempted to assess inbreeding in two Mount Rogers National Recreation Area (MRNRA) populations of unresolved taxonomic status (see section II.C.1.c of this review), as well as in two West Virginia *G.s. fuscus* populations. Another study by Arborgast and others (2005) assessed the genetic status of the two listed *G. sabrinus* subspecies (*G.s. fuscus* and *G.s. coloratus*). The Service's review of these studies raised questions about the adequacy of sampling methods and data interpretation; nonetheless, the results of these studies indicate no cause for concern about inbreeding threats in *G.s. fuscus* populations. While Sparks surmised that isolated *G.s. fuscus* are susceptible to increased inbreeding and suggested that establishment of habitat corridors would increase the long-term genetic health of this subspecies and other boreal fauna, the Service recognizes that long-

[3] During nest box monitoring, biologists place nest boxes in an area and check the boxes periodically for occupancy, typically twice each year, once in the fall and spring. Northern flying squirrels are nocturnal, leaving their nests to forage at night and returning during the day, which facilitates daytime nest box monitoring. Nest box monitoring results are contingent upon squirrels occupying the boxes on the day of the survey. In her radio telemetry study, Menzel (2003) found *G.s. fuscus* only in cavities or drey nests (despite the availability of nest boxes in the area) and further noted that *G.s. fuscus* used multiple den sites, switching nests on average every 3 days in summer.

standing isolation can produce important local adaptations that could be compromised through artificially-induced connectivity. There is currently no information to support either inbreeding or outbreeding threats to known *G. s. fuscus*.

II.C.1.c. Taxonomic classification:

G.s. fuscus is a formally recognized subspecies, genetically and morphologically distinct and geographically separate from *G. sabrinus* to the north (in north-central Pennsylvania) and to the south (in North Carolina and Tennessee) and from the remainder of the species (Miller 1936, Handley 1953, Arbogast 1999). The only taxonomic question with regard to this subspecies is the status of northern flying squirrel populations in southwestern Virginia.

The 1985 listing of the two Appalachian northern flying squirrel subspecies, *G.s coloratus* and *G. s. fuscus*, cited Handley's (1979) description of the Mt. Rogers/Grayson Highlands population of squirrels in southwestern Virginia (Highland, Smyth, and Grayson Counties) as *G.s. fuscus*. Reynolds et al. (1999) subsequently completed a morphological study of northern flying squirrels in the area, finding tail-length measurements more similar to *G.s. coloratus*. Nonetheless, they concluded that "the taxonomic status of the northern flying squirrel in southwestern Virginia is not adequately determined." Sparks (2005; see II.C.1.b) failed to resolve the taxonomic status of the southwestern Virginia populations, and Service review suggests that the study was constrained by insufficient numbers of populations, individuals, and loci sampled and reliance on samples from museum specimens.

Although the 1990 recovery plan treated the southwestern Virginia *Glaucomys sabrinus* population *as G.s. coloratus* for management purposes, both the plan and the information that has become available since then leaves the taxonomy of this population as an open question. This uncertainty is only germane to the ESA status of *G.s. fuscus* if the MRNRA populations play a critical role in assuring the persistence of this subspecies; see section II.D of this review. In the event that recovery planning efforts for *G.s. coloratus* determine a potentially important role for the southwestern Virginia population, it may be appropriate to pursue further taxonomic research in the context of *G.s. coloratus* recovery.

II.C.1.d. Spatial distribution, trends in spatial distribution:

The historic range of *G.s. fuscus* is thought to be consistent with the historic old growth spruce forests within the Allegheny Highlands. Prior to European settlement, there were in excess of 500,000 acres (some sources suggest 600,000 acres) of old-growth spruce forests (i.e. optimal *G.s. fuscus* habitat) in the Allegheny Highlands. These forests extended from the vicinity of Mount Storm (Grant County) in the north to Cold Knob (Greenbrier County) in the south, east to the Allegheny Front (Pendleton County), and west to Webster and Nicholas Counties in West Virginia, occupying ridges, slopes, and drainages. These spruce forests were more contiguous across the Allegheny Highlands than are the well-known "sky-islands" of the Southern Appalachians (Bailey and Ware 1990), which support *G.s. coloratus.* At the periphery of the Allegheny Highlands in all directions, the topography changed, and the plateau became more broken by lower elevation valleys.

At the time of listing, 10 *G.s. fuscus* specimens had been collected from four geographic areas or 'population centers' in the Allegheny Highlands: Laurel Fork (Highland County, VA), Cranberry Glades (Pocahontas County, WV), Cheat Bridge/Cheat Mountain (Randolph County, WV), and Stuart Knob (Randolph County, WV)(Figure 1).

Currently, *G.s. fuscus* is known to occupy 107 widely dispersed sites (105 sites in West Virginia and at two sites in Virginia) (Figure 2). Based on these capture sites, the current known range of *G.s. fuscus* follows the spine of the high Allegheny Plateau in a northeast to southwest alignment. Helmick Run

(Grant County, WV) marks the northeast periphery and Briery Knob (Greenbrier County, WV) the southwest periphery, covering seven counties in West Virginia and Highland County, Virginia. The 107 capture sites are dispersed across 7 general areas of relict habitat in the Allegheny Highlands region (Figure 3):

- Cranberry Glades/Upper Williams (Pocahontas, Webster Co., WV)
- Gauley Mountain (Randolph, Webster, Pocahontas Co., WV)
- Kumbrabow/ Mead Westvaco Experimental Research Forest (Randolph County, WV)
- Cheat Mountain (Randolph, Pocahontas Co., WV)
- Spruce Knob/Laurel Fork (Pocahontas, Randolph, Pendleton Co., WV; Highland Co., VA.)
- Stuart Knob (Randolph, Tucker Co., WV)
- Blackwater Canyon/Dolly Sods (Tucker, Grant, Randolph Co., WV)

In addition *G.s. fuscus* has proven to be a resilient species and despite the devastation of the historic old growth spruce forests, it is distributed extensively across the Allegheny Highlands. Its persistence is largely due to the mobile nature and plasticity in nest tree selection. Studies have confirmed the ability of *G.s. fuscus* to adjust its activity patterns and use of space to persist in and around relict spruce and mixed spruce-northern hardwood patches of forest to meet their ecological requirements for food and den resources.

II.C.1.e. Habitat or Ecosystem Conditions

Currently, it is estimated that there are approximately 242,000 acres of *G.s. fuscus* habitat. This estimate is based in part on the results of several habitat models, and includes all "optimal" habitat as well as "likely"[4] habitat located adjacent or in close proximity to red spruce forests. These habitat models are described below.

Odom and others (2001) derived a squirrel habitat model from topographic conditions and proximity to conifer cover, which emphasized the importance of spruce for squirrel habitat. A more recent model in 2003 by Menzel, delineates areas of the Allegheny Highlands in which squirrels are likely to occur based on elevation, aspect and vegetative composition. Derived from habitat use and availability studies in West Virginia, Menzel's model (Menzel 2003) incorporated high resolution aerial photography for vegetation characteristics. While much more rigorous than previous work, this effort further emphasized the squirrel's dependence upon red spruce. Areas with greater than 50 percent predicted probability of use by squirrels are classified as "likely" habitat, while areas with a greater than 75 percent predicted probability of use by squirrels are classified as "optimal" habitat. The model was applied only to USGS 7.5 min quads within the Monongahela and George Washington/Jefferson National Forests showing areas from which squirrels had been recorded (Menzel 2003).

In 2006, the Menzel model was manipulated to include a rangewide approximation (Figure 4). This included the original Menzel model and topographic quadrangles without captures, or areas outside the proclamation boundary for the MNF (WVFO files, Menzel et al. 2006b). Although the models do not take into account forest structure and do not address the extent and quality of habitat needed to support a viable *G.s. fuscus* population, they do allow us to estimate the amount of potential and high quality habitat in the Allegheny Highlands, prioritize areas for restoration and recovery, assess anthropogenic and geologic fragmentation of the spruce forest, and analyze stewardship of the suitable habitat.

[4] 'Likely' and 'optimal' are terms and definitions imparted by the Menzel model (Menzel 2003). In summary, 'likely' areas have a better chance than not of being occupied by the squirrel (i.e. >50% chance); and 'optimal' areas have a >75% probability of being occupied.

Based on the 2006 model, there are approximately 47,350 acres of optimal *G.s. fuscus* habitat. These areas have a greater than 75 percent chance of being occupied by *G.s. fuscus* based on their position on the landscape and the presence of red spruce. This was confirmed through habitat use studies. Studies in West Virginia indicate that *G. s. fuscus* primarily use spruce and mixed spruce-northern hardwood forests, while passing freely through limited areas of open habitats surrounded by forest. This generalist approach to nest site selection has made it possible for *G. s. fuscus* to persist in and around relict spruce and mixed spruce-northern hardwood patches despite the past natural habitat changes and the more catastrophic anthropogenic forest disturbances in the last century. Therefore, while areas modeled as optimal habitat only identify red-spruce dominated forests, we know that squirrels use forested habitat dominated by hardwoods that are adjacent to red spruce. As such, this estimate of optimal habitat underestimates areas currently utilized by *G.s. fuscus*. The Menzel model estimates over 600,000 acres of likely *G.s. fuscus* habitat. Even though these areas have a better chance than not (i.e. >50%) of being currently occupied by *G.s. fuscus* based upon their elevation, aspect and position on the landscape, some areas modeled as likely currently do not provide *G.s. fuscus* habitat. Areas modeled as likely that are currently unsuitable to the squirrel include areas that burned and have subsequently been replaced by mixed mesophytic forests (e.g. Oak); areas far-removed from a larger stand of red spruce forest; or other very localized areas cleared from past anthropogenic affects. While areas identified as likely habitat by the Menzel model are thought to approximate the historic extent of the range of *G.s. fuscus*, it is an over-estimate of habitat currently, or even potentially, available to *G.s. fuscus*. Generally, areas modeled as likely habitat located in close proximity to modeled optimal habitat[5] provide a more realistic representation of habitat available to *G.s. fuscus*.

The historic range of *G.s. fuscus* is thought to be consistent with the historic old growth spruce forests within the Allegheny Highlands. Prior to European settlement, there were in excess of 500,000 acres (some sources suggest 600,000 acres) of old-growth spruce forests (i.e. optimal *G.s. fuscus* habitat) in the Allegheny Highlands. In the final rule listing the species, it was suggested that vast stretches of unsuitable habitat separated the four known population centers in 1985. It is now recognized that there is more connectivity within and between the seven currently known general areas of relict habitat, supported by large acreages of optimal and likely habitat. Increasing connectivity is expected to continue as the current spruce and spruce/hardwood forests continue to mature. Additional spruce restoration projects already underway will only enhance the current conditions.

As further described in the threats section, the red spruce-fir forests to the north and south have been described as experiencing a general 'forest decline'. However, in a recent study in West Virginia, Rollins (2005) shows that the red spruce forest type in West Virginia is improving across representative samples (e.g. red spruce forests and northern hardwood forests with a red spruce component) in terms of forest health and expanding in terms of extent of red spruce across the landscape. This would suggest that natural regeneration of *G.s. fuscus* habitat is occurring throughout the range of the species.

II.C.2. Five-Factor Analysis

To facilitate an analysis of the squirrel's appropriate status under the ESA, a threats assessment that conforms to the five listing factors was conducted in December 2003. Identified threats were analyzed for the spatial magnitude, severity, and immediacy of their impact on the long-term survival of *G.s. fuscus*. That assessment and additional information used in this five-factor analysis are provided in Appendix C. Although the listing rule was for both *G.s. fuscus* and *G.s. coloratus*, the following analysis

[5] Based on several different movement studies in West Virginia, the average maximum distance moved by female *G.s. fuscus* from the center of their home range was approximately 500 meters (1,000 meters for males). Therefore, it is reasonable to assume that likely habitat within 500 meters of areas modeled as optimal habitat may be utilized by individual *G.s. fuscus*

applies only to *G.s. fuscus*.

II.C.2.a. Factor A. Present or threatened destruction, modification or curtailment of habitat or range

At the time of listing, it was thought that "... both subspecies still exist but that they are very rare and perhaps no longer present in much of their former range. ...(the northern flying squirrels)... have a relictual distribution, restricted to isolated areas at high elevations, separated by vast stretches of unsuitable habitat." The rarity of *G.s. fuscus* was understood to be primarily a consequence of its specialized use of a habitat type that had declined precipitously since presettlement times. Optimal habitat is reduced from historical levels, but we now know that the squirrel is more resilient in its habitat use than formerly thought and that habitat trends are moving in a positive direction in terms of forest regeneration and conservation.

Habitat loss and degradation
G.s. fuscus is dependent upon the red spruce ecosystem and mixed spruce-northern hardwood forests of the Allegheny Highlands. Historical logging activity and associated wide-spread fires led to replacement of most of the old-growth forest by northern hardwood forests with a much reduced conifer component (Adams and Stephenson 1989, Schuler et al. 2002). The final rule qualitatively described historic habitat losses and suggested that, "[I]n these last occupied zones, the squirrels and their habitat may be coming under increasing pressure from human disturbances such as logging and development ..."

Since the time of listing, modeling has allowed quantification of habitat quantity and quality (Menzel 2003). As previously described, while the Menzel model allows for us to estimate the amount of likely and optimal habitat, both groupings of habitat misrepresent the amount of available *G.s. fuscus* habitat. However, the Menzel model does validate that within the historic range of *G.s fuscus*, over 60 percent of areas with a greater than 50% probability of being occupied is now considered secured by public ownership and/or managed for the protection of the species.

Activities contributing to habitat loss and degradation on private lands since the time of listing have been localized and/or have occurred on the periphery of the species' range. These activities include limited highway development, recreational development (primarily at Canaan Valley and Snowshoe Mountain), mining/gas exploration, and wind farm development. Activities such as these are expected to continue on private lands. While some low level of local impacts are likely to continue into the future, there is no indication that the activities would occur over a landscape level, or at such a magnitude as to pose a threat to the continued existence of *G.s. fuscus*.

While the structure of *G.s. fuscus* habitat is degraded in comparison to historic conditions, the forested areas used by the squirrel have matured over the 20 years since listing across most of the squirrel's range. For example, on the MNF, approximately 24,330 acres of optimal *G.s. fuscus* habitat are more than 75 years old. This encompasses about half of the rangewide area modeled as optimal habitat. We assume that, with the exception of localized habitat impacts, improved forest structure, through forest succession, reflects a continuing and rangewide trend. With regard to forest composition, the amount and extent of red spruce also appears to be gradually increasing, as suggested by Rollins (2005).

Range and habitat connectivity
We now know that *G.s. fuscus* continues to occupy the areas identified in the final rule as well as numerous additional sites. The location of these sites indicates that the squirrel's current range roughly approximates the extent of its historical range. Studies have confirmed the ability of *G.s. fuscus* to adjust its activity patterns and use of space to persist in and around relict spruce and mixed spruce-northern

hardwood patches of forest to meet their ecological requirements for food and den resources (Menzel et al. 2004; Menzel et al. 2006a, b; Ford et al. 2004; Menzel 2003). The squirrel's resiliency is largely attributable to their mobile nature and plasticity in nest tree selection.

Protection and Management Activities
Since the time of listing in 1985, land stewards, biologists, and conservation groups have undertaken a number of measures to benefit the northern flying squirrel and the ecosystem upon which it depends. Collectively these measures cover the majority of the range of the squirrel.

Federal Lands:

Monongahela National Forest. The MNF harbors the majority of the squirrel's habitat, including over 80 percent of its optimal habitat (Menzel 2003). Importantly, approximately 65 percent of the likely habitat in close proximity to optimal habitat[6] occurs on the MNF. In addition, approximately 34% of the habitat on the MNF is currently protected by management designations of Wilderness, Backcountry, Semi-primitive, or Special Use Areas. It is likely that this habitat will be conserved through passive management, regardless of ESA status, because of the prohibition of commercial timber management in areas allocated to these management prescriptions. Adjustments to allow timber management or other actions that would adversely affect squirrel habitat in Wilderness and Special Use Areas would need agency level or Congressional approval. With regard to Backcountry and Semi-primitive Areas, the MNF's intent is that existing allocations will remain in place at least until the next revision in 10-15 years.

The 2001 recovery plan amendment and the 2004 amendment to the MNF Land and Resource Management Plan significantly removed the threat of habitat loss (via logging) across much of the squirrel's range. The recovery plan amendment required that suitable *G.s. fuscus* habitat be deemed potentially occupied for projects subject to ESA section 7(a)(2) consultation. This was reinforced through an amendment to the MNF Land and Resource Management Plan, which stated that vegetation management in all "suitable habitat" (as determined collaboratively by the Forest, Service, and WVDNR) can only occur under limited situations that include: research covered under an ESA Section 10 permit; actions to improve or maintain *G.s. fuscus* populations after research has demonstrated the beneficial effects of the proposed management; or when project-level assessment results in no adverse effects. This conservation strategy, which resulted in the Forest Service avoiding all detrimental impacts to G.s fuscus habitat, has been carried forward into the proposed Forest Plan Revision.

We expect additional habitat on the MNF to be protected in the future through adoption of the proposed Forest Plan Revision, anticipated for summer 2006. Approximately 10,600 acres of optimal habitat (or approximately 20-25 percent of the rangewide optimal habitat) and 76,200 acres of likely habitat in close proximity to optimal habitat (30-35 percent of the rangewide total) likely will become protected, irrespective of the ESA. These areas comprise existing or proposed Wilderness, Backcountry or Special Use Areas on the MNF and the likelihood of their protection for the foreseeable future is described above. Additionally, the proposed Management Prescription 4.1(Spruce and Spruce-Hardwood Restoration) focuses on restoration and management of disjunct red spruce and spruce-hardwood communities of the central Appalachians (i.e., *G.s. fuscus* habitat) within a 155,000 acre area, including a goal to conduct species composition and enhancement work on 3,000 to 5,000 acres over the next 10 years.

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[6] As described in Section II.C.1, the Menzel model of likely habitat is an over-estimate of habitat currently or potentially available to *G.s. fuscus*. Furthermore, based on the generalist approach to nest site selection of *G.s. fuscus*, combined with the preference towards areas in close proximity to red spruce, areas modeled as likely habitat located adjacent to optimal habitat provide a more realistic representation of available habitat.

George Washington/Jefferson National Forest (GWJF). According to the Menzel model, approximately 25,250 acres of *G.s. fuscus* habitat occurs in Highland County, Virginia. Of this area, approximately 50 percent occurs on the George Washington/ Jefferson National Forest, 80 percent of which is within the Laurel Fork semi-wilderness backcountry area and, therefore, protected by the same measures as described above, regardless of the listing status of *G.s. fuscus*. The GWJF has initiated revision of their Forest Plan, and emphasis will be placed on conservation of the squirrel and its habitat, regardless of ESA status.

Canaan Valley National Wildlife Refuge. The Canaan Valley NWR, established in 1994, includes 2,800 acres of spruce-northern hardwood forests in the northern Allegheny Highlands. The largest area of this forest type was acquired in the late 1990s, and the first northern flying squirrel was recorded on the Refuge in spring of 2003. There are no observed threats to *G.s. fuscus* and its habitat on the Refuge. Habitat restoration efforts (e.g., red spruce planting) are underway, and studies are ongoing to determine active habitat restoration potential and best management practices for the squirrel on Refuge lands.

Non-federal Lands:

The following *G.s. fuscus* conservation measures have occurred or are being pursued on non-federal lands.

- In 2000, the West Virginia Division of Forestry (WVDOF) approached the Service with the intent of serving as a model for the private land owner in conservation of endangered species. For the last four years, the Service has worked with the WVDOF on an intermittent basis to develop a Safe Harbor Agreement for *G.s. fuscus* habitat at Kumbrabow State Forest, which encompasses 6,680 acres of likely and 645 acres of optimal habitat. This is significant in that this area is located west of the National Forest proclamation boundary and is disconnected from the heart of the squirrel's range; thus, it added to the known range of the squirrel (until 1997, it was thought that the squirrel was extirpated from this area because of the devastating impacts to the red spruce forest from the industrial timber era and the area's naturally disjunct character). The WVDOF expects to continue working with the Service to implement management prescriptions for the squirrel regardless of its ESA status.

- Snowshoe Mountain, Inc. has completed two HCPs for *G.s. fuscus* : Camp Wilderness (BHE 2003) and Recreation and Infrastructure Expansion at Snowshoe (BHE 2006). These HCPs include several strategies for minimizing, avoiding, and mitigating for the loss of habitat and possible take of the northern flying squirrel. As a consequence, habitat conservation planning has resulted in the permanent protection of 200 acres of *G.s. fuscus* habitat while authorizing loss of approximately 80 acres. Snowshoe has expressed an interest in continuing habitat conservation for the squirrel at Snowshoe Mountain, regardless of ESA status. Snowshoe Mountain harbors 5,567 acres of likely habitat and 3,400 acres of optimal habitat. The optimal habitat at Snowshoe is over 50 percent of the total area of optimal habitat that is privately owned. Snowshoe Mountain is located in the core of the squirrel's range and is the southern extent of the Cheat Mountain area. The Cheat Mountain area is considered an Ecoregional priority according to the Nature Conservancy (TNC).

- As summarized in a letter to the Service from TNC (dated August 18, 2005), TNC has identified several major landscapes for conservation of *G.s. fuscus* and the red spruce forests, including the Cheat Mountain Conservation Area, the Canaan Valley/Dolly Sods Conservation Area, the Spruce Knob Conservation Area, and the Cranberry Conservation Area. In addition to the emphasis TNC has placed on restoration of the spruce ecosystem, conservation measures

facilitated by TNC have included:

- The purchase of 57,000 acres of mineral rights on Cheat Mountain and over 2,000 acres of surface rights in high elevation red spruce/northern hardwood forests, which were transferred to the MNF;
- Creation of a nearly 100-acre preserve within the red spruce forest on the Shavers Fork River;
- Contribution of a grant to the Service to complete the purchase of a 450-acre tract that became a part of the CVNWR;
- The award of two Private Stewardship Grants from the Service to restore red spruce;
- Completion of a 100-acre conservation easement on Spruce Mountain.

- Another few thousand acres of likely *G.s. fuscus* habitat occurs on State-owned lands at the Handley Wildlife Management Area (WMA) and the Blackwater Falls and Canaan Valley state parks. Although timber management is not a common occurrence on the state parks, it does occur at Handley WMA, the Service has and will continue to work closely with the State to avoid adverse impacts to *G.s fuscus* regardless of its ESA listing status.

- Allegheny Wood Products (AWP) owns several hundred acres of *G.s. fuscus* habitat in and adjacent to the Blackwater Canyon in Tucker County, West Virginia. They have expressed an interest to continue working with the Service to implement management prescriptions for the spruce ecosystem, regardless of the squirrel's ESA status.

- Other land stewards have expressed interest in spruce restoration on their properties.

The Service is working with the Federal and Non-federal land stewards described above to secure long-term commitments through Memoranda of Understanding or other instruments, to continue conservation efforts already initiated to protect, manage, restore, and monitor *G.s. fuscus* and its habitat, irrespective of its listing status.

Together, this information indicates that the current range of *G.s. fuscus* approximates the historical range of the species, although within this range there is less optimal old-growth spruce habitat than likely occurred across the landscape prior to industrial logging and the widespread fires associated with that activity. Further, it is improbable that the squirrel's range, which is delimited by topography and elevation, will contract in the foreseeable future. In addition, the threat of habitat loss has been largely abated across most of the squirrel's range, apart from localized impacts primarily on private lands.

II.C.2.b. Factor B - Overutilization for commercial, recreational, scientific, or educational purposes

The final rule concluded that *G.s. fuscus* and *G.s. coloratus* were not known to be jeopardized by human utilization but noted that "...flying squirrels are highly desirable as pets to some persons, and collecting for such purposes is at least a potential threat to the already rare *G.s. coloratus* and *G.s. fuscus*." However, in the 21 years since listing the Service has not received any evidence that overutilization is a threat, and given the species' rarity, nocturnal and secretive habits, and the remoteness of its habitat, there is no expectation that overutilization will emerge as a threat in the future.

Specifically, there is no evidence of commercial use in the pet trade or of recreational use of *G.s. fuscus*. In addition, collection of *G.s. fuscus* for scientific purposes has been limited. *G.s. fuscus* is a thinly dispersed mammal that is very difficult to catch. For example, Menzel captured *G.s. fuscus* at a rate of 0.227 captures/100 trap nights (Menzel 2003). The 2001 recovery plan amendment acknowledges the

limitations of conducting live trap surveys or nest box monitoring to catch the flying squirrel.

II.C.2.c. Factor C - Disease or predation

The final rule made no mention of disease as a threat to *G.s. fuscus*, and the Service is not aware of any evidence since the time of listing suggesting that the health of *G.s. fuscus* individuals is threatened by disease. Of the more than 1,100 squirrels captured since 1985, none has shown signs of debilitating disease. (However, see factor E for discussion of parasites.)

With reference to predation, the final rule predicted that increasing human recreational use in northern flying squirrel habitat might result in predation on *G.s. fuscus and G.s. coloratus* by pets, especially cats. The Service is not aware of scientific or circumstantial evidence since the time of listing to support this projected impact. As analyzed in the Service's biological opinion for the Camp Wilderness Habitat Conservation Plan (Service 2003), there are no documented occurrences of adverse effects or death of northern flying squirrels, particularly *G.s. fuscus*, as a result of impacts of human recreational use or occupancy in or near northern flying squirrel habitat. Predation induced by human encroachment has not been a threat to this species in the past and is not predicted to be a substantial threat in the future. Indeed, human encroachment per se has been uncommon and localized (e.g., Canaan Valley and Snowshoe Mountain), and this will continue to be the case, particularly since most *G.s. fuscus* habitat is found on the MNF.

II.C.2.d. Factor D - Inadequacy of existing regulatory mechanisms

The final rule stated that this factor was "not known to be applicable," perhaps meaning that there were no known existing regulatory mechanisms protecting the species prior to listing. Since listing, the ESA has been the primary regulatory mechanism providing protection for the species across its range. To ensure compliance with the ESA, the MNF Land and Resource Management Plan and the GWJF Forest Plan contain provisions to protect, manage, restore, and monitor *G.s. fuscus* and its habitat. These provisions will likely be retained in the plans for both forests irrespective of the squirrel's listing status. In addition, the National Forest Management Act and other U.S. Forest Service implementing guidance and regulations, which state that national forests should be managed to preserve and enhance the diversity of plant and animal communities, would continue to apply in the event of the squirrel's delisting. According to the Forest Service Manual, if a species is removed from the federal list of threatened and endangered species, that species would be placed on a list of sensitive species for five years, during which time the USFS would evaluate whether any of their proposed actions would result in a trend toward federal listing.

In West Virginia, outside the MNF, there are no existing regulatory mechanisms affecting private lands that provide protections for *G.s. fuscus* in the absence of the ESA, nor is it likely that such regulations will be promulgated in the future. West Virginia does not have any state laws protecting endangered species, and there are few land use regulations that would restrict activities within squirrel habitats. Nonetheless, several non-federal entities, particularly the State of West Virginia (WVDNR and WVDOF) and Snowshoe Mountain, Inc., have expressed an interest in voluntarily conserving *G.s. fuscus* habitat.

In Virginia, the squirrel is listed as endangered under the Virginia Endangered Species Act. This act, which is administered by the Virginia Department of Game and Inland Fisheries, prohibits take of state-listed species and is applicable to *G.s. fuscus* regardless of the squirrel's status under the ESA. Should the squirrel not be afforded protection under the federal ESA, it would remain protected under Virginia state law.

Overall, existing regulatory mechanisms in conjunction with continuing forest management provisions and landowner agreements make it highly likely that *G.s. fuscus* will be protected and managed for the long term across most of its range, irrespective of the subspecies' listing status under the federal ESA. This, in conjunction with improving habitat conditions, the squirrel's resiliency, and lack of rangewide threats, indicate that the long-term survival of *G.s. fuscus* can be sustained within a regulatory environment that does not necessarily include ESA protections.

II.C.2.e. Factor E - Other natural or man-made factors affecting the continued existence of the species

Impacts caused by sympatry with the southern flying squirrel

The final rule concluded that the northern flying squirrel (*G. sabrinus*, including the subspecies *fuscus*) was threatened by competition with the southern flying squirrel (*G. volans*) for habitat and by spread of a parasite from *G. volans* to *G. sabrinus*. According to the rule, "[w]hen [the southern flying squirrel] began to expand into the habitat of the [northern flying squirrel], it seems to have successfully competed with and displaced the latter species." The Service recognizes that much of the area formerly dominated by red spruce forests was replaced with northern hardwood stands with a greater hard-mast producing capacity. This increase in mast benefits the southern flying squirrel by providing a cachable, high-energy food source in a zone that is otherwise too energetically demanding throughout much of the dormant season (Ford et al. 2004).

Expanded zones of sympatry could impact *G.s. fuscus* because: (1) the southern flying squirrel is considered a superior competitor for dens where it co-occurs with *G.s. fuscus* and when inter-specific competition is not mediated by parasites (Weigl 1978, Pagels et al. 1990, Reynold et al. 1999, Sparks 2005), and (2) the southern flying squirrel may transmit the parasite *Strongyloides* (nematode) to *G. sabrinus* (Weigl et al. 1999, Ford et al. 2004). However, evidence collected since the time of listing indicates that the occurrence and potential severity of these impacts are limited. *G. volans* presence has been confirmed at 23 of the 107 *G.s. fuscus* capture sites and disproven at 38 of the sites . The sympatric occurrence of the two species has been documented for decades at many of these sites, spanning generations of *G.s. fuscus*. A case in point is Stuart Knob, where the two species have been known to co-exist since the 1950s.

Ironically, competition between the two species may be somewhat ameliorated by the spread of beech bark disease (discussed in the following section), which would result in the reduced availability of beech nuts, an important food source for *G. volans*. In any case, over-competition by *G. volans* for den sites does not appear to be affecting population persistence of *G.s. fuscus*, as indicated by the long time period over which the two species have co-existed.

With regard to the nematode parasite, the final rule cited evidence from a captive study in the 1960s, later presented at a symposium by the investigator (Weigl 1975). The final rule stated "All the [northerns] weakened and died within three months, and this mortality was associated with heavy infestations of the nematode parasite. All the [southerns] also carried the parasite, but they remained in apparent good health and continued to breed." Based on review of the original dissertation by Weigl (1968), we now know that the cause of northern flying squirrel mortality was never completely understood. Weigl (1968) concluded that the correlation between parasitism by *Strongyloides* and *G. sabrinus* mortality was not proven and was complicated by toxic substances in the captive environment. Wetzel and Weigel (1994) later proposed an ecological mechanism for a less severe impact of *Strongyloides* parasitism in wild populations compared to captive populations. They hypothesized that survival and maturation rates of *Strongyloides* are limited by below- freezing temperatures, such as occurs within the range of *G.s. fuscus*. This is bolstered by observations of *G.s. fuscus* individuals captured in the last 20 years, which have shown no signs of sickness, debilitation, or death due to parasite infestation.

It is thus reasonable to conclude that the risk of competition with the southern flying squirrel does not threaten the continued existence of *G.s fuscus*, because of the co-existence of the two species and persistence of *G.s. fuscus* through many generations. In addition, as habitat conditions continue to improve, either naturally or through active restoration efforts, the impacts associated with the presence of *G. volans* should be ameliorated, because co-occupancy is a reflection of degraded habitat conditions for *G.s. fuscus*.

Other Threats

Since the time of listing, information on other potential threats to the habitat of *G.s. fuscus* has become available. These threats include forest pests, acid rain, and climate change. We note that these threats generally pose either an unknown risk or a low to moderate degree of risk that is being addressed by adaptive management in the majority of the subspecies' range.

Hemlock and Balsam Woolly Adelgids. The balsam fir is limited to a minor component of *G.s. fuscus* habitat in the center of the squirrel's range. Because of the presence of spruce in or near stands with balsam fir, and the minor amount of *G.s. fuscus* habitat containing balsam fir, the balsam woolly adelgid is anticipated to have a discountable effect on *G.s. fuscus* habitat and is not discussed further.

The hemlock woolly adelgid, *Adelges tsugae,* has been in the United States since 1924. By sucking sap from the young twigs, the insect retards or prevent tree growth, causing needles to discolor from deep green to grayish green, and to drop prematurely. The loss of new shoots and needles seriously impairs tree health, leading to defoliation and possible death within several years. It is possible that within a decade, the hemlock will be reduced to a very minor component of the forests in West Virginia. For *G.s. fuscus* capture sites dominated by hemlock instead of red spruce (7%, or 7 of the 107 capture sites), loss of hemlock may reduce the chances of *G.s. fuscus* dispersal between patches and within meta-populations, potentially having a very local, isolating impact in a limited number of situations. While hemlock woolly adelgid may remove the montane conifer component at less than 10 percent of the known capture sites, most, if not all, of these areas are in close proximity to red spruce forests, thus significantly reducing the occasions where loss of hemlock will be detrimental to *G.s. fuscus*. Further, the associative link (as has been proven with red spruce) between the tree roots of hemlock and a valuable food source for *G.s. fuscus*, is unproven for hemlock.

Forty-four (or approximately 40%) of the 107 *G.s. fuscus* capture sites have a hemlock and spruce component. It is assumed that the effects of hemlock woolly adelgid on *G.s. fuscus* would be minor at these sites because there would still be a montane conifer component (e.g. red spruce).

The West Virginia Department of Agriculture has an active detection program for hemlock wooly adelgid (in place since 1992) and a treatment program (in place since 1999) that will remain in place regardless of the listing status of *G. s. fuscus,* due to hemlock's many values. The Service anticipates working with the West Virginia Department of Agriculture to prioritize areas of hemlock for chemical and biological treatment.

Therefore, while hemlock woolly adelgid is anticipated to impact a minor component of northern flying squirrel habitat, we consider it to pose a negligible degree of risk to *G.s. fuscus* because of the limited role of hemlock in *G.s. fuscus* survival, and presence of red spruce in the majority of areas.

Beech Bark Disease. Beech bark disease results from attack by the beech scale insect, *Cryptococcus fagisuga,* followed by one of two fungi, *Nectria coccinea* var. *faginata* or *Nectria galligena.* Most of the

actual damage to the tree is due to fungi that are able to kill the beech's cambium (the layer just beneath the bark), which is stressed by the scale infestations (Cammermeyer 1993). Depending on the tree's age and health (and to a lesser extent other environmental conditions), the fungus can either cause just a few localized lesions or can lead to the decay of the entire cambium layer and subsequent death. The roots of each dead beech tree are able to support the growth of several new sprouts. Sprouting, also called "advanced regeneration," allows beech to spread quickly and form a dense understory of beech thickets after initial die-off of mature beech trees. In 1981, when beech scale was first detected in West Virginia, the scale insect had infested beech across 70,000 acres of timberland in Randolph and Pocahontas Counties (Hoff 2005). By 2003, the beech scale had infected beech throughout the range of *G.s. fuscus,* and as of 2005, beech mortality had been noted throughout the range of *G.s. fuscus,* with the exception of Greenbrier County.

Although American beech trees are common to the spruce-northern hardwood forests of the Allegheny Highlands, in *G.s. fuscus* habitat they usually occur in combination with spruce and other hardwoods, particularly birch and maple. Despite having a devastating impact on the beech component of the spruce-northern hardwood forest of the Allegheny Highlands, it is not thought to render *G.s. fuscus* habitat unsuitable. There may also be a short-term benefit due to the creation of new nest cavities in the boles of dead and decaying beech. Further, the removal of beech nuts, a high-energy food source for the southern flying squirrel, is thought to be more detrimental to *G.volans* than *G.s. fuscus*; for example, the winter survival of *G. volans* is linked to stored nuts and large seeds (Weigl et al. 1978).

Therefore, while beech bark disease affects a minor component of northern flying squirrel habitat rangewide, we consider it to pose an overall low-to-moderate degree of risk for *G.s. fuscus*, and this risk may be offset by the potential benefits of creation of nest cavities for *G.s. fuscus* and potential harm to the food supply of *G. volans*, a competitor of *G.s. fuscus*.

Acid precipitation and climate change

Since listing, acid precipitation and climate change have been cited as factors in the decline of spruce-fir forests to the north and south of the Allegheny Highlands. With regard to acid deposition, detrimental effects to the north and south are well documented; however, with a much smaller balsam fir component than the Southern Appalachians and warmer winter temperatures than the northern forests, these effects cannot be extrapolated to the spruce forests of the Allegheny Highlands, nor can accurate inferences be drawn from the data in Appendix C.

Although empirical data are lacking regarding specific effects on *G.s. fuscus* habitat, the long-term potential exists for anthropogenic climate change to diminish the extent and quality of the boreal-like spruce forests that have survived on the high ridges and plateau by pushing them farther up the slopes, and, if warming continues, reducing and eventually eliminating habitat at higher elevations (Delcourt and Delcourt 1984). However, there has been no evidence of climate change reducing the extent of red spruce in the Allegheny Highlands since listing, and it is not possible to predict measurable impacts on *G.s. fuscus* habitat through the foreseeable future.

Thus, the effects of acid precipitation and climate change on *G.s. fuscus* and its habitat are less predictable than in the forests to the north and south of squirrel's range. Further, it is beyond our capacity to eliminate threats such as acid deposition and global climate change through interventions at the species level. Land managers can, however, develop contingency plans to deal with these concerns through mitigation and remediation measures. The MNF Forest Plan Revision calls for monitoring and management responses to any potential effects of acid deposition that may emerge in the future, and the GWJF Forest Plan makes a commitment to retain the integrity of high-elevation forests. Other entities have also expressed an interest in perpetuating a healthy red spruce ecosystem in the Allegheny

Highlands.

II.D. Synthesis

Up to this point, this review has discussed the information (and its implications) that has become available since the time of listing in 1985. The Synthesis section brings this information together to draw an overall picture of the squirrel's biological status relative to the requirements of the ESA. The fundamental question is whether *G.s. fuscus* is in danger of extinction throughout all or a significant portion of its range (i.e., meets the ESA definition of endangered), or is likely to become endangered in the foreseeable future (the ESA definition of threatened). The information pertinent to addressing this question includes: (1) the population status of *G.s. fuscus*, (2) implementation of recovery actions, and (3) threats to the long-term survival of this subspecies.

The biological principles that allow us evaluate the rangewide population status of the squirrel relative to its long-term conservation are representation, redundancy, and resiliency. At the time of listing, *G.s.fuscus* was thought to be an extremely rare and declining taxon that had disappeared from most of its historical range. We now know that occupancy of available habitat is much more widespread than formerly thought, and that the geographic extent of the squirrel's range approximates historical range boundaries. Although the red spruce and spruce-hardwood ecosystem upon which the squirrel depends has not rebounded to pre-logging conditions, we have learned that *G.s. fuscus* populations can utilize sub-optimal habitat around the spruce stands that constitute the most essential landscape-level component of the squirrel's habitat. From this, we can infer that there is more habitat connectivity than previously thought, although there is geographic separation (and likely has been since the last geologic event) between habitat areas supporting population centers. Thus, there is adequate representation (i.e., occupancy of representative habitats formerly occupied by the squirrel across its range) and redundancy (i.e., distribution of populations in a pattern that offsets unforeseen losses across a portion of the squirrel's range) of *G.s. fuscus*.

Also, despite the short life span of *G.s.* fuscus and the difficulties inherent in conducting population studies for this subspecies, the squirrel has proven to be resilient. Not only has *G.s. fuscus* been shown to be more mobile and plastic in its habitat use than previously thought, survey and monitoring efforts at 107 sites over the past 21 years have shown that *G.s fuscus* is persistent at multiple locations for multiple generations. For example, long-term nest box monitoring efforts at over 30 sites have shown persistence of *G.s. fuscus* at all locations, with proof of reproduction at approximately 65 percent of the long-term sites. Further, although *G.s. fuscus* is essentially trapped on high elevation areas, this isolation does not appear to have a direct impact on its nesting ecology (Menzel 2003). As habitat availability increases into the foreseeable future, the carrying capacity of secured and protected habitat should allow for persistence of viable populations of *G.s. fuscus.*

With regard to active conservation of the squirrel, numerous conservation actions have been implemented since 1985 by land stewards, biologists, and conservation groups. These include research and recovery actions specified in the 1990 recovery plan and 2001 recovery plan update for *G.s. fuscus*, minimization and mitigation measures specified in two HCPs at Snowshoe Mountain (2003 and 2006), and conservation provisions in the 1986 MNF Land and Resource Management Plan, 2004 Forest Plan Amendment, and near-complete Forest Plan Revision. Of particular note are the habitat protection initiatives that have occurred on both public and private lands, the development of a habitat model and research on red spruce habitat restoration and recovery, the establishment of a National Wildlife Refuge, and the growing interest in spruce ecosystem restoration.

The status of *G.s. fuscus* relative to the ESA is contingent not only on population viability and proactive conservation, but also on the demonstrated abatement of threats to the continued existence of the species.

Rarity, isolation, range restriction, and habitat loss were key factors leading to the listing of *G.s. fuscus* as endangered in 1985. Our current understanding of rarity and isolation are discussed above. Although further concerns have been voiced about habitat loss and modification since 1985, no additional factors have been identified as posing an extinction risk for *G.s. fuscus*.

Available information indicates that the threat posed by continued habitat loss has been largely abated across most of the squirrel's range, and it is now evident that the geographic extent of the range approximates the historical extent. The Menzel model has shown that within the historic range of *G.s fuscus*, over 60% of areas with a greater than 50% probability of being occupied is now considered secured by public ownership and/or managed for the protection of the species. These areas include Canaan Valley National Wildlife Refuge (NWR), two state parks, Laurel Fork Special Management Area, and MNF wilderness, non-motorized, recreation, and special management areas. Further, the primary cause of habitat loss in the past, logging, has been abated on the MNF, and proactive conservation on the MNF will lead to avoidance of future impacts from logging and a focus on restoration of the red spruce ecosystem through the restoration and management of disjunct red spruce and spruce-hardwood communities of the central Appalachians.

Localized threats to the subspecies, such as recreational and wind farm development, continue to occur on non-federal lands in some areas, but these do not constitute extinction factors. Non-federal land managers in several key areas (Kumbrabow State Forest, Snowshoe Mountain, Blackwater Canyon and Canaan Valley) have expressed an interest to further red spruce conservation, regardless of regulatory status of *G.s. fuscus*.

In sum, currently available information shows that the species is persisting throughout its historic range, with areas of known occupancy occurring much more widespread than at the time of listing. Habitat loss is localized, and a substantial amount of habitat is now considered secure and improving in quality. Therefore, based on this 5-year review, it is evident that *G.s. fuscus* does not meet the definition of endangered or threatened.

RESULTS

III.A. Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
_x__ Delist
____ No change is needed

III.B. New Recovery Priority Number: not applicable

III.C. Listing and Reclassification Priority Number (FWS only):

Reclassification (from Threatened to Endangered) Priority Number: not applicable

Reclassification (from Endangered to Threatened) Priority Number: not applicable

Delisting Priority Number: __4__

IV. RECOMMENDATIONS FOR FUTURE ACTIONS -

Based on the outcome of this 5-year review, initiate the process to delist *G.s. fuscus,* which will include development of a proposed rule and post-delisting monitoring plan.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Glaucomys sabrinus fuscus*

Current classification: Endangered

Recommendation resulting from the 5-Year Review: Delist

Listing/reclassification priority number: N/A

Review conducted by: Shane Jones and Laura Hill, West Virginia Field Office; Glen Smith, Diane Lynch, Mary Parkin, Region 5 Regional Office

FIELD OFFICE APPROVAL:

Approve _____ Date 8 MAY 2006

REGIONAL OFFICE APPROVAL:

Approve _____ Date May 19, 2006

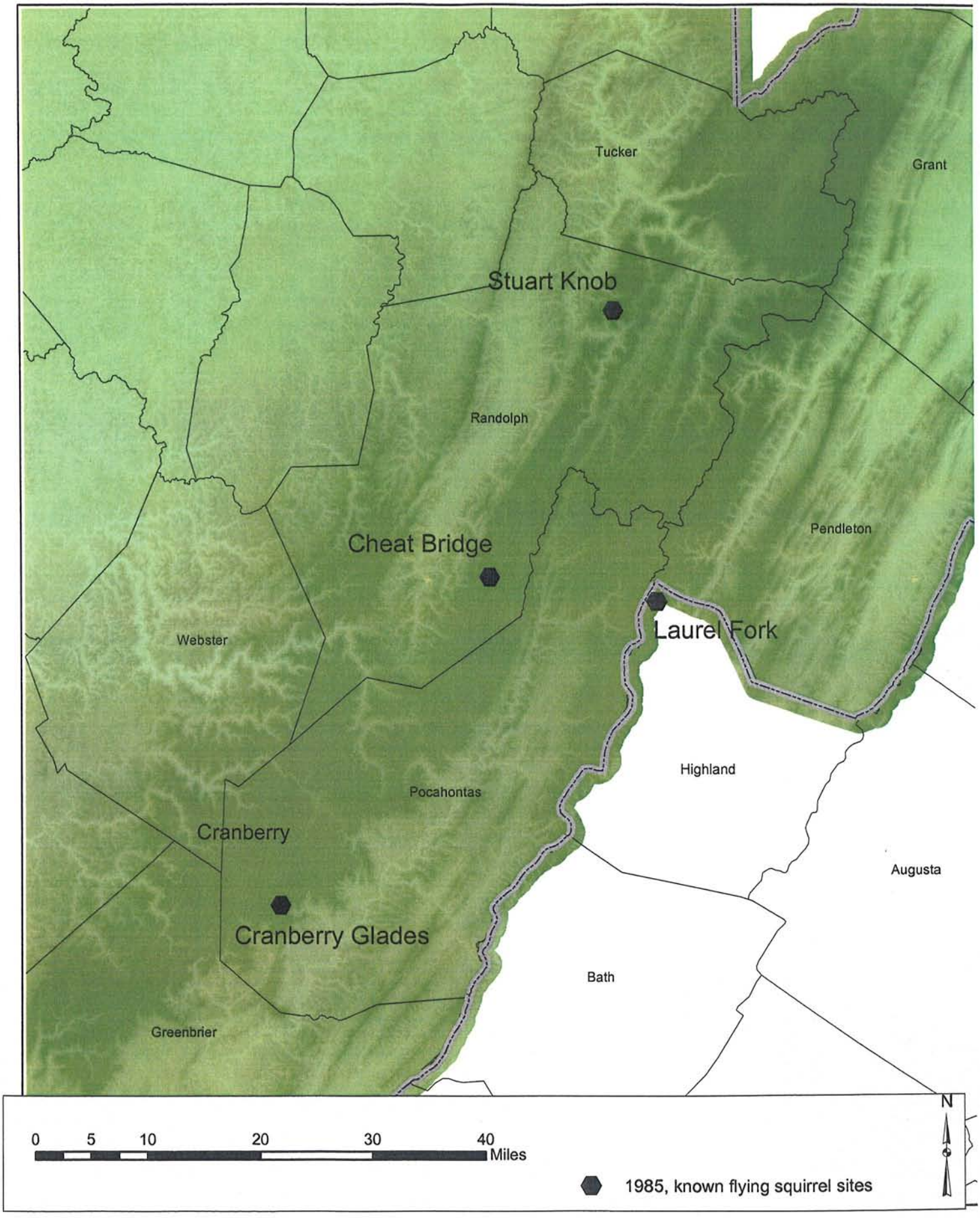

Figure 1. Known West Virginia northern flying squirrel distribution at time of listing (1985)

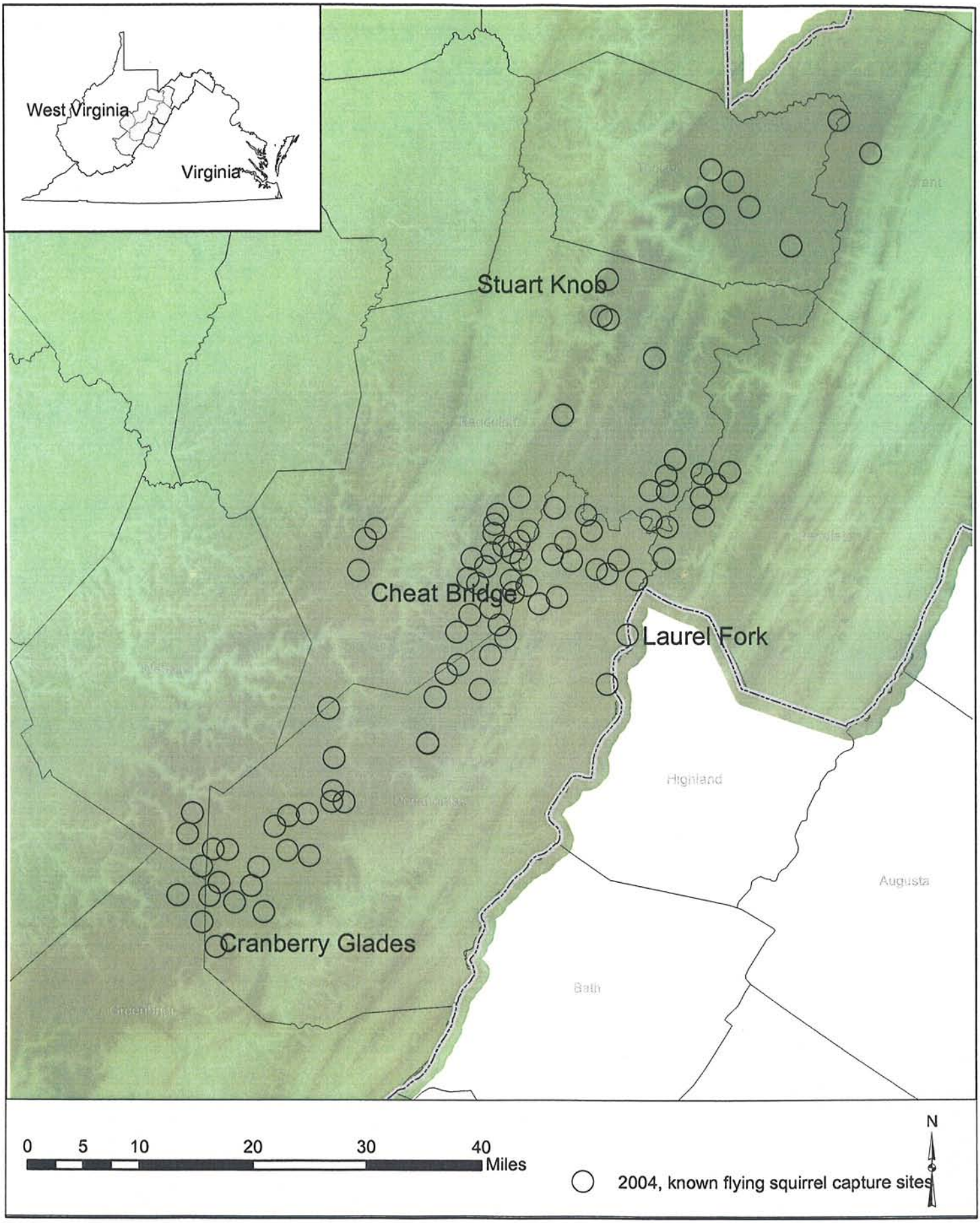

Figure 2. West Virginia northern flying squirrel capture sites
Inset map shows location of the Allegheny Highlands.

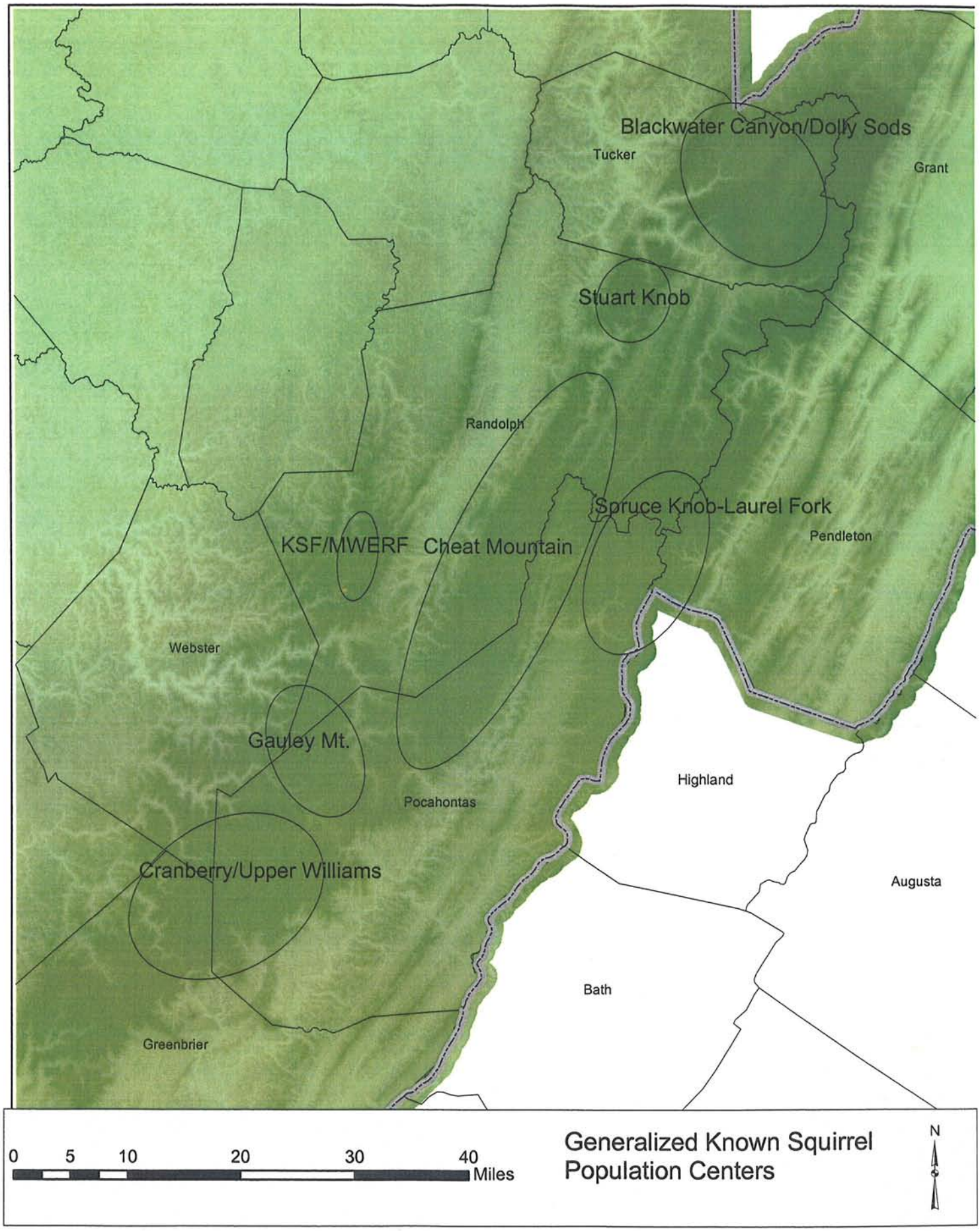

Figure 3. General areas of relict WVNFS habitat in the Allegheny HIghlands region

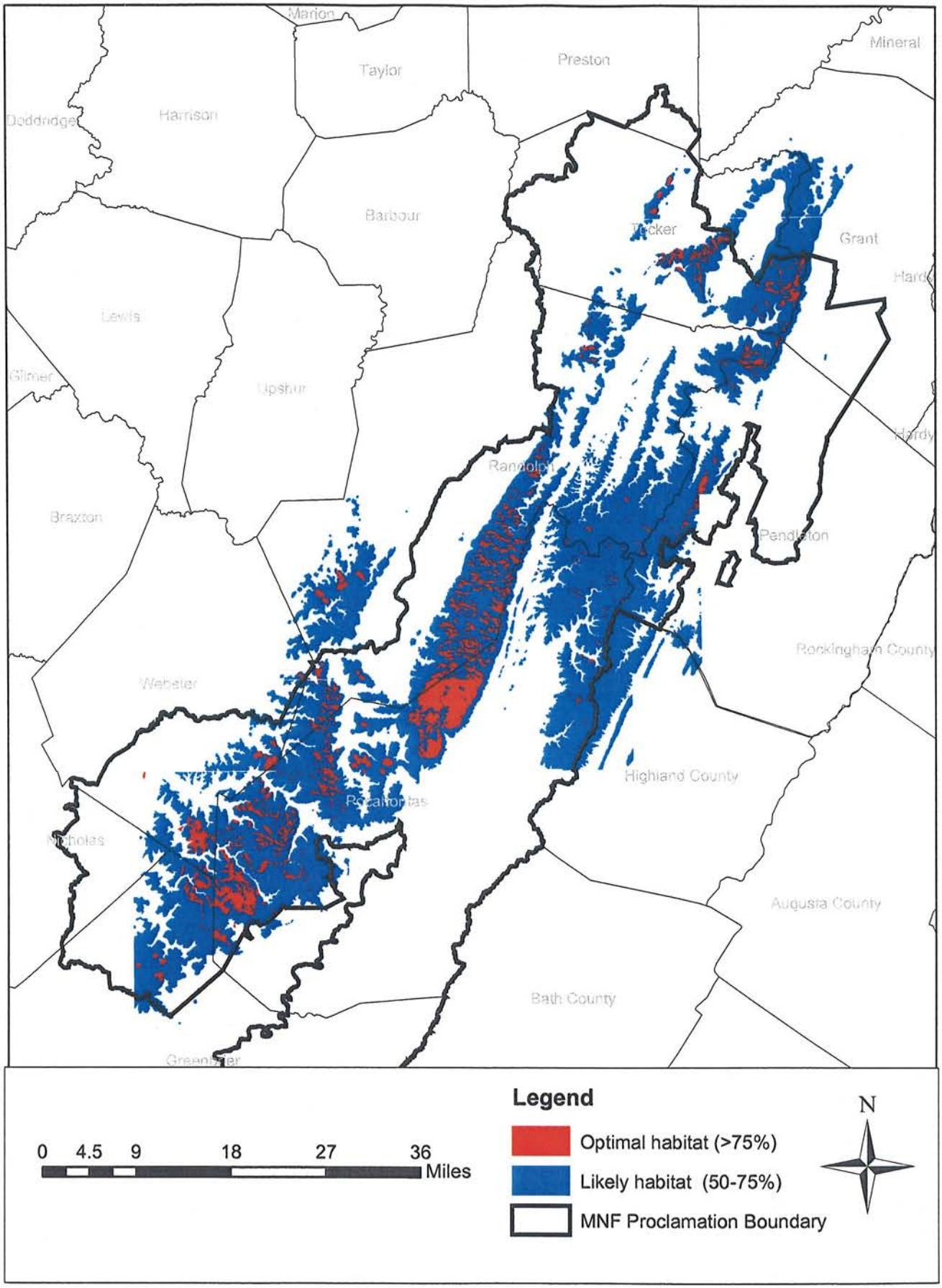

Figure 4. Menzel model of Northern Flying Squirrel Habitat (Menzel et al. 2006)