# APPENDIX A – HABITAT QUALITY RANKING

**Appendix A**
**Summary of April, 2004 Habitat Quality Ranking, Focused HCP, Snowshoe Mountain Inc.**
**West Virginia northern flying squirrel, *Glaucomys sabrinus fuscus***

**Northern flying squirrel**

A total of 24 sub-species of the northern flying squirrel, *Glaucomys sabrinus*, occur in boreal coniferous and mixed coniferous/hardwood forest of the northern United States and Canada, the mountain ranges of the western United States, and certain highland areas of the central and southern Appalachian Mountains. In the core of the range, *Glaucomys sabrinus sabrinus* occurs across the extreme north central United States and eastern and central Canada.

In areas where the northern flying squirrel is more abundant, coniferous forests with old-growth features are the preferred habitat (Carey 1989, Carey 1991, Carey 1995, Carey 1999, Rosenburg 1990, McDonald 1995, Mowry and Zasada 1982). Old-growth conditions include stands with large, mature or over-mature trees (both healthy and decadent) consisting of various age and size classes (Tyrell et al. 1998). This results in a multi-layered canopy with dead trees and relatively high amounts of large dead and decaying logs on the forest floor (coarse woody debris, CWD) and an abundance of lichen and fungi.

The Carolina northern flying squirrel, *Glaucomys sabrinus coloratus* (CNFS), and the WVNFS are two sub-species of the northern flying squirrel which occur in the central and southern Appalachians. Both are federally-listed. Due to the changing climatic and vegetation conditions since the last Ice Age, they have become isolated in small patches of suitable habitat. These disjunct sub-species are a great distance from the center of the species' range in the northern United States and Canada, suggesting that they are relicts.

**West Virginia northern flying squirrel**

Old-growth red spruce forests were optimal habitat for the WVNFS. These forests were once widespread throughout the central Appalachians in the Allegheny Mountains subsection of Virginia and West Virginia. The structure of the forest, the size of trees (trees in excess of 3 feet in diameter at breast height), the depth/composition of humus layer, and quantity of CWD of these forests were more similar in many ways to current conditions in mature and older growth forests found in the Pacific Northwest (Core 1966). During the industrial logging era (1880s-1940s), widespread timber harvest removed the vast majority of these old-growth red spruce forests in West Virginia (Clarkson 1964). Additionally, fires degraded soil conditions by consuming the ecologically critical humus layer characteristic of montane and boreal conifer ecosystems. As a result, most of the relict montane forest communities were severely degraded in composition and structure during this time period (Stephenson and Clovis 1983 *in* Schuler et al. 2002).

The extent and structure of the red spruce forest has never returned to pre-exploitation conditions following the railroad logging era and subsequent wide-spread fires from 1880 to the mid 1900s. In West Virginia, red spruce-dominated forests were reduced from approximately 500,000 acres in the 1880s to 50,000 acres extant today (Schuler et al. 2002). Currently, red spruce forests displaying old-growth characteristics represent less than one percent of the remaining type and are extremely isolated (Adams and Stephenson 1989).

The West Virginia subspecies of the northern flying squirrel (WVNFS) occurs at the edge of the species range. Like other edge-of-range species, the habitat conditions here are sub-optimal. Climatic conditions limit the availability of food, secure nest sites, and the extent of boreal forest communities for the WVNFS. With these natural limitations, exacerbated by the widespread timber harvest during the industrial logging era, forest stands that optimize habitat conditions become more valuable to the continued existence of the WVNFS.

Different habitat characteristics provide different food, shelter, mobility, breeding, and predator avoidance options for the WVNFS. From the continuum of available habitat, the WVNFS chooses to use some areas more than others. As previously mentioned, most information about the WVNFS habitat preferences is extrapolated from studies where other sub-species of the northern flying squirrel are more abundant in the Pacific Northwest, Alberta, and California (Lundelius et al. 1983, Higgelke and MacLeod 2000, Maser and Trappe 1985, Maser et al. 1986, Carey et al. 1997, Rosenberg and Anthony 1992, Carey and Johnson 1995, Carey et al. 1999, McDonald 1995, Mowrey and Zasada 1982, Wells-Gosling and Heaney 1984, Maser et al. 1979, Maser and Maser 1988, Hall 1991). Nevertheless, recent studies (Menzel 2003, Menzel et al. 2004) in high elevation forests with a red spruce component in West Virginia detected no differences in elevation, absolute forest basal area, overstory tree species richness, total shrub density, percent CWD cover, percent herbaceous cover, percent emergent rock cover, percent soil organic matter (humus) and presence of hypogeal fungi between occupied or unoccupied WVNFS sites. However, these studies do indicate that the WVNFS prefers landscapes with higher elevations, northern aspects and spruce and mixed hardwood spruce vegetation. In other words, at various scales, from the landscape level to the size of the home range of an individual WVNFS, forests with a red spruce component (relative importance value[1] of 35%-90%) were chosen over other available forest types (Menzel 2003). Habitat studies of the CNFS, found in the southern Appalachians, indicate similar preferences (Weigl et al. 1999, Payne et al. 1989, Loeb et al. 2000).

Old-growth red spruce forests are considered optimal habitat for the WVNFS. Because old-growth attributes are highly variable within a stand, data is lacking to adequately quantify these characteristics. Therefore, the Service has chosen the following key habitat attributes to assess WVNFS habitat: relative importance value of overstory red spruce trees; relative importance value of overstory and midstory snags; size of overstory red spruce trees; size of overstory hardwood trees; and, amount of CWD. Table 1 provides a summary of these key habitat attributes for optimal WVNFS habitat.

The relative importance value is a measure of the relative dominance of red spruce, and in this case, snags, in a forest community. Importance values rank species or snags within a site based upon three criteria: 1) how commonly red spruce trees, or snags, occur across the entire forest; 2) the total number of individual red spruce trees or snags; and 3) the total amount of forest area occupied by red spruce or snags.

These key habitat attributes are intended to assess WVNFS habitat in terms of composition (presence of red spruce) and structure (age and maturity) of the forest.
The relative importance value of red spruce assesses the forest composition, particularly

**Table 1. Summary of Key Habitat Attributes in Optimal WVNFS Habitat**

| Key Habitat Attribute | Condition |
|---|---|
| Relative Importance Value[2]– Red Spruce | Medium to High |
| Relative Importance Value – Snags | High |
| Size of overstory red spruce | Red spruce trees in excess of 36 inches in diameter at breast height (dbh) |
| Size of overstory hardwoods | Trees in excess of 36 inches dbh |
| Presence of CWD | Medium to high |

[1] Recent research in West Virginia (Menzel 2003) has shown that areas with a relative importance value of approximately 35-90% are preferred habitat for the WVNFS.

[2] The relative importance value is a measure of a tree species' dominance in a forest community. Importance values rank species within a site based upon three criteria: 1) how commonly it occurs across the entire forest or sampled area (frequency); 2) the total number of individual trees (density); and 3) the total amount of forest area or sampled area occupied by that species (dominance). Relative importance value is a percentage ranging from 0-100. 0 would represent an area where the species is absent and 100 would represent an area which contains nothing but that species. To compare communities that may differ in size, or that were sampled at different intensities, importance values are calculated using relative rather than absolute values. Relative frequency: number of occurrences of one species as a percentage of the total number of occurrences of all species; relative density: number of individuals of one species as a percentage of the total number of individuals of all species; and relative basal area: total basal area of one species as a percentage of the total basal area of all species (Curtis and McIntosh 1951, Kent and Coker 1992).

the presence of red spruce. All of the other key habitat attributes are assumed to provide a relative means of describing the forest structure. The size of trees found in the overstory is assumed to be indicative of the maturity of the surrounding forest.

## Habitat Quality Ranking

The purpose of this effort is to describe why these key habitat attributes are a good foundation to provide a relative quantitative assessment of various qualitative habitat parameters deemed important to the WVNFS, particularly with regard to behavior essential to survival (i.e., sheltering, feeding and breeding).

### Feeding

Higher plants have evolved with an obligatory symbiotic relationship with mycorrhizal (root-inhabiting) fungi (Maser et al. 1978). Hypogeous (below ground) mycorrhizal fungi are dependent upon small animals as the primary vector of spore dissemination. Mycophagous animals, such as the northern flying squirrel, including the WVNFS, feed on, among other things, fungal spores (Mitchell 2001, Loeb et al. 2000, Maser et al. 1986, Maser et al. 1978, Maser 1988, Waters et al. 1997). They defecate within the coniferous forest ecosystem, spreading the viable spores, which regenerates the mycorrhizal fungus necessary for the health and survival of the coniferous forest (Maser et al. 1978, Maser et al. 1986, Maser and Maser 1988, Colgan et al. 1999). Generally, neither mycorrhizal fungi nor their hosts complete their life cycles independently, and trees with this association are healthier than those without this symbiotic relationship. While this three-way relationship between the mycorrhizal fungi, coniferous forest and the northern flying squirrel is better understood in the Pacific Northwest coniferous ecosystems, it is believed that this may be an explanation for the apparent dependence of a conifer component in the habitat of the WVNFS (USFWS 2001). While there are many different types of hypogeous fungi and mycorrhizal fungi, for the sake of this analysis, these underground fungi associated with coniferous forests will be referred to collectively as truffles.

A California study suggested that although northern flying squirrels search for truffles primarily using olfaction, they may also benefit by searching near downed CWD as an above-ground cue to truffle locations (Pyare and Longland 2001). Large decaying wood on the forest floor (CWD) provide an ideal medium for fungal growth, including truffles, in that it is rich in nutrients and retains moisture. Since locations in close proximity to CWD yield fruiting truffles in consecutive years, mycophagous animals, such as the northern flying squirrel, may benefit by memorizing fruiting locations and forage there from year to year (Pyare and Longland 2001). Therefore, CWD is considered a key habitat attribute, particularly with regard to feeding opportunities for the WVNFS.

Research in northern California suggests that flying squirrel numbers are closely correlated with hypogeous fungus biomass (Waters *in* Weigl et al. 1999). Old growth forests with their large trees and many downed logs support larger standing crops of fungi and sporocarps than younger stands (Maser et al. 1979). The legacy of timber harvest and fires in the red spruce forests in the central Appalachians destroyed much of the humus layer (Clarkson 1993) and undoubtedly much of the CWD associated with the original old-growth forest, leaving a depauperate forest floor condition in second-growth forests. Based on research conducted in the central Appalachians and other regions, these events reduced the growth medium suitable for hypogeal fungi or substantially changed the fungal species composition locally (Waters et al. 1994, North and Greenberg 1998, Ferris et al. 2000, Orrock and Pagels 2002). Ford et al. (2004) noted the difficulty in surveying for hypogeal fungi in the central Appalachians and could not conclusively demonstrate a link between WVNFS presence and hypogeal fungi abundance. Loeb et al. (2000) noted that hypogeal fungi are patchily distributed and vary greatly in their abundance in northern hardwood-red spruce forests in the southern Appalachians. This relationship between the abundance of the northern flying squirrel and amount of underground fungi may explain the sparse WVNFS population in the central Appalachians. If this hypothesis is correct, as forests age and decadence increases, fungi biomass, and therefore WVNFS numbers will increase. Because of the apparent relationship between the ages of a spruce forest, the amount of truffles, and northern flying squirrel abundance, the size of overstory trees, are considered key feeding habitat attributes for the WVNFS.

While no studies have shown what role the WVNFS has on truffles in the forest, Mitchell (2001), suggests that the WVNFS facilitates spore dispersal of the mycorrhizal fungi and may contribute to the health of the high elevation red spruce forests in West Virginia. Studies in the southern Appalachians (Loeb et al. 2000) show a correlation between the presence of red spruce and the presence of truffles. This is supported by a study in West Virginia: as the relative importance value of conifer (spruce or hemlock) exceeds 35%, the forest stand was likely occupied by the WVNFS. In other words, at various scales, ranging from the landscape level to the home range of an individual WVNFS, forests with spruce (greater than 35% relative importance value) were selected over other available forest types such as mesic or xeric northern hardwood forests. It is assumed that the presence of red spruce is interconnected with the presence of the WVNFS; therefore, the relative importance value of red spruce in the overstory is a key habitat attribute, particularly with regard to WVNFS feeding habitat.

While truffles are considered a critical part of the northern flying squirrel diet, the more highly digestible seeds, fruits, nuts, and insects are considered occasional, but nutritionally significant additions to the diet of the northern flying squirrel (Duncan 2004). While this is true in the Pacific Northwest, it is assumed to be even more important for the WVNFS because of the apparent lack of truffle abundance in the central and southern Appalachians following the legacy of industrial timber harvesting. Red spruce is an important component of WVNFS habitat, but a pure red spruce stand is not favorable to the WVNFS. Therefore, the value of squirrel habitat is highest when the relative importance value of red spruce is approximately 35-90%.

**Sheltering**

Nest sites are used for protection from weather and predators and for raising young. Northern flying squirrels, including the WVNFS, use tree cavities as dens and are also known to utilize nests (known as dreys) constructed of lichen, twigs, moss and shredded bark on the boles or branches of trees (Maser et al. 1986, Carey et al. 1997, Rosenburg and Anthony 1992, Waters and Zabel 1995, Carey et al. 1997, Menzel 2000). The Northern flying squirrels have been known to build dreys in close proximity to high quality foraging areas rather than occupying a tree cavity located far from necessary food resources (Carey et al. 1997). Older trees, with a greater likelihood for cavities, provide more secure nest sites. It is thought that northern flying squirrels show a preference to live trees because of the shelter and hiding cover offered by the overhead branches and because live trees may persist for a longer period of time than snags (McDonald 1995, Carey et al. 1997).

Availability of suitable nest sites may limit the number and distribution of the WVNFS. This species typically occupies natural tree cavities, dreys and also nests in man-made boxes (USFWS 2001). During the cooler months, the WVNFS commonly occupies tree cavities or woodpecker holes (Baker 1983 *in* USFWS 1990, Booth 1963 *in* Wells-Gosling and Heaney 1984). In the summer, the WVNFS and the CNFS are known to construct dreys in conifer branches or in hardwood foliage (USFWS 1990, Stihler et al. 1995, Weigl et al. 1999, Cowan 1936 *in* FWS 1990, Urban 1988). In West Virginia, both spruce and mature hardwoods, especially yellow birch and Fraser magnolia, serve as den sites (Menzel 2003).

Nest sites were commonly located on north-facing slopes with dense tree canopy (Menzel et al. 2000). The minimum dbh of deciduous trees occupied by nesting WVNFS was 4.3 inches, and the minimum dbh of spruce was 5.5 inches. While the WVNFS is very resourceful in nest tree selection, nest trees appear to be larger and taller than the surrounding trees (Menzel 2003). In North Carolina, the CNFS occupied cavity nests in trees with dbh ranging from 8.3 inches to 39.4 inches (Weigl et al. 1999). In Alaska, one *Glaucomys sabrinus yokonensis* was observed using up to 34 alternate den trees (Mowrey and Zasada 1982). Individual CNFSs are known to have more than 3 active nests at a given time (Weigl et al. 1999). WVNFS are known to have multiple den sites at any given time, averaging 3.6 den sites per month and utilizing up to 12 den sites per month in fragmented habitat (Menzel 2000).

Although the northern flying squirrel, including the WVNFS may utilize dens year-round, reproductively active females change dens during the breeding season (Higgelke and MacLeod 2000, Michael pers. Comm. 2002). The transition to a new den for birthing may be a result of the presence of parasites in a used den. In the Pacific Northwest and Alberta, female northern flying squirrels have used downed logs for natal dens (Carey et al. 1997, Kiggelke and MacLeod 2000). This could be a result of the inter- and intra-specific competition for cavities high in the canopy (Carey et al. 1997).

Larger sized standing trees, both dead (snags) and live provide ideal potential nesting sites for the WVNFS. Therefore, the relative importance value of snags and the size of overstory trees are considered key habitat attributes with regard to WVNFS sheltering habitat. While not as important as large standing dead and live trees, the relative importance value of red spruce is also considered a key habitat attribute because of the increased opportunity for dreys in the canopy of conifer trees. Also, the presence of overstory spruce would indicate favorable foraging conditions are nearby.

**Breeding**
The Service recommends that all tree clearing operations in WVNFS habitat occur at the time of year least likely for a female WVNFS to have immobile young. Therefore, it is assumed that breeding is a subset of the sheltering habitat. In other words, so long as reproductively active females, with immobile young, are not likely to be disturbed, successful breeding is dependent on the availability of secure nesting sites.

**Movement**
Daily and seasonal movement (migration or dispersal) is critical to WVNFS survival. However, it is less of a limiting factor to WVNFS relative to the feeding and sheltering habitat components if a project would not create a migration barrier. Since one biological goal for the Focused-HCP is to avoid the creation of migration barriers for the WVNFS by limiting the width of forest clearing, this potential impact is not evaluated in this HQR. If the project would create migration barriers, this impact must be evaluated.

**Competition**
The past disturbances which diminished the area and quality of the high-elevation habitats increased the amount of hard mast tree species such as northern red oak. Increased oak masts benefits the southern flying squirrel, *Glaucomys volans volans*, by providing a cacheable, high-energy food in a climate zone that is energetically demanding throughout much of the dormant season. Competition for nest sites between the WVNFS and southern flying squirrels in areas where they occur sympatrically has been considered a potential limiting factor for the WVNFS. The proposed project area and surrounding area does not have a northern red oak component. Additionally, it is located some distance from northern red oak. Therefore, it is assumed that competition is not a limiting factor for this project.

Based on this information, the Service has created a matrix which demonstrates the relative value of key habitat attributes in WVNFS habitat (Table 2). This matrix provides a relative quantitative assessment of various qualitative habitat parameters deemed important to the WVNFS, particularly with regard to behavior essential to survival (sheltering, feeding and breeding). Because the breeding component of WVNFS habitat is poorly understood and the ranking is based on assumptions, the breeding component is given a value of 5 out of the total habitat quality points (100). Regardless of the actual habitat type, the ranking for breeding is dependent on the amount of adjacent habitat. This matrix is specifically designed to add up to

100 in order to provide a means to compare current habitat to what would be considered ideal (sheltering [45], feeding [50] and breeding [5]). Because of the past land use, no habitat type is currently considered optimal (100 points).

**Table 2. Summary of Value of Key Habitat Attributes to the WVNFS**

| | Sheltering | Feeding | Total |
|---|---|---|---|
| Rel. Importance Value - Red Spruce (overstory) | 5 | 15 | 20 |
| Rel. Importance Value - Snags (overstory and midstory) | 20 | 0[1] | 20 |
| Dbh - Red spruce (overstory) | 10 | 15 | 25 |
| Dbh – Hardwoods (overstory) | 10 | 5 | 15 |
| CWD | 0 | 15 | 15 |
| **Sheltering + Feeding** | | | 95 |
| **Breeding** | | | 5 |
| **Total** | | | 100 |

[1] This evaluation is a snapshot of current habitat conditions. While snags provide future value to feeding habitat because they will eventually become CWD, their current value is for sheltering.

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