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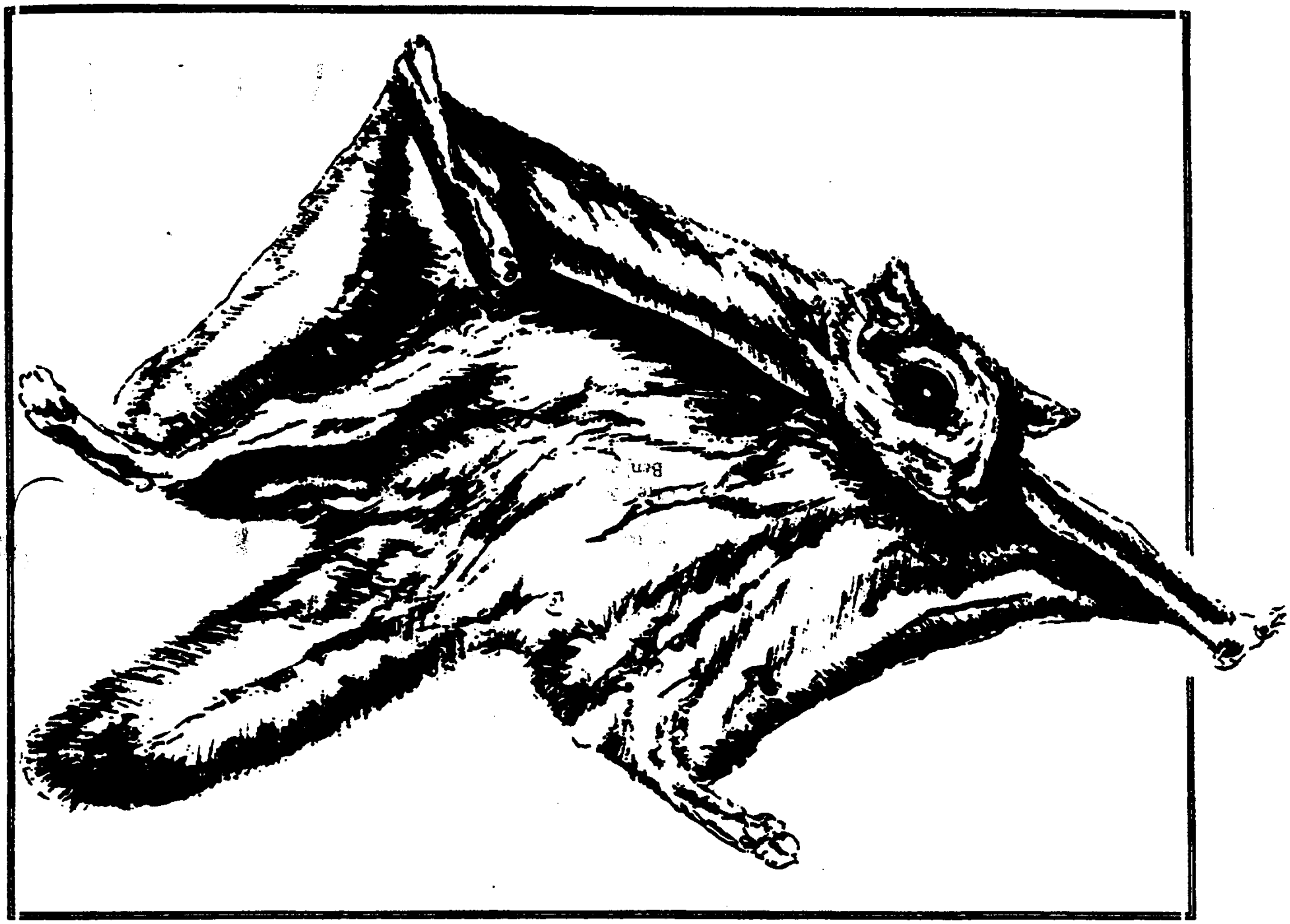
APPALACHIAN NORTHERN FLYING SQUIRRELS

(Glaucomys sabrinus fuscus) *(Glaucomys sabrinus coloratus)*



RECOVERY PLAN

Region 5
U.S. Fish and Wildlife Service

62 pp.

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Appalachian Northern Flying Squirrels

(*Glaucomys sabrinus fuscus*)
(*Glaucomys sabrinus coloratus*)

Recovery Plan

Prepared by:

Annapolis Field Office
U. S. Fish and Wildlife Service
Annapolis, Maryland

in cooperation with the

Northern Flying Squirrel Recovery Team

For:

Region 5
U.S. Fish and Wildlife Service
Newton Corner, Massachusetts

Approved: Ronald E. Lambertson
Regional Director,
U.S. Fish and Wildlife Service

Date: September 24, 1990

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EXECUTIVE SUMMARY – Appalachian Northern Flying Squirrels

Species status: Endangered

Habitat requirements: High-elevation forests in southern Appalachians, usually in spruce/fir-hardwood ecotone

Recovery Objective: To de-list the Virginia and Carolina northern flying squirrels

Recovery criteria:

To down-list: (1) Populations are stable or expanding at ≥ 80% of designated Geographic Recovery Areas for 10 years; (2) Sufficient life history data are available to permit effective management; (3) GRAs are managed for squirrels in perpetuity.

To de-list: In addition to 1, 2, and 3, continued existence of high-elevation forests is assured.

Actions Needed:

1. Survey for new populations and monitor known populations.
2. Study habitat requirements.
3. Study diet, interactions with other squirrels and genetics.
4. Study effects of various land use practices (mining, logging, recreation).
5. Ensure implementation of appropriate habitat management guidelines, based on results of 1-3. (This would include periodic monitoring, even following de-listing.)

Total estimated cost of recovery: (X 1000)

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Total
1991	80	60	30	30	25	225
1992	80	120	30	30	25	285
1993	80	120	40	30	25	285
1994	80	--	10	15	25	120
1995	70	--	--	10	25	105
1996	60	--	--	10	25	95
1997	40	--	--	10	25	75
1998	25	--	--	--	25	50
1999	25	--	--	--	25	50
2000	25	--	--	--	25	50
Total	565	300	110	135	250	1360

Down-listing may be initiated by the year 2000, depending on population status.

* * *

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1990. Appalachian Northern Flying Squirrels (Glaucomys sabrinus fuscus and Glaucomys sabrinus coloratus) Recovery Plan. Newton Corner, Massachusetts. 53 pp.

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PART I: INTRODUCTION

Description

The two endangered subspecies of northern flying squirrel, Glaucomys sabrinus fuscus Miller and Glaucomys sabrinus coloratus Handley, are small, nocturnal, gliding mammals 260-305 mm in total length and 90-140 g in weight. They possess a long, broad, flattened tail (80% of head and body length), prominent eyes, and dense, silky fur. The distinctive patagia (folds of skin between the wrists and ankles) are fully furred and supported by slender cartilages extending from the wrist bones; these plus the broad tail create a large gliding surface area and are the structural basis for the squirrel's characteristic gliding locomotion (Thorington and Heaney, 1981). Adults are dorsally gray with a brownish, tan, or reddish wash, and grayish white or buffy white ventrally. Juveniles have uniformly slate gray backs and off-white undersides. The more southern subspecies, G. s. coloratus, is larger (avg. 286 vs. 266 mm total length) than G. s. fuscus, with a longer tail (avg. 134 vs. 115 mm) and brighter coloration (Handley, 1980).

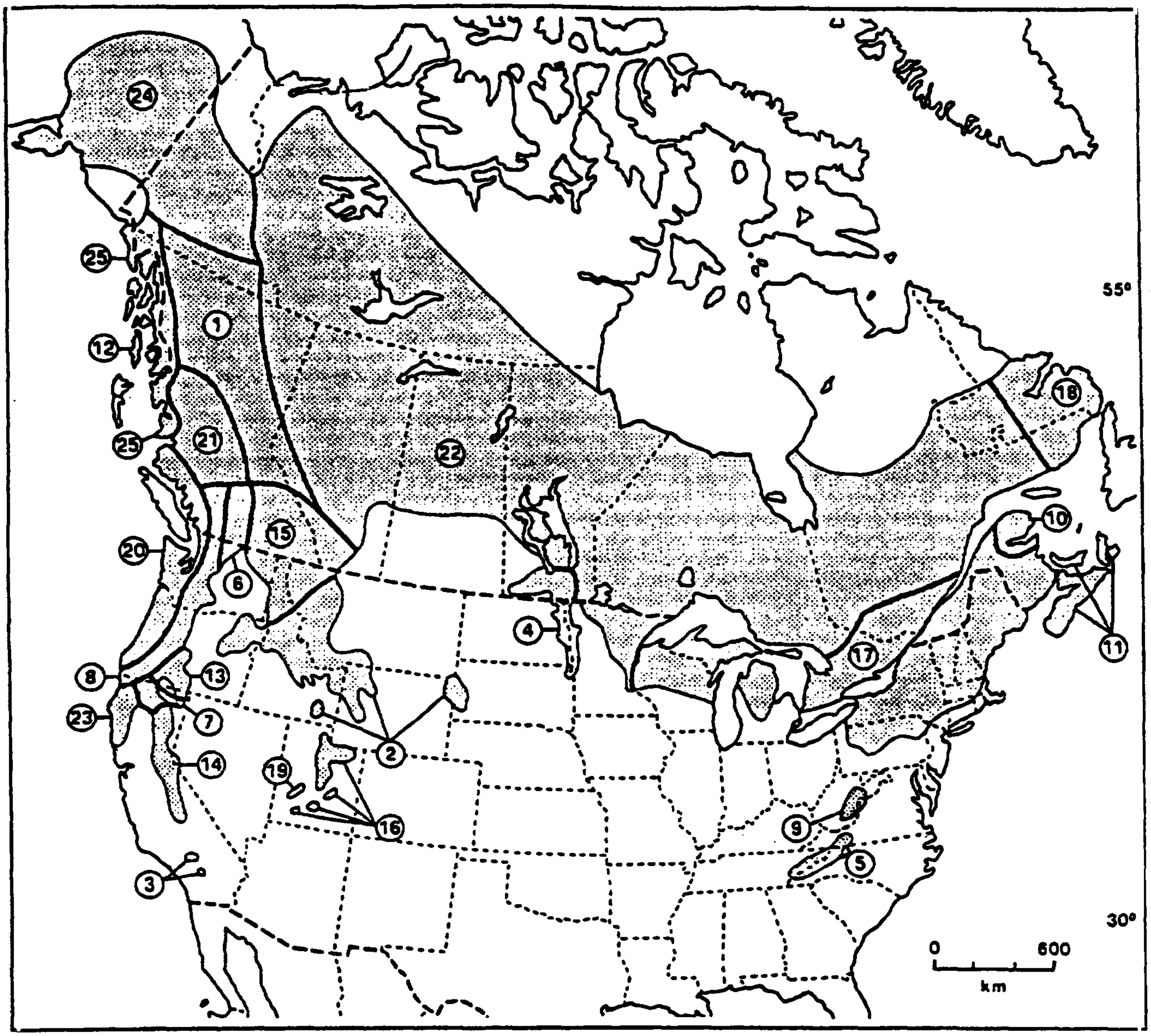
Glaucomys sabrinus can be distinguished from the southern flying squirrel, G. volans, by its larger size (e.g., hindfoot 33-41 mm vs. < 33 mm for G. volans); greater adult weight (90-140 g for G. sabrinus vs. 50-90 g for G. volans); the gray base of its ventral hairs as opposed to the white base in the southern species; the relatively longer upper tooth row; and the much shorter, stouter baculum (penis bone) of the males. A full account of the species' taxonomic history can be found in Howell (1918) and Wells-Gosling and Heaney (1984). The original descriptions of the two Appalachian subspecies are available in Miller (1936) and Handley (1953). Wells-Gosling (1985) provides numerous photographs of both Glaucomys species.

Distribution

A total of 25 subspecies of Glaucomys sabrinus occur in boreal coniferous and mixed coniferous/hardwood forests of the northern United States and Canada, th mountain ranges of the western United States, and certain highland areas of the southern Appalachian Mountains (Figure 1). The general distribution of the two endangered subspecies in the southern Appalachians is shown in Figure 2.

Prior to their Federal listing, these two subspecies were known from fewer than 3C specimens collected from eight localities (U.S. Fish and Wildlife Service, 1985). Since these subspecies were listed, intensive field work as well as apparent population increases in some localities have led to the capture of many additional animals and their discovery in new areas. Sites of capture prior to 1985 are considered historic localities.

The subspecies fuscus is now known from the following areas in West Virginia: (1) the Stuart Knob area (Randolph County); (2) the Cheat Bridge area (Pocahontas and Randolph Counties); (3) the Cranberry area (Greenbrier, Pocahontas, Randolph, and Webster Counties); (4) the Spruce Knob area (Pendleton and Randolph Counties); and (5) the Blackwater Falls area (Tucker County). At least 187 G. s. fuscus have been captured in these areas since intensive efforts to locate the animals began in 1985 (C. Stihler, WV DNR, pers. comm.). In Virginia G. sabrinus is known from three localities: (1) Highland County; (2) the Whitetop-Grayson Highlands area (Smyth and Grayson Counties); and (3) one site in Montgomery County (J. Cranford, Biology Dept., VPI&SU, pers comm., 1985). The habitat at this third site is atypical, and northern flying squirre have not been captured here since 1982. A total of 46 individuals have been captured in Virginia since 1985 (M. Fies, VA Department of Game and Inland Fisheries; J. Pagels, VA Commonwealth University, pers. comm., 1990).



Numbers 5 and 9 indicate G.s. coloratus and fuscus respectively. Other subspecies are as follows: 1) G.s. alpinus, 2) G.s. bangsi, 3) G.s. californicus, 4) G.s. canescens, 6) G.s. columbiensis, 7) G.s. flaviventris, 8) G.s. fuliginosus, 10) G.s. goodwini, 11) G.s. gouldi, 12) G.s. griseifrons, 13) G.s. klamathensis, 14) G.s. lascivus, 15) G.s. latipes, 16) G.s. lucifugus, 17) G.s. macrotis, 18) G.s. makkovikensis, 19) G.s. murinauralis, 20) G.s. oregonensis, 21) G.s. reductus, 22) G.s. sabrinus, 23) G.s. stephensi, 24) G.s. yukonensis, 25) G.s. zaphaeus. Modified from: Wells-Gosling and Heaney (1984).

Figure 1. General Distribution of Glaucomys sabrinus

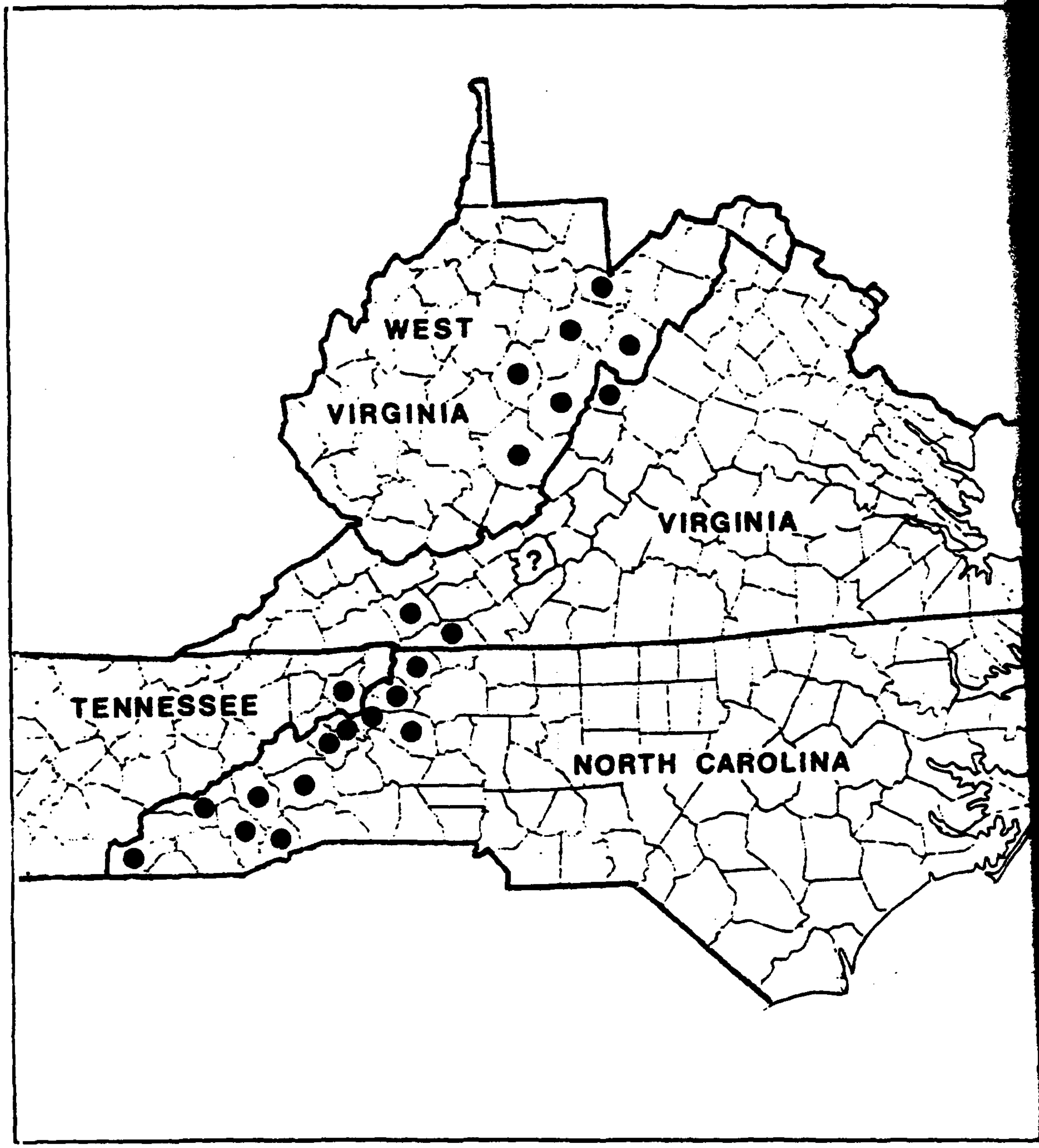


Figure 2. Distribution of Glaucomys sabrinus fu
and G. s. coloratus

Glaucomys sabrinus coloratus, the southernmost subspecies, has now been found in the following isolated localities in North Carolina and Tennessee: (1) the Roan Mountain area (Mitchell County, NC and Carter County, TN); (2) the Grandfather Mountain area (Avery, Caldwell, and Watauga Counties, NC); (3) the Black Mountains, including Mt. Mitchell (Buncombe and Yancey Counties, NC); (4) the Great Balsam Mountains (Haywood and Transylvania Counties, NC); (5) the Plott Balsam Mountains (Haywood and Jackson Counties, NC); (6) the Great Smoky Mountains (Jackson and Swain Counties, NC); (7) the Unicoi Mountains (Cherokee County, NC); and (8) the Long Hope Valley area (Ashe and Watauga Counties, NC). Approximately 150 northern flying squirrels have been captured in these areas since 1985 (P. Weigl, pers. comm.).

The taxonomic status of Glaucomys sabrinus in southern Virginia (Smyth and Grayson Counties) presents a special situation. Due to the geographic proximity of these populations to those in North Carolina and their apparent intermediate morphological characteristics (C. Handley, Jr., Smithsonian Institution, pers. comm., 1988), we are for the purposes of this plan including these squirrels within the subspecies coloratus. This is a management, not a taxonomic, decision. The true subspecific affiliation of these animals will be determined through analysis of additional specimens as they become available.

The pre-settlement distribution of Glaucomys sabrinus in the Southeast is unknown, but fossil remains indicate a much larger range during the late Pleistocene and early Holocene (Kurten and Anderson, 1980; Lundelius et al., 1983; Semken, 1983). The disjunct distribution of these subspecies in the southern Appalachians and their great distance from the center of the species' range in the northern United States and Canada suggest that they are relicts which have become isolated in small patches of suitable habitat by changing climatic and vegetational conditions since the last ice age.

Habitat

Throughout its eastern range the northern flying squirrel is usually associated w boreal habitats, especially spruce-fir and northern hardwood forests. In the southern Appalachians G. sabrinus shows a relict distribution and tends to occu rather small and potentially vulnerable islands of high elevation habitat. The subspecies fuscus and coloratus are commonly captured in conifer-hardwood ecotones or mosaics consisting of red spruce (Picea rubens) and fir (Abies fras and A. balsamea) associated with mature beech (Fagus grandifolia), yellow birch (Betula alleganiensis), sugar maple (Acer saccharum) or red maple (Acer rubrum hemlock (Tsuga canadensis), and black cherry (Prunus serotina). A recent habi analysis of 13 capture sites in the southern Appalachians revealed that while species composition of the occupied forest may vary in different locations, some combination of hardwoods and conifers (particularly spruce and fir) appears essential to support these animals. Understory components did not appear to b significant indicators of G. sabrinus habitat (Payne et al., 1989). Studies with captives indicate that G. sabrinus will readily use both deciduous and coniferous environments. In contrast, both distributional data and experimental studies indicate that G. volans has a marked preference for hardwood forests (Weigl, 1978).

It could be argued that the capture of northern flying squirrels in conifer/hardwoo ecotonal areas may be partially an artifact of the elimination of large, contiguous spruce or stands in the southern Appalachians and the over-sampling of ecotonal habitats. However, trapping that has been conducted in the remaining stands of pure conifers has so far failed to yield any sabrinus (Weigl and Boynton, 1990).

Although conifers are clearly an important component of G. sabrinus habitat, northern flying squirrels have also been taken in deciduous areas some distance from spruce-fir forest in the central Appalachians and in New England (P. Weigl, pers. obs.). As mentioned above, Dr. J. Cranford of Virginia Polytechnic Institute and State University (pers. comm.) captured the species in April of 1978 and March of 1982 in a riparian hemlock-hardwood-rhododendron forest in Montgomery County, Virginia. Nest boxes placed at this site have so far revealed no additional northern flying squirrels. Recently, a juvenile female G. s. coloratus was captured in the Unicoi Mountains of North Carolina, 45 km away from the nearest natural spruce-fir stands (A. Boynton, NC Wildlife Resources Commission, pers. comm., 1989). Further study is needed to determine the importance of the spruce-fir forest component to the survival of northern flying squirrels in the southern Appalachians.

Northern flying squirrels have been captured in stands of varying age, understory density, and composition, but most have been taken from moist forest with at least some widely spaced, mature trees and an abundance of standing and down snags (ideally old-growth forest). Such habitats seem well suited to the species' gliding form of locomotion, use of cavities for nesting, and reliance on wood-borne fungi and lichens for food. The relative abundance of natural cavities in old hardwoods and their resistance to windthrow (compared to many conifers) may account for the northern flying squirrel's occupation of mixed woodland and deciduous forest just below the spruce-fir zone.

Since the northern hardwood/spruce-fir ecotone occurs at progressively higher elevations from north to south, it is not surprising that captures of G. sabrinus show a similar latitudinal trend. While individuals have frequently been found at elevations less than 800 m in New England, New York, and Pennsylvania, most West Virginia specimens have been taken at 1000-1350 m (C. Stihler, pers. comm.). In Virginia G. sabrinus generally occupies forests 1170-1630 m in altitude. In North Carolina all captures have occurred above 1540 m with the exception of two individuals, one taken in the Great Smoky Mountains at 1230 m and the other taken in the Unicoi Mountains at 1463 m (Hall, 1981; Weigl, 1968; A. Boynton, pers. comm., 1989).

Life History and Ecology

Because of their rarity, nocturnal and secretive habits, and the remoteness of t[...] habitat, little was known of the ecology of northern flying squirrels in the south[...] Appalachians prior to their listing (Weigl, 1977). In the forests they occupy, the[...] presence usually goes unnoticed. These squirrels have been located during th[...] day by shaking or pounding on snags and dead branches, especially if these a[...] hollow. They sometimes nest in bluebird boxes and will occasionally come to b[...] feeders (Wells-Gosling, 1985). Their presence is often betrayed by their characteristic repeated warning calls or "chirps."

Unlike G. volans, G. sabrinus are not highly dependent on seeds and nuts for [...] (Weigl, 1978), and, in fact, may not be able to use conifer seeds effectively in so[...] boreal habitats (Brink and Dean, 1966). Over much of their range they can apparently subsist on lichens and fungi (Maser et al., 1985; Weigl, 1968), but al[...] eat seeds, buds, fruit, staminate cones, insects, and other animal material (McKeever, 1960), and have been observed ingesting tree sap (Foster and Tate, 1966; Schmidt, 1931). The year-round abundance of lichens and many species [...] hypogeous (underground) fungi may provide a steady and, at certain seasons, almost exclusive food supply and may reduce food competition with other squirr[...] species. A recent analysis of habitat features in Virginia revealed lichen abundan[...] to be significantly correlated with the presence of G. sabrinus (J. Pagels, pers. comm., 1990). Periodic dependence on certain species of fungi may be a factor restricting the species to high-elevation, mesic habitats. Studies in the Pacific Northwest have indicated that northern flying squirrels play an important role in forest maintenance by dispersing nitrogen-fixing bacteria and fungal spores that form symbiotic mycorrhizal relationships with overstory species (Maser and Mase[...] 1988).

Because of the flying squirrel's small size, the climatic severity of its habitat, and abundance of avian and mammalian predators, secure nesting sites represent a critical limiting factor. During the cooler months squirrels commonly occupy tree cavities and woodpecker holes (Baker, 1983; Jackson, 1961). Recently, they have been observed using the dense branches in the tops of spruce and fir trees as a winter refuge (P. Weigl, pers. obs.). In the summer these squirrels construct and use outside leaf nests (Cowan, 1936; Urban, 1988; Weigl and Osgood, 1974). The interior of both types of nest is lined with lichens, sedges, moss, or finely chewed bark. Squirrels have been observed entering burrows in the ground (C. Stihler, pers. comm.; Weigl, 1968; Urban, 1988), although the extent of their use is not yet known.

Northern flying squirrels are relatively gregarious and commonly share nests (Osgood, 1935; Maser et al., 1981). In West Virginia, seven adult G. sabrinus were recently observed in a single nest box and four seen in another (C. Stihler, pers. obs.); however, the spectacular winter nesting aggregations reported for G. volans (up to 50 in a nest) are unknown for this species. Northern flying squirrels apparently live in family groups of adults and juveniles, for when the species has been located, it has been possible to trap 2-8 individuals within a discrete area (P. Weigl, pers. obs.). Also, adult females have been found in nest boxes with juveniles that are clearly large enough to fend for themselves (C. Stihler, pers. obs.).

Only limited reproductive information is available for these subspecies. Investigators working with other subspecies mention two litters of 2-6 young per year and a gestation period of 37-42 days (Muul, 1969; Davis, 1963). Trapping data from the southern Appalachians provide evidence of only a single litter in spring or summer. Fourteen litters observed in nest boxes in Virginia and West Virginia over the past five years contained from one to five young, with an average of 2.9 young per litter (C. Stihler and M. Fies, pers. obs.). Two captive females from North Carolina each had litters of four young (P. Weigl, pers. obs.). Wean occurs at about two months of age. Normal longevity in the wild is unknown, individual squirrels have been observed to reach four years of age.

Telemetry studies in the southern Appalachians have provided some data on th northern flying squirrel's activity and use of space. Animals radiotracked during summer have a marked biphasic activity pattern with peaks between sundown midnight and 1-3 hours before sunrise (Weigl and Osgood, 1974). During these times squirrels are extremely active in trees and on the ground and enter a num of different nests or refuges (Ferron, 1981). Studies in both West Virginia (Urba 1988) and Alaska (Mowrey and Zasada, 1982) and earlier accounts (e.g., Cove 1932) confirm this tendency to spend long periods moving along the ground. It possible that such behavior is associated with foraging on hypogeous fungi. Wh heavy fog (cloud), rain, and high winds delay the onset and decrease the intens of activity, they do not suppress it altogether (Radvanyi, 1959). At such times, flying squirrels appear to spend more time moving along the branches than glidi

Summer telemetry data also suggest individual home ranges of 2-3 hectares in North Carolina (Weigl and Osgood, 1974) and 5-7 hectares in West Virginia (Urb 1988). Radiotracking and trapping studies indicate approximate squirrel densitie of one squirrel per 2-3 hectares in areas of good habitat. In Alaska, G. s. yukonensis have been observed moving their daily ranges within a large foreste area, and using up to 34 alternate den trees (R. Mowrey, pers. comm.) Mowrey suggests that possible explanations for the long distance night-to-night movemen of sabrinus might include: (1) taking advantage of fungal "blooms" in remote areas, (2) a near miss by a predator forcing the squirrel into a new area, (3) ectoparasites in a previous nest, or (4) adverse weather conditions.

Recent telemetry studies in North Carolina have revealed that in winter G. sabrinus cover large areas (over 30 ha) in a short time and may move almost a kilometer in a direct line in a few minutes (Weigl and Boynton, 1990). Further data are required to determine with certainty the size and habitat characteristics of the area needed by an individual or to maintain a stable population of these squirrels.

Difficulties of Present and Future Research

All available information indicates that these two subspecies are rare over most of their range and restricted in their choice of habitat. In spite of the field studies of Linzey (1983) and extensive small-mammal trapping by numerous researchers in many parts of the Appalachians, relatively few range extensions have been reported. It is, of course, possible that the squirrel's rarity, secretive nature, and remote habitat militate against detection of populations at old or new sites. It is also conceivable that these squirrels may periodically abandon particular habitats or undergo periodic population oscillations and thus become undetectable for extended intervals. Such changes in "detectability" have been observed by Osgood (1935), J. Christian (pers. comm. to Weigl, 1970), P. Weigl (pers. obs.), and R. Mowrey (pers. comm.).

Not only are G. s. fuscus and coloratus relatively new to science, rare, and apparently localized in distribution, they are also extremely difficult to collect and study. Weigl (1968) had a capture success of one animal per 80 trap-nights in an area known to have a resident population; this record includes several week-long trapping sessions without any captures. Overall capture success in the West Virginia study at Stuart Knob, also an area with a known resident population, was one animal per 127 trap-nights (Stihler et al., 1987; Urban, 1988). These represent the minimal effort; R. Mowrey (pers. comm.) reported even lower trapping success in Alaska. Two techniques -- live-trapping and use of nest boxes -- have been used successfully to collect these squirrels. Trapping has proved the most tim[e] effective collecting method; however, the placement and periodic checking of [n]... boxes will likely produce more captures and demographic information per unit effort in the long run. Reports of G. sabrinus using bluebird boxes in West Vir[ginia] (D. Hollingsworth, U.S. Forest Service, pers. comm., 1985) indicate the potenti[al] attractiveness of artificial nest structures to these animals. State wildlife biolog[ists] and U.S. Forest Service personnel within the range of G. s. fuscus and colorat[us] have undertaken extensive nest box placement programs, which are providing a wealth of additional data on squirrel locations and habits. Other potential mean[s of] detecting the presence of G. sabrinus include observation of tracks in snow or a prepared substrate, use of feeding stations, night viewing devices, etc. What[ever] technique is employed, working with these animals is a highly unpredictable endeavor and is likely to remain so until more is known about their ecology and behavior.

Reasons for Listing

The limited and discontinuous range of this species in the southern Appalachian[s] makes it vulnerable to a number of both natural and human-related impacts. Ev[en] without human intervention, small, relict populations might suffer disproportionat[ely] from genetic constraints (e.g., increased homozygosity) as well as from climatic and vegetational processes associated with post-Wisconsin changes in mountai[n] environments. However, habitat destruction, fragmentation, or alteration associa[ted] with clearing of forests, introduced insect pests, mineral extraction, recreational o[r] other development, pollution (heavy metals, pesticides, acid rain), and the poten[tial] for global warming outweigh any known natural threats to the species or its habi[tat]. For example, in West Virginia red spruce, an important component of northern flying squirrel habitat, originally covered nearly half a million acres. Timbering operations beginning in the 1880's and ending in the 1920's removed all but 200...

acres of spruce! Roughly 20% of the original forested areas have since regenerated, but not all of this acreage has yet attained the maturity characteristic of good flying squirrel habitat (Bones, 1978; Zinn and Sutton, 1976).

Introduced pests, in particular, the balsam wooly adelgid (Adelges piceae) [Ratz] [possibly also the gypsy moth (Lymantria dispar)] threaten to further reduce the extent and quality of remaining forest habitats required by a conifer-hardwood ecotone species like G. sabrinus. The balsam wooly adelgid, accidentally introduced from Europe around 1900, has spread throughout the fir forests of the eastern United States. This insect is a relatively innocuous parasite of firs in Europe, but it is extremely damaging in North America. In the eastern United States, the balsam fir (Abies balsamea) and the Fraser fir (A. fraseri) are the host species, with the latter sustaining the more serious damage and higher mortality. The death of Fraser firs occurs within 2-7 years following the initial infestation by the adelgid. Although Fraser firs were estimated to cover some 60,000 acres in the southern Appalachians (Barry and Oprean, 1979), it has been predicted that if current trends continue, the balsam wooly adelgid will eliminate mature Fraser firs within the next several decades and may eventually cause the extinction of this southern Appalachian endemic conifer (Eager IN White, 1984). The impact of this potential extinction on sabrinus is not known.

Paradoxically, the solution to one problem may be the cause of another. Lindane (gamma isomer of benzene hexachloride), the primary chemical used to control the balsam wooly adelgid, has come under scrutiny due to its toxicity to aquatic organisms (Ulmann, 1972) and its persistence in the environment. Biodegradable alternatives, such as potassium oleate, an insecticidal soap, have been used with some success on balsam wooly adelgids. However, their usefulness is limited, since they lack residual activity.

Spruce and spruce-fir declines and die-offs associated with factors other than th
adelgid have become of increasing concern in the Northeast and at higher elevations in the southern Appalachians (Adams et al., 1985; Vogelmann, 1982
Although acid precipitation is believed to play some role in these declines, its ex
role, as well as the contribution of heavy metal pollution, is still being investigat
(Zedaker et al., 1989). High elevation sites in the spruce-fir zone of the souther
Appalachian Mountains exhibit higher concentrations of heavy metals such as le
copper, nickel, zinc, and manganese in forest floor material and soil than low elevation sites in the same region. Lead concentrations have been found to be
much as ten times higher on the summit of Mount Mitchell, North Carolina (northern flying squirrel habitat), than in surrounding lowlands (Bruck, 1984). In
some high elevation forests, lead concentrations approach those of urban areas
and areas adjacent to highways (Bogle and Turner IN White, 1984). The possib
of lead and copper toxicity to plants needs to be investigated with relation to the
decline of conifers at high elevations in the southern Appalachians. Vogelmann
(1982) suggested a possible synergistic effect of lead and acid rain, resulting in
death or the sharp decline of red spruce and other plant species. Heavy metals
may also have direct effects on the squirrels. For example, lichens and mycorrh
fungi are known to accumulate lead (Dey IN White, 1984) and could thus pass th
contamination to flying squirrels; the toxicity of lead (Eisler, 1988) and other heav
metals to animals is well documented.

In addition to synergistic chemical effects, acid rain may exert deleterious effects
conifers through other subtle interactions. For example, Bruck (1984) reported li
successful reproduction of fir, spruce, or woody shrubs above 6,350 feet on Mou
Mitchell. In this area acid rain has been found to destroy the mycorrhizae living
association with conifer roots, interfering with the regeneration and vigor of the trees. Petersen (IN White, 1984) also mentioned a potential connection between
the decline of high elevation conifers and the effect of acid precipitation-caused declines in mycorrhizal symbionts. As a result, northern flying squirrels could be

affected by loss or contamination of both their mycorrhizal food source and their coniferous habitat. Intensive investigations of the causes of spruce/fir decline are currently being conducted by the U.S. Forest Service and EPA, as a part of the National Acid Precipitation Assessment Program.

Modification of northern flying squirrel habitat may also have favored the spread and proliferation of competitors and pathogens. Research with captive animals indicates that G. sabrinus may be displaced by the more aggressive and agile G. volans in certain hardwood habitats where their ranges overlap (Weigl, 1978). It is unknown to what extent southern flying squirrels are expanding their range into northern flying squirrels' habitat and, if this does occur, whether sabrinus will be displaced. Evidence on the species' interactions is mixed. In two areas in North Carolina once occupied by sabrinus, only volans are now captured (P. Weigl, pers. obs.). While both species have recently been captured in close proximity in North Carolina, West Virginia, and Virginia, previous work elsewhere suggests that such sympatry is often unstable (Osgood, 1935; J. Christian, pers. comm., P. Weigl, pers. obs.). Both species have been trapped near Stuart Knob, Randolph County, West Virginia, at intervals over the past 36 years (C. Stihler, pers. comm.), but the extent and frequency of their sympatry over that time period are not clearly documented. Further studies of the species' interactions are indicated. There is also some evidence that the southern flying squirrel harbors a parasitic nematode (Strongyloides robustus) which, if transferred to the northern species, could prove lethal or debilitating (Weigl, 1975), especially in the more southern parts of the species' ranges.

Strategy for Recovery

The limited nature of existing data on the two southern subspecies of Glaucomys sabrinus and the potential vulnerability of their habitat suggest a four-part strategy for recovery. First, it is necessary to determine the distribution of the species in southern Appalachians by conducting surveys of former capture sites and new areas with apparently suitable habitat. This task is well underway. Second, are found to support this species or especially favorable habitat conditions must receive adequate protection from human-related disturbance. Fortunately, the majority of areas occupied by these endangered squirrels is in public ownership (U.S. Forest Service, National Park Service) and these agencies are cooperating management for the squirrels. Third, a concerted effort must be made to obtain information on flying squirrel ecology -- in particular, habitat requirements, diet, relations with G. volans. Finally, the squirrels' response to various habitat modification measures should be studied. These studies should focus on habitat enhancement measures (e.g., thinning of dense stands of spruce regeneration) as well as determining timber harvest methods that are compatible with protection and maintenance of squirrel populations.

Trapping and nest box captures to date have revealed clusters of capture sites, such that general areas of occupancy by these squirrels may be described. For the purposes of assessing recovery, we are defining these as "Geographic Recovery Areas" (GRAs) for each subspecies.

In keeping with the section on distribution, the following GRAs are noted for G. s. fuscus:

1. the Stuart Knob area (Randolph County, WV)
2. the Cheat Bridge area (Pocahontas and Randolph Counties, WV)
3. the Cranberry area (Greenbrier, Pocahontas, Randolph, and Webster Counties, WV)
4. the Blackwater Falls area (Tucker County, WV)
5. the Spruce Knob/Laurel Fork area (Pendleton and Randolph Counties, WV and Highland County, VA)

GRAs for _G_. _s_. _coloratus_ are:

1. the Roan Mountain area (Mitchell County, NC and Carter County, TN)
2. the Grandfather Mountain area (Avery, Caldwell, and Watauga Counties, NC)
3. the Black Mountains (Buncombe and Yancey Counties, NC)
4. the Great Balsam Mountains (Haywood and Transylvania Counties, NC)
5. the Plott Balsams (Haywood and Jackson Counties, NC)
6. the Great Smoky Mountains (Haywood and Swain Counties, NC)
7. the Unicoi Mountains (Cherokee County, NC and Monroe County, TN)
8. the Long Hope Valley area (Ashe and Watauga Counties, NC)
9. the Whitetop-Grayson Highland area (Smyth and Grayson Counties, VA)

Additional GRAs may be defined as further survey data are accumulated.

PART II: RECOVERY

Recovery Objective:

To remove Glaucomys sabrinus fuscus and Glaucomys sabrinus coloratus from the list of endangered and threatened species.

This is envisioned as a two-step process. **Down-listing** from endangered to threatened status will be possible when it can be documented that:

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 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.

De-listing will be possible when, in addition to the above factors, it can be demonstrated that:

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.

Recovery criteria for the two subspecies will be assessed independently. For example, the threat imposed by the balsam wooly adelgid to Fraser firs in the southernmost portions of the Appalachians may preclude recovery of G. s. coloratus beyond threatened status.

Narrative Outline of Recovery Tasks

1.0 Establish a recovery advisory committee to coordinate all recovery actions.

Because these squirrels occur in two FWS regions and because of the increasing interest from government and academic agencies in studying them, such a committee is necessary to ensure that recovery criteria are being met, to provide a centralized data repository, and to ensure that research efforts are not duplicated or inconsistent. The advisory committee initially will be comprised of members of the recovery team, although membership may change over time.

2.0 Determine distribution and viability of G. sabrinus populations in the southern Appalachians.

Accurate knowledge of the species' distribution is essential for protecting individual populations, understanding the relationships among populations, and monitoring long-term population changes. Great strides have been made towards completion of this task, as indicated by the establishment of GRAs. At this time, it is a matter of filling in the gaps in our information base.

2.1 Delineate occupied and potential habitat.

Historic and recent capture data provide strong evidence of a habitat preference for conifer-hardwood ecotones and mosaics, especially at higher elevations. Potential habitat may be defined areas with vegetation and elevational components similar to tha known occupied habitats. Spruce stands in much of the easter U.S. have been mapped and the data compiled in a GIS databa by the U.S. Forest Service. These data are available from the Forest Service and have been obtained by the state wildlife biologists involved with northern flying squirrel research. Information on other potential habitat types may be obtained fro aerial photos, cover type and photographic maps, and forest sta data. This task has been largely completed, although some refinement may be necessary.

2.2 Survey potential habitat to locate additional populations.

First priority areas to survey are mature spruce/fir/northern hardwood forests and ecotonal areas. Other types of habitat tha should also be surveyed, but are a lower priority, include hemlock/hardwood forests, especially in riparian areas, and northern hardwood stands.

Surveys of potential habitat via the placement and monitoring of nest boxes and/or live-trapping have proven to be highly successful. Other techniques, such as night-scope observation a feeding stations, auditory surveys, smoked aluminum and/or sno tracking and hair identification may be useful, but require addition research.

2.3 Monitor known populations.

More frequent monitoring may be at times desirable. For example, if late summer breeding is suspected, an additional check in late summer is warranted. Moreover, certain key sites may be designated for yearly monitoring. In addition to population trend data, monitoring will provide data on weights and measurements, litter size and breeding seasons, sex ratio, age structure, and social behavior; over time, information on life expectancy may be acquired as well.

As much information as possible will be obtained in the course of monitoring, including fecal samples for dietary and parasite analysis, ectoparasites, etc.

3.0 Obtain life history and ecological information for known populations of G. sabrinus of the southern Appalachians.

Such studies are necessary to determine critical factors favoring survival, growth, and reproduction.

3.1 *Conduct in-depth studies of habitat requirements.*

Such information is very limited for G. s. fuscus and coloratus, yet it is essential for determining whether recovery goals are being met and for making informed management decisions. For example, we must learn more about the squirrels' seasonal habitat requirements and home range to determine the size and configuration of areas that need to be protected and what manipulations, if any, are permissible.

3.11 Determine the importance of spruce and fir forest components to the survival of sabrinus.

As noted in the Habitat section, the two endangered squirrel subspecies have been captured almost exclusi in stands containing spruce or spruce/fir. Yet in the U Mountains of North Carolina and Tennessee, sabrinus i apparently surviving in the complete absence of a spru component. One capture site in West Virginia also has virtually no spruce component, although there are spru stands nearby (C. Stihler, pers. obs.). Notably, both of these sites do contain hemlock in the overstory. An understanding of the importance of a coniferous forest component to these squirrels is crucial, for example, in cases where firs are being extirpated by the balsam woo adelgid, or where widespread spruce die-offs are occurri To gain this understanding, a comparative study of movements and habitat use of squirrels in areas with no spruce or fir, versus that of squirrels in more typical habit will be conducted. The importance of spruce-fir may also be determined via long-term monitoring of populations in non-spruce/fir habitats and in areas where spruce or fir mortality is high. Such areas will be monitored annually, a opposed to biennially, to detect any subtle changes that may occur.

3.111 Monitor ongoing studies of loss or degradation of high elevation forest resulting from insect damage and air pollution.

Since the ecology of Glaucomys sabrinus in this region is intimately linked to boreal forests and ecotonal areas, widespread die-offs or reduced growth of spruce/fir or northern hardwood forests associated with insect damage or environmental contaminants could have a tremendous negative impact on these squirrels. A major wide-reaching study of spruce/fir decline is presently being conducted jointly by EPA and the U.S. Forest Service as a part of the Forest Response Program, a sub-program of the National Acid Precipitation Assessment Program (NAPAP). Two of the southern Appalachian intensive study areas in this investigation are at Mt. Rogers and Mt. Mitchell, both known to be occupied by northern flying squirrels. Squirrel researchers should be aware of this program and coordinate with spruce-fir decline investigators to understand the rates and causes of forest loss and to interpret effects of these on sabrinus.

3.12 Study the relationships among population size, habitat size and habitat quality.

Answers to such questions as 'How large a population size can a given area of habitat support?' are notably elusive and relate necessarily to the quality of the habitat in question. However, such questions must be addressed if we are to manage these squirrels effectively in the long run. Answering these questions will require long-term

comparative studies of squirrel numbers and habitat us
during different seasons and in different habitat types.

3.13 <u>Study the effects of modification or loss of habitat resu</u>
<u>from timber operations or other development</u>.

Timber harvest often precedes other developmental activities such as powerline construction or recreational development. The effects of road construction and vari timber harvest and reforestation methods on sabrinus w be evaluated primarily on Forest Service lands. While to loss of spruce is almost certainly detrimental to G. sabri some thinning or opening of the canopy could be acceptable or even beneficial to these squirrels. Examp of timber harvest methods to be assessed include: (1) small block cuts, as opposed to larger clearcuts; (2) cuts of irregular shape, to complement site-specific topographic or vegetational features; (3) shelterwood cut (approximately 40 square feet basal area per acre) for regeneration; and (4) removal of over-mature hardwoods (but not along the spruce-hardwood ecotone).

Additionally, a study or studies should be conducted specifically to determine use by sabrinus of clearcuts of various ages as well as their use of areas where other timber management techniques have been employed. These studies should be closely coordinated with those conducted under Task 3.11.

Certain timber management practices may favor G. sabrinus over G. volans (e.g., possibly selection against heavy mast-producing species). This possibility could be examined in conjunction with studies conducted under Task 3.3.

Some experimental timber harvesting has already been permitted in G. sabrinus habitat on the Monongahela National Forest, with an eye toward determining long-term impacts to the squirrels (W. Tolin, U.S. Fish and Wildlife Service, Elkins, WV, pers. comm., 1989). Additionally, squirrels have been located in West Virginia on a large tract with several areas that have been recently timbered. Following the response of these populations will enhance our knowledge of the long-term effects of timber harvest on these squirrels.

3.2 Study the diet of G. sabrinus.

The importance of lichens and hypogeous fungi to northern flying squirrels in the southern Appalachians requires further examination as it relates to potential competition with G. volans, the importance of G. sabrinus in forest maintenance, and the potential contamination of this food source by pesticides or heavy metals.

3.21 Examine the role of G. sabrinus in the dispersal of mycorrhizal fungi and forest maintenance.

The role that G. sabrinus plays in dispersing mycorrhizal spores, thus promoting forest regeneration (Maser et al., 1978), requires further investigation. Part of this work co[...] be done in association with ecological or monitoring stu[...] by collecting feces and determining whether certain fung[...] spores are present. Further investigations may be necessary to understand fully the relationships between these flying squirrels, mycorrhizal fungi, and forest regeneration.

3.22 <u>Investigate potential accumulation of toxics in food supp[...]</u>

As already stated, pesticides and heavy metals are findin[...] their way into the northern flying squirrel's environment, b[...] their effects are not yet known. Tests for the presence o[...] Lindane in animals and stream water adjacent to treated areas on Mt. Mitchell have been negative (Eager IN Whit[...] 1984). Monitoring studies were also conducted recently [...] Roan Mountain, in conjunction with adelgid control by the U.S. Forest Service. Redback voles (*Clethrionomys gapperi*), which occupy northern flying squirrel habitat an[...] have similar food habits, were collected for tissue analysis to determine levels of Lindane, as well as other potentially harmful pesticides and heavy metals. Much more work is needed on biomagnification of toxins in high elevation habitats.

Although previous studies have shown that lichens concentrate toxic substances, extensive studies have not been conducted in areas occupied by northern flying squirrels. Preliminary collection and analyses of lichens from flying squirrel habitat should reveal any potential problems and determine whether additional analyses are indicated.

3.3 Study interactions with other squirrels.

3.31 Examine behavioral interactions.

The relationship between G. sabrinus and G. volans needs to be studied, to determine whether interspecific interactions impact negatively upon G. sabrinus in the long run. If this proves to be the case, habitat occupied by sabrinus will be managed to favor this species over volans. Potential competition for nesting sites between G. sabrinus and red squirrels (Tamiasciurus hudsonicus) should also be investigated.

3.32 Examine effects of Strongyloides and other parasites or diseases.

Field and laboratory studies should be conducted to elucidate more fully the pathogenicity of this parasite to G. sabrinus, and to determine whether G. volans is an effective vector. Preliminary evidence indicates that a light infestation, as has recently been found in several specimens in West Virginia and Virginia, appears to be tolerated (Pagels et al., 1990); heavier infestations may weaken the animals so that they succumb to other stresses such as pneumonia. Any other pathogens found to affect G. sabrinus specifically should be similarly studied.

4.0 Determine genetic variability within and among populations.

As our knowledge of habitat requirements expands, there will come a when we should examine genetic variability within and among populati (= GRAs), to gain a better understanding of the origin of and interacti among populations. This information will assist in determining the appropriateness and necessity of maintaining or establishing migration corridors among the various GRAs. Additionally, genetic studies may r any population segments with an unusual amount of diversity or rare a Techniques used to obtain genetic material (e.g., blood sampling) shou be standardized for all researchers and designed to avoid any possibili significant injury to the animals.

5.0 Develop management guidelines.

5.1 Develop and refine habitat management guidelines for agencies and private landowners involved in habitat-altering activities with the range of G. s. fuscus or coloratus.

Guidelines developed for private landowners and general guideli for National Forests appear in Appendix A. All national forests ar parks within the subspecies' range will be encouraged to adopt similar guidelines tailored for their own needs. Guidelines will be revised as more information becomes available.

5.11 Where these guidelines specify placement of nest boxes project areas, designate a "data coordinator" for each sta to keep up with results and regularly report findings to sta and Federal wildlife agencies and to the recovery advisor committee.

Because placement of nest boxes is becoming a primary means of gathering data on the effects of specific management activities (i.e., road building and timber sales), the number of boxes placed in project areas may become quite large. One individual per state should be assigned the task of keeping track of nest box data, live-trapping or other survey methods. State coordinators should compile a list of captures each year for the recovery advisory committee.

5.2 Develop policy and, if appropriate, methodology for translocation/reintroduction and captive rearing.

At this time, the distribution, abundance, and the genetic interchange among populations of Glaucomys sabrinus in the southern Appalachians is incompletely known. Until such information becomes available, it is not prudent to consider relocation and/or introduction an appropriate management tool. This policy may change as more is learned about life history and distribution of these squirrels.

6.0 Implement appropriate management and protection procedures.

6.1 Implement habitat management guidelines on public lands and encourage their use on private lands.

On Federal lands or where Federal permits, funding, or authorization are involved, appropriate management will be implemented through consultation under Section 7 of the Endangered Species Act. Natural resources agencies will encourage the adoption of appropriate management for those private actions affecting squirrel habitat.

6.2 <u>Protect occupied habitat through land acquisition or other means as appropriate</u>.

Encourage protection of unprotected occupied habitat via conservation easement, fee title acquisition, long-term lease, etc., by Federal, state, or local government agencies or by private conservation groups, in order to ensure habitat protection in perpetuity.

6.3 <u>Protect individual squirrels and their habitat through vigorous enforcement of the Endangered Species Act and other applicable Federal and state laws</u>.

The southern Appalachians are receiving more and more impact from mining of high elevation deposits of valuable low-sulphur coa and from recreational interests, including the development of ski resorts and vacation communities in higher elevation habitat. This mining is generally permitted by the states, in coordination with th Fish and Wildlife Service. Whenever possible, biologists should provide design input to decrease the impacts of such activities. If any Federal funds, permits, or authorization are involved, such projects would require review through Section 7 of the Endangere Species Act. Where no permits are required, developers will still b encouraged to consider potential presence of northern flying squirrels in their development plans.

7.0 Implement information/education programs.

7.1 Provide educational/management training for state and Federal foresters, game managers, and others.

Training will be provided to familiarize these individuals with the northern flying squirrel and the types of habitat it occupies.

All appropriate biologists, foresters, etc., should receive training, so that they will be sensitized to the presence of potential northern flying squirrel habitat in the course of their day-to-day activities. One such workshop was conducted in 1986 at Roan Mountain.

7.2 Prepare and distribute educational displays and informational materials.

Pamphlets, brochures, and/or displays will be used to inform the public of the differences between southern and northern flying squirrels, the importance of old-growth northern forest types to the latter species, and the adverse effects of habitat loss or modification.

7.3 Coordinate with private landowners to eliminate or minimize threats to populations.

A major threat to these squirrels is habitat alteration associated with human activities. This and other threats can be eliminated or minimized through education of individuals and public and private land-owning organizations (Tasks 7.1 and 7.2) and through land acquisition (Task 6.2).

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PART III: IMPLEMENTATION

Priorities in column one of the following implementation schedule are assigned as follows:

1. Priority 1 - All actions that are absolutely essential to prevent extinction of the species.
2. Priority 2 - All actions necessary to maintain the species' current population status.
3. Priority 3 - All other actions necessary to provide for full recovery of the species.

Appalachian Northern Flying Squirrels
Implementation Schedule

September, 1990

Priority	Task Number	Task Description	Task Duration	Responsible Agency*		Cost Estimates** ($000)			Comments
				FWS	Other	FY1	FY2	FY3	
1	2.1	Delineate occupied and potential habitat.	Completed	R4,5 / FWE	USFS, NPS, and SWA	--	--	--	
1	2.2	Survey potential habitat to locate additional populations.	Continuous	R4,5 / FWE	USFS, NPS, and SWA	45	45	45	
1	2.3	Monitor known populations.	Continuous	R4,5 / FWE	SWA	35	35	35	
1	3.13	Study effects of timber operations.	7 years	R4,5 / FWE Research	USFS and SWA	30	30	30	
1	3.32	Examine effects of <u>Strongyloides</u> and other pathogens.	3 years	R4,5 / FWE	SWA	10	10	10	
1	5.1	Develop and refine habitat management guidelines.	1 year	R4,5 / FWE	USFS, NPS, and SWA	--	--	--	Guidelines for use on private and public lands appear in Appendix A.
1	6.1	Implement habitat management guidelines	Continuous	R4,5 / FWE	USFS, NPS, and SWA	25	25	25	
1	6.3	Protect individual squirrels and their habitat through enforcement of the ESA and other laws.	Continuous	R4,5 / FWE, LE	USFS, NPS, and SWA	1	1	1	
2	3.11	Determine importance of [illegible]	3 years	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

Priority	Task Number	Task Description	Task Duration	Responsible Agency*		Cost Estimates** ($000)			Comments
				FWS	Other	FY1	FY2	FY3	
2	3.111	Monitor ongoing studies of effects of spruce/fir die-offs.	Continuous	R4,5 / FWE	USFS, EPA, NPS, and SWA	--	--	--	
2	3.12	Study population size/ habitat size and quality relationships.	3 years	R4,5 / FWE	USFS and SWA	30	60	60	
2	3.22	Investigate accumulation of toxics in food supply.	3 years	R4,5 / FWE (EC)	SWA	10	10	10	
2	3.31	Study behavioral interactions with other squirrels.	3 years	R4,5 / FWE	SWA	10	10	10	
2	4.0	Examine genetic variation within and among populations.	2 years	R4,5 / FWE	SWA	--	--	10	
2	5.11	Designate data coordinator in each state.	Continuous	R4,5 / FWE	SWA	3	3	3	
2	5.2	Develop policy for translocation/reintroduction.	---	R4,5 / FWE	SWA	--	--	--	Accomplished methodology will be developed if/when policy changes.
2	6.2	Protect occupied habitat through land acquisition, etc.	Continuous	R4,5 / FWE	USFS, NPS, SWA, and TNC	1	1	5	
2	7.1	Provide training for state and Federal foresters, game managers, and others.	Continuous	R4,5 / FWE	USFS and NPS	1.5	1.5	1.5	

Priority	Task Number	Task Description	Task Duration	Responsible Agency* FWS	Other	Cost Estimates** ($000) FY1	FY2	FY3	Comments
2	7.3	Coordinate with private landowners to eliminate or minimize threats to populations.	Continuous	R4,5 / FWE	SWA	2	2	2	
3	3.21	Study dispersal or mycorrhizal fungi.	2 years	R4,5 / FWE	SWA	2	2	--	
3	7.2	Prepare and distribute educational displays and informational materials.	Continuous	R4,5 / FWE	SWA	2	2	2	Results of ongoing research are needed to develop brochures and displays.

* FWS = U.S. Fish and Wildlife Service
R4,5 = Region 4, Region 5
FWE = Division of Fish and Wildlife Enhancement
LE = Division of Law Enforcement
EC = Environmental Contaminants Section

USFS = U.S. Forest Service
NPS = National Park Service
SWA = State wildlife agencies of all participating states (VA Department of Game and Inland Fisheries, WV Department of Natural Resources, NC Wildlife Resources Commission, and TE Wildlife Resources Agency).
TNC = The Nature Conservancy

** Cost estimates are for all funds: Federal, state, and private.

APPENDIX A
Suggested Guidelines for
Habitat Identification and Management

Guidelines may vary, depending on location, land use, and land ownership. Below, we present general guidelines for use on private lands, and guidelines designed for use on National Forests. These guidelines are subject to change as more data are gathered on the ecological requirements and associates of these flying squirrel subspecies in the southern Appalachians.

(1) General Guidelines for Management of G. s. fuscus and G. s. coloratus Habitat on Private Lands.

1. Potential habitat includes areas of mature spruce and/or fir stands, pure or mixed with northern hardwood and/or hemlock trees. In the southern Appalachians these forested areas are generally found at elevations above 3,300 feet, or higher further south.

2. Ideally, potential habitat, particularly old-growth areas, should be maintained intact; while limited selective cutting may be conducted, clearcutting should be avoided.

3. Any timber rotation schedules should be of a sufficient length to maintain the old-growth character of the area.

4. Nest boxes may be installed and checked regularly, to determine whether northern flying squirrels are occupying the area. Installation and checking of boxes should be coordinated with state non-game wildlife agencies. Permits are required for working with any endangered or threatened species.

(2) Suggested Standards and Guidelines for Habitat Management of the Endangered Flying Squirrels (Glaucomys sabrinus fuscus and G. s. coloratus) o Public Lands.

I. Habitat Identification

A. Occupied Habitat is defined as any area where G. s. fuscus or coloratus is known to exist through positive identification, as throug trapping.

B. Potentially Occupied Habitat is described as:

1. All stands containing spruce or fir [USFS Region 8 timber typ 06,07,17; Region 9 types 11,13,17,87]

or

2. All stands above [3300 feet for fuscus] [4500 feet for coloratu containing hemlock or northern hardwoods in any combinatio [USFS Region 8 types 05,08,81; Region 9 types 81,82,85,86,89]

and

3. Stands with at least some 10 inch dbh or larger trees present and at least partial canopy closure (e.g. in mixed conifer/hardwood stands a minimum basal area of 100 squar feet per acre.

II. Occupied Habitat Management

A. The size of the occupied area is defined as all area within 1/2-mile o the trapping or identification site.

B. Within occupied areas, the following options are available:

1. Redesign the project to avoid the area.

2. Consult with a wildlife biologist <u>and</u> the USFWS to determine appropriate management measures.

III. Potentially Occupied Habitat Management

A. An evaluation (based on best information and professional judgment) must be performed by a wildlife biologist to determine one of two suitability classes (high or low) (see table, p. 52).

B. If the evaluation indicates low potential suitability, the area may be treated as unoccupied.

C. If the evaluation indicates high potential suitability, the following options are available:

1. Redesign the project to avoid the area.

2. Establish reasonable evidence that the identified area is unoccupied by G. sabrinus through the use of live trapping, and/or nesting boxes. Trapping and/or use of nesting boxes must follow procedures presented in Appendix B of this plan and must be supervised by a wildlife biologist.

3. Consult with a wildlife biologist to determine appropriate management measures.

IV. Management Measures

A. Some examples of appropriate management measures that may be recommended by a wildlife biologist are:

1. Save standing snags, trees with cavities, culls and down logs.

2. Retain spruce, fir, yellow birch and beech.

3. Plant spruce or encourage natural regeneration of spruce.

4. Avoid drainages, spring seeps, and moist areas.

5. Retain a certain stocking level of residual trees of a certain diameter and/or species to accomplish a specific objective.

6. Specify size and shape of treatment areas in order to accomplish a particular objective.

Factors to score in determining habitat suitability rating (high or low):

Factor	Suitability Rating	
	Low	High
temperature	warmer	cooler
humidity	low	high
soil moisture	low	high
presence of downed logs	few	many
lichen growth	sparse	abundant
presence of moss, fern, liverwort, Lycopodium groundcover	sparse	abundant

In addition to these factors, highly favorable sabrinus habitat would have at least some large trees, with elaborate branching systems dispersed throughout. These facilitate the squirrels' movements through their home range.

APPENDIX B
Recommended Procedures for trapping, handling, and use of nest boxes for Glaucomys sabrinus

BEFORE CONDUCTING ANY FIELD WORK WITH G. SABRINUS CONTACT APPROPRIATE STATE AND FEDERAL AGENCIES CONCERNING PERMIT REQUIREMENTS

1. Conduct trapping from spring through mid-autumn. Do not trap during extremely cold, wet or windy weather. Trapping success may be decreased on clear moonlit nights.

2. Use wire mesh live-traps of size appropriate for chipmunks. Metal box traps have proven ineffective for flying squirrel capture and could cause fatality.)

3. To increase capture success, put up feeding platforms where the traps will be placed, and "pre-bait" them for several nights before trapping (time permitting).

4. Set 20 to 40 traps at a minimum spacing of 50 m. in 1 or 2 transects through areas to be trapped. The number and spacing of the traps should be tailored to the area being trapped.

5. Secure traps to the ground or attach horizontally to large, mature trees at a height of about 6 feet. Be sure to flag or otherwise visibly mark trees with traps.

6. Place moss, leaves, etc. over traps, to break the outline and to provide some cover.

se

7. Insert a suitable bedding material (e.g. leaves and/or cotton batting) into the traps.

8. Bait traps with a peanut butter-oat and bacon grease-fruit (apple, prune) mixture.

9. Run traps 1 week to 10 days per area. If possible, each area should be trapped during more than one season.

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