Northern Flying Squirrel
(Glaucomys sabrinus)

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FIG 1. A northern flying squirrel finds refuge in the top of a shore pine (*Pinus contorta*) near the edge of a muskeg bog on Prince of Wales Island. Old-growth forests are considered important habitat for flying squirrels throughout their range in North America. (Jeff Nichols)

The northern flying squirrel is an arboreal rodent widely distributed throughout forests of the northern United States and Canada from the eastern seaboard to the Pacific coast and from California to Alaska (Fig 1). Because of its largely nocturnal behavior, the flying squirrel—although common in many forests—remains a mystery to most people. The flying squirrel has enormous eyes and thick, soft fur, brown on top and light underneath. Smaller than the red squirrel (*Tamiasciurus hudsonicus*), the flying squirrel actually glides, not flies, through the forest canopy by stretching out the lateral skin (patagia) between its front and back legs.

The flying squirrel plays a key ecological role in forest regeneration in the Pacific Northwest because it forages on the fruiting bodies of underground fungi and disseminates fungal spores throughout the forest (Maser and Maser 1988). These colonies of mycorrhizal fungi form a symbiotic relationship with the roots of many woody plants, including conifer trees. The mycorrhizal fungi expand the root function of conifers, enhancing nutrient acquisition for trees while extracting sugars from the trees. Throughout the Pacific Northwest, the flying squirrel is considered a species closely affiliated with old-growth forests (Carey 1995).

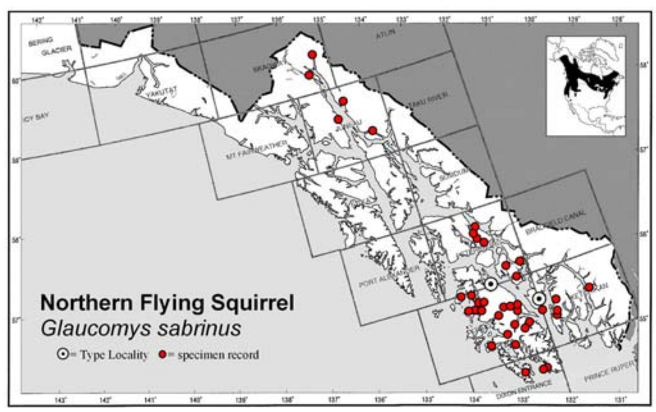

FIG 2. Range map showing the specimen records of northern flying squirrels in Southeastern Alaska (courtesy of MacDonald and Cook in press). Note the distribution is broader than the specimen records.

STATUS IN SOUTHEASTERN ALASKA

Distribution

Northern flying squirrels inhabit forests along the mainland coast of Southeastern Alaska (Southeast) east of Glacier Bay and south to the Canadian Border (MacDonald and Cook 1996, 1999) (Fig 2). Flying squirrels also occur on at least 15 islands within the southern Alexander Archipelago south of Sumner

Strait, including Mitkof, Wrangell, Etolin, Prince of Wales (POW), Kosciusko, Heceta, Suemez, Tuxekan, Dall, Revillagigedo, and the Barrier islands (MacDonald and Cook 1999, Bidlack and Cook 2001).

Abundance

The density of flying squirrels in the Alexander Archipelago of Southeast is among the highest documented in North America. Smith and Nichols (2003) reported mean densities of 7.9 and 4.2 squirrels per acre (3.2 and 1.7 squirrels per hectare) on POW in old-growth western hemlock (*Tsuga heterophlla*)-Sitka spruce (*Picea sitchensis*) forest and muskeg-bog scrub forest, respectively.

Taxonomic Considerations

Recent genetics research has substantiated the occurrence of two subspecies of flying squirrels from Southeast: the Alaska Coast flying squirrel (*G. s. zaphaeus*) of the mainland and adjacent islands (such as Mitkof, Etolin, Wrangell, and Revillagigedo islands) and the Prince of Wales flying squirrel (*G. s. griseifrons*) from 11 islands within the POW Island complex (Demboski et al. 1998, Bidlack and Cook 2001). These studies suggest that the Prince of Wales flying squirrels appear to be the result of a relatively recent (Holocene) event from a single founder population on POW Island and represent a unique island lineage of flying squirrels.

Significance to the Region and the Tongass National Forest

Flying squirrels fill a distinctive ecological niche in Southeast and may play a key ecological role in nutrient cycling within the temperate rainforest by dispersing spores of mycorrhizal fungi, which are important vectors for nutrient transfer to conifer roots (Maser et al. 1978, Maser and Maser 1988, Mowrey 1994, Carey et al. 1999, Smith et al. 2005). Flying squirrels are also important prey for hawks, owls, and small carnivores (Mowrey 1994, Smith et al. 2005). Flying squirrels were a "design" species for small size old-growth reserves (<10,000 acres [4,050 hectares]) in the 1997 *Tongass National Forest Land and Resource Management Plan* (TLMP) (U.S. Forest Service [USFS] 1997a) because of their assumed "dependency on the forested habitats" (Suring et al. 1993). The subspecies *G. s. griseifrons*, endemic to the POW Island complex (Fig 3), has been listed as a subspecies of ecological concern in the Tongass National Forest (West 1993) and as potentially endangered in the Status Survey and Conservation Action Plan for North American Rodents prepared by the International Union for the Conservation of Nature (Hafner et al. 1998).

FIG 3. The Prince of Wales flying squirrel occurs throughout forested habitats on Prince of Wales and adjacent islands of the Alexander Archipelago. These southern islands are an important center of endemism for many small-mammal species, including this subspecies of flying squirrels. (Jeff Nichols)

HABITAT RELATIONSHIPS

Compared to studies in the Pacific Northwest, relatively few ecological studies of flying squirrels have been completed in Southeast. Smith et al. (2004) investigated habitat relationships of flying squirrels on Prince of Wales Island. They measured spring and autumn habitat use by squirrels in old-growth western hemlock-Sitka spruce forests (Fig 4) and in scrub-mixed-conifer forests associated with muskeg bogs (Fig 5). Squirrel densities were higher in old-growth hemlock-spruce forests than in scrub forests in spring and autumn, but particularly in autumn when mean densities were 56% higher in old growth hemlock-spruce (Smith and Nichols 2003, Smith et al. 2004). Flying squirrel densities increased with density of large trees (>29 in. [74 cm] diameter at breast height [dbh]) and snags (20–29 in. [51–74 cm] dbh. Cavities in trees and snags are used by flying squirrels in Southeast for denning habitat (Baker and Hastings 2002) (Fig 6). Other habitat variables that appear important to flying squirrels include cover of ericaceous shrubs (such as *Vaccinium spp.*) and coarse woody debris (Smith et al. 2004). Although the features described above are typical in old-growth forests, no studies comparing flying squirrel density or habitat use in old growth and second growth have been conducted in Southeast.

FIG 4. A productive old-growth hemlock spruce forest on Prince of Wales Island. Old-growth forests are uneven aged with multi-layered canopies and abundant plant communities on the forest floor. On well-drained soils such as those supporting this stand, old-growth forests support large-diameter trees and snags, which include cavities and structure used by flying squirrels for denning and resting. They are structurally complex and provide important habitat for flying squirrels. Western hemlock-Sitka spruce stands with large trees have high-density populations of flying squirrels. (Jeff Nichols)

FIG 5. Scrub old growth on Prince of Wales Island. This stand of hemlock, cedar, and pine is situated on poorly drained soils near a muskeg bog. Trees in these forests are generally shorter and smaller in diameter than those on well-drained soils and have lower densities of flying squirrels. (Jeff Nichols)

FIG 6. Flying squirrel climbing a snag on Prince of Wales Island. Large-diameter snags and old-growth trees provide important habitat for flying squirrels. (Jeff Nichols)

The northern flying squirrels are omnivores generally associated with old forests. In much of the coniferous forest habitat of western North America, truffles (fruiting bodies of underground fungi) form a major component of flying squirrel diets and flying squirrels play a significant role in dispersing truffle spores throughout the forest (Maser et al. 1985, Carey et al. 1999). In Southeast, flying squirrels also consume truffles, although to a lesser degree than in southern forests. The primary summer and autumn diet (% occurrence) of flying squirrels in old-growth forests from the POW Island complex was vegetation (55%), truffles (50%), mushrooms (36%), lichens (27%), and insects (4%) (Pyare et al. 2002).

In Interior Alaska, flying squirrels use a mosaic of forested habitats for denning and foraging. Squirrels may move their dens up to 20 times a year among many different den trees within a 20-acre (8-hectare) area and can travel as much as 1.2 mi (1.9 km) in a single night (Mowrey 1994).

FOREST ECOLOGY AND MANAGEMENT

Forest Composition and Ownership

Temperate coniferous rainforests cover more than 11 million acres (4.5 million hectares), or about 46%, of the land area of Southeast (Hutchison and LaBau 1975, Harris and Farr 1979). The majority of the forested land in Southeast occurs in the Tongass National Forest, which makes up 80% of the Southeast land base (USFS 2003). About two-thirds of the Tongass is forested, although productive old growth encompasses only 5 million acres (2 million hectares) (~30%) of the land area in Southeast (USFS 2003). The USFS (2003) defines productive old growth as "…forest capable of producing at least 20 cubic ft of wood fiber per acre per year." The majority of productive old growth on state and private lands has been harvested during the last 40 years (USFS 2003).

Timber Harvest

Clearcutting is the dominant timber harvest method in Southeast (USFS 1997b) and has a much different effect on forest structure than the natural disturbance regime caused primarily by wind (Alaback 1982, Brady and Hanley 1984). Forest succession in Southeast following clearcutting has been described by Harris (1974), Harris and Farr (1974, 1979), Wallmo and Schoen (1980), and Alaback (1982). In general, herbs, ferns, shrubs, and conifer seedlings grow abundantly several years after logging and peak at about 15 to 20 years. At about 20 to 30 years, young conifers begin to overtop shrubs and dominate the second-growth stand. After 35 years, conifers completely dominate second growth, the forest floor is continually shaded, and forbs, shrubs, and lichens largely disappear from the even-aged, second-growth stands. The absence of understory vegetation in second growth generally continues for more than a century following canopy closure (30–130 years). Clearcutting old growth and managing second growth on 100- to 120-year rotations significantly reduces the structural complexity of the forest, including herb and shrub layer understory plants, coarse woody debris, snags, and multiple canopy layers (Harris 1974, Wallmo and Schoen 1980, Alaback 1982) (Fig 7). The ecological characteristics of old growth generally take 2 to 3 centuries to develop following disturbance (Fig 8). For more detailed information on forest succession, refer to Chapter 5.

FIG 7. All the trees in this 50-year old second-growth forest are generally the same size and age. Habitat conditions in second-growth stands are less diverse than in old growth stands, and forest floor vegetation is significantly reduced because sunlight is blocked by the dense canopy cover. (John Schoen)

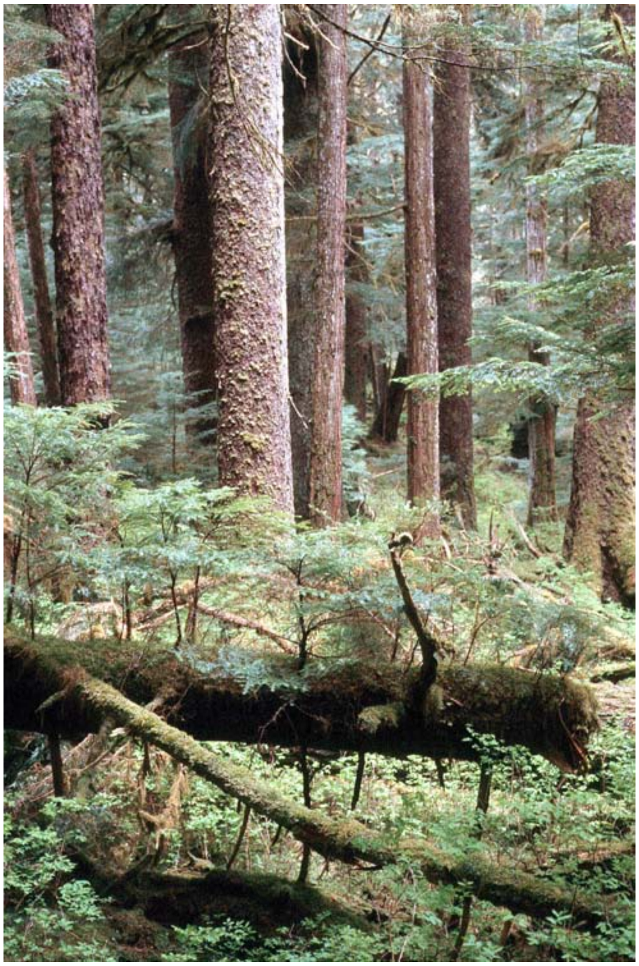

FIG 8. Old growth is structurally more complex than second growth, increasing habitat diversity. A nurse log in the foreground of the photo provides habitat and nutrients for young conifer seedling and saplings. The mycorrhizal fungi form a symbiotic relationship with roots of conifers and enhance their nutrient acquisition. Flying squirrels eat the fruiting bodies of these fungi, distributing the fungal spores throughout the forest, thus playing an important role in the ecosystem. (John Schoen)

IMPLICATIONS FOR CONSERVATION

The Prince of Wales flying squirrel is an island endemic associated with old-growth forests. Island endemics are particularly vulnerable to risks of extinction because of restricted ranges, small population sizes, minimal genetic variation, and susceptibility to random events (Soule 1983, Reichel et al. 1992, Frankham 1998). Although the 1997 TLMP (USFS 1997a) includes standards and guidelines for reducing extinction risks to island endemics, the guidelines are only applied to islands where there is evidence of endemic species (Smith 2005). Unfortunately, the distribution of small mammals on many islands remains unknown (MacDonald and Cook 1996, 1999).

The northern flying squirrel is closely associated with old-growth forest in the southern portion of its range (Witt 1992, Carey 1995, Carey et al. 1999; although see Rosenberg and Anthony 1992). Although no studies in Southeast have compared densities of flying squirrels between old-growth and younger forests, Smith et al. (2004, 2005) determined that large trees and snags were ecologically significant correlates of flying squirrel density and habitat use. The presence of large trees and snags provides nesting cavities for flying squirrels (Baker and Hastings 2002) and may provide food sources that are more abundant in habitats with larger trees (Smith and Nichols 2003, Smith et al. 2005).

Travel corridors are especially important to flying squirrels because of their method of gliding locomotion (volplaning). A study of flying squirrel old-growth relationships in interior upland forests by Mowrey and Zasada (1984) found that uninterrupted forest corridors were important for maintaining flying squirrel populations. The distance between the launching and landing trees is important for flying squirrels to move through their home range. Volplaning enabled the flying squirrels to reach distances of between 33 and 164 ft (10-50 m) in Interior Alaska (Mowrey and Zasada 1984). Wider gaps in forest cover were found to increase the risk of predation, especially those gaps wider than 98 ft (30 m) that lack tall trees scattered throughout forest openings.

Converting structurally diverse old-growth forests with large trees and snags to clearcuts and young second-growth stands with smaller trees and snags, less large woody debris, and fewer shrubs will likely reduce carrying capacity for flying squirrels in Southeast. This forest transformation is particularly a concern on the Prince of Wales Island complex, where substantial timber harvest has occurred and future harvests are planned both on national forest and private lands. Although scrub forests (which are unlikely to be logged) have been demonstrated to support reasonable densities of flying squirrels and may provide a buffer against extensive logging of productive old growth (Smith and Nichols 2003, Smith 2005), additional fragmentation of productive old-growth stands may increase risks of maintaining viable, well-distributed populations of the endemic Prince of Wales flying squirrel in the long term. Maintaining adequate old-growth reserves across the POW Island complex as well as promoting second-growth restoration (for example, including snags, large woody debris, legacy trees, and thinning) will likely be important for conserving this island endemic (Fig 9). Although Smith et al. (2005) indicated that flying squirrels were not an ideal management indicator species of old-growth forest structure, they suggested that the occurrence of widely distributed populations of flying squirrels may be a good indicator of landscape permeability and functional connectivity of the forest ecosystem. Clearly, additional research on the forest habitat relationships of flying squirrels in Southeast is needed to develop a comprehensive conservation strategy for populations of this important endemic arboreal rodent.

FIG 9. The Naukati watershed is located on northwest Prince of Wales Island. Note the patchwork of clearcuts, second growth, and old growth that occurs in this region of the island. Fragmentation of the natural forest mosaic has raised conservation concern for this endemic population of flying squirrels. (John Schoen)

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