# NORTHERN FLYING SQUIRREL

***(Glaucomys sabrinus)***

Source: Microsoft® Encarta® Encyclopedia (1996)

**Prepared for Millar Western Forest Products' Biodiversity Assessment Project**

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# Table of Contents

# List of Tables

# List of Figures

# 1.0 CONSERVATION AND THE EFFECT OF FOREST ACTIVITIES

## 1.1 Introduction

The Northern Flying Squirrel (*Glaucomys sabrinus*) ranges from the circumpolar treeline across the northern coniferous forests of Alaska and Canada and south along mountain ranges almost to Mexico (Maser *et al.* 1985; Payne *et al.* 1989; Rosenberg and Anthony 1992; Witt 1992; Carey *et al.* 1997).

Though widely distributed throughout North America, there is relatively little available information on its habitat requirements and activities in the wild. It is arboreal and nocturnal which makes it difficult to observe (Maser *et al.* 1985; Witt 1992; Carey *et al.* 1997). In Alberta, few studies have been carried out on Northern Flying Squirrel habitat use (Boutin pers. comm. 1999). In fact, to our knowledge, only one researcher has published Alberta-specific data on this species. For this reason, the information collected by McDonald (1995) in Alberta was used in combination with the results of studies completed in the Pacific northwest to create the Northern Flying Squirrel HSM. As more Alberta-specific research becomes available, it should be incorporated into the model.

## 1.2 Effects of Forest Management Activities

In the western portion of North America, the Northern Flying Squirrel is most frequently found in coniferous or mixedwood forests (Maser *et al.* 1985; Rosenberg and Anthony 1992; McDonald 1995). It is thought that the squirrel is associated with older forests and that it may avoid logged second-growth stands (Rosenberg and Anthony 1992; Witt 1992; Carey *et al.* 1997). This may indicate that forestry activities have a detrimental impact

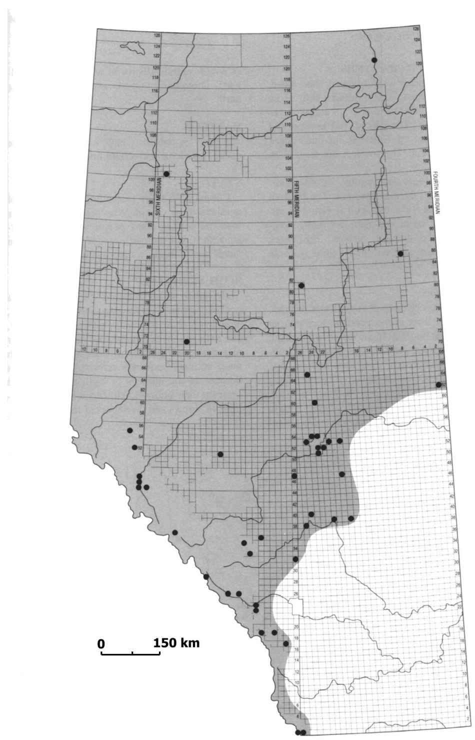


**Figure 1. Estimated distribution of the Northern Flying Squirrel in Alberta (Smith 1993).**

on some aspect of the animal's habitat. As the squirrel prefers to create dens in tree cavities or large downed logs, logging has the potential to influence habitat suitability by decreasing the abundance of these resources within the stand (Rosenberg and Anthony 1992; Carey *et al.* 1997). In fact, research has shown that the squirrel will continue to use logged habitat that has been managed for the maintenance of these features (Rosenberg and Anthony 1992). It has, therefore, been suggested that long rotations of 70 to 130 years be employed to promote perpetuation of the features typical of old forests (Carey *et al.* 1997). Similarly, McDonald (1995) recommended that until the specific habitat requirements of the Northern Flying Squirrel are identified, forest managers should err on the side of caution and maintain older seral stages within the boreal mixedwood landscape.

# 2.0 HABITAT USE INFORMATION

## 2.1 Food Requirements

The Northern Flying Squirrel has similar food habits throughout its distribution (Maser *et al.* 1985). The most commonly used sources of nutrition are fungi, both hypogeous and epigeous, lichens, and the flowers of coniferous and deciduous trees (McKeever 1960; Weigl 1978; Maser *et al.* 1985; Rosenberg and Anthony 1992).

While the animals consume a variety of foods, fungi, particularly mycorrhizal fungi, were recorded in stomach content surveys as the resource most commonly ingested (Maser *et al.* 1985; Maser *et al.* 1986; Hall 1991). In fact, evidence suggests that these squirrels are obligate mycophagists (Maser *et al.* 1986; Hall 1991), though arboreal lichens are consumed more frequently during the winter when snow covers the ground (Payne *et al.* 1989; Hall 1991; Rosenberg and Anthony 1992). Overall, fungi and lichens comprise between 90 and 100% of the year-round diet (Maser *et al.* 1978; Maser *et al.* 1986).

Mycorrhizal fungi are obligate symbionts with the roots of coniferous trees (Maser *et al.* 1978). These hypogeous fungi rely on small mammalian mycophagists to disperse their spores (Maser *et al.* 1978). Mixedwood or coniferous-dominated forests with ample fungi and lichen resources are thought to provide optimal foraging habitat (McDonald 1995).

## 2.2 Cover Requirements

Though it has long been thought that Northern Flying Squirrels are associated with overmature coniferous stands (Payne *et al.* 1989; Carey *et al.* 1992), research has shown that the animals can be equally as common in second-growth stands (Rosenberg and Anthony 1992; Waters and Zabel 1995) provided coarse woody debris and cavity trees remain on site following harvesting. In Alberta, Northern Flying Squirrels may be most commonly found in aspen-white spruce mixedwood forests (McDonald 1995), as long as suitable hiding cover and denning sites are available.

### *Hiding Cover*

The relationship between ground vegetation cover and habitat suitability for Northern Flying Squirrels has been assessed by several researchers (Payne *et al.* 1989; Rosenberg and Anthony 1992; McDonald 1995). While Payne *et al.* (1989) did not report a connection between the understorey characteristics of the stand and the suitability of the habitat for squirrels, both Rosenberg and Anthony (1992) and McDonald (1995) have determined that population density is positively correlated with shrub cover. This relationship may be explained by the capacity of the shrubby understorey to hide squirrels as they forage on the forest floor (McDonald 1995; Waters and Zabel 1995). In fact, predation rates by lynx and coyotes have been shown to be reduced in these environments (Rosenberg and Anthony 1992; Waters and Zabel 1995).

### Denning Sites

Northern Flying Squirrels use tree cavities as dens but may also construct nests of lichen, twigs, moss, and shredded bark (Maser *et al.* 1986; Carey *et al.* 1997) on the boles or branches of trees (Rosenberg and Anthony 1992; Waters and Zabel 1995; Carey *et al.* 1997). Though dead cavity trees can be used, more than two-thirds of the cavities frequented by Northern Flying Squirrels are in live trees (Carey *et al.* 1997). In Alberta, dens are typically found in live aspen trees with at least 80% bark coverage, > 25 cm dbh, and > 7 m height (McDonald 1995). In addition, some dens were found in balsam poplar trees and very few were found in white spruce and birch trees (McDonald 1995). It is thought that live trees may be preferred due to the shelter and hiding cover offered by the overhead branches and because live trees may persist within the stand for a longer period of time than snags (McDonald 1995; Carey *et al.* 1997).

It appears that the squirrel prefers to use cavities as dens since they provide shelter from inclement environmental conditions such as cold and rain and offer protection from predators (Weigl 1978; Carey *et al.* 1997). The absence of cavity trees will not restrict the animals' use of a stand, however (Rosenberg and Anthony 1992). In fact, the squirrel has been known to select the option of building a stick nest in close proximity to high quality foraging areas rather than occupying a tree cavity located far from necessary food resources (Carey *et al.* 1997).

The Northern Flying Squirrel will not remain in one den for a long period of time. Den movement may be related to the evasion of predators, the reduction of the risk of parasitism, or the improvement of the squirrel's ability to obtain food (Carey *et al.* 1997). Possession of multiple dens appears beneficial as the squirrel has access to a variety of foraging areas simultaneously. Our literature review did not reveal the optimal number of denning trees per ha. Therefore, we will assume that at least six suitable trees should be available per ha to provide the flying squirrels with the opportunity to select one near foraging habitat. As information on the preferred availability of denning sites becomes available, it should be incorporated into the model.

The Northern Flying Squirrel exhibits a strong social behaviour of denning in groups (Layne and Raymond 1994). Group denning activities peak in January when as many as 25 individuals can be found in one den (Layne and Raymond 1994). It has been estimated that denning in groups could reduce an individual's energy expenditure by 26 to 33% (Stapp *et al.* 1991; Carey *et al.* 1997).

## 2.3 Reproduction Requirements

Though the squirrel maintains dens year-round, denning sites chosen by females change during the breeding season. At this time, females tend to move to lower structures in which to construct natal dens (Carey *et al.* 1997). While some natal dens have been located in large logs (> 25 cm, but optimally > 40 cm diameter) on the forest floor, others have been found 6 to 21 m above the ground in cavity trees. Downed logs used for den creation must be in a suitable stage of decay (able to be excavated by a squirrel but still rigid enough to support the cavity structure, Carey *et al.* 1997). The desire to create new dens for birthing may be related to the presence of parasites in used dens. The option of denning in downed logs could also be attractive due to the significant inter- and intra-specific competition for cavities high in the canopy (Carey *et al.* 1997). While the female could create a stick nest for her young, she prefers to use cavity structures at any height probably because they better provide protection from both predation and the elements.

## 2.4 Habitat Area Requirements

Home range size can be an indicator of habitat quality (Carey *et al.* 1997). In environments where food and shelter are substandard, the animal may have to venture further to obtain needed resources. In general, dispersing subadults occupy less suitable habitat than adults and must travel greater distances between feeding and resting sites (Doyle 1990). Individual movements of up to 350 m have been observed (Weigl and Osgood 1974; Carey *et al.* 1991; Witt 1992). Research in Oregon revealed that squirrels use home ranges of up to 12 ha (Weigl and Osgood 1974; Witt 1992). Although work in Alberta has shown a territory to be twice this size (Boutin pers. comm. 1999), we believe that this area may represent a Northern Flying Squirrel's home range size in suboptimal habitat. Therefore, for the purposes of HSM development, territory size will be set at 12.6 ha, or a circular area of radius 200 m.

## 2.5 Landscape Configuration Requirements

Foraging, resting, and denning habitats are similar in required features. Even if denning trees are not available, a squirrel will locate in proximity to food resources.

## 2.6 Sensitivity to Human Disturbance

Our literature review did not reveal evidence that Northern Flying Squirrels are negatively impacted by human activities that do not destroy habitat.

# 3.0 MODEL

## 3.1 Envirogram

There are three elements that are thought to influence a Northern Flying Squirrel's selection of habitat: the ability to acquire sufficient food resources, to access cover from inclement environmental conditions, and to avoid predators (Figure 2).

As food, the Northern Flying Squirrel will consume predominantly fungi and arboreal lichens. The potential of the stand to produce mycorrhizal fungi can be predicted by its coniferous representation since these fungi are obligate symbionts of conifers.

The squirrel builds a den in the cavity of an aspen or poplar tree with suitable characteristics. During the breeding season, females may select new dens for the purpose of sheltering young. These dens may be created in lower cavities or in large pieces of downed woody debris.

While foraging, the squirrel is vulnerable to predation. Hiding cover is provided by shrubby vegetation and trees with low height to crown. We assume that plentiful downed woody debris will also provide suitable hiding cover for the squirrels. Since the information presented in the literature did not clearly indicate that hiding cover is important only during foraging activities, the habitat features relating to foraging have been kept separate from those relating to hiding cover in the HSM. If future research on Northern Flying Squirrels suggests that hiding cover is used only while foraging, these variables should be combined into one SI equation.

## 3.2 Application Boundaries

**Season:** This model produces SI values for use year-round.

**Habitat Area:** Home range size used for home range smoothing is 12.6 ha.

**Model Output:** The model assigns a SI value for foraging, cover, hiding cover, and habitat suitability to each 25 m pixel of forested habitat.

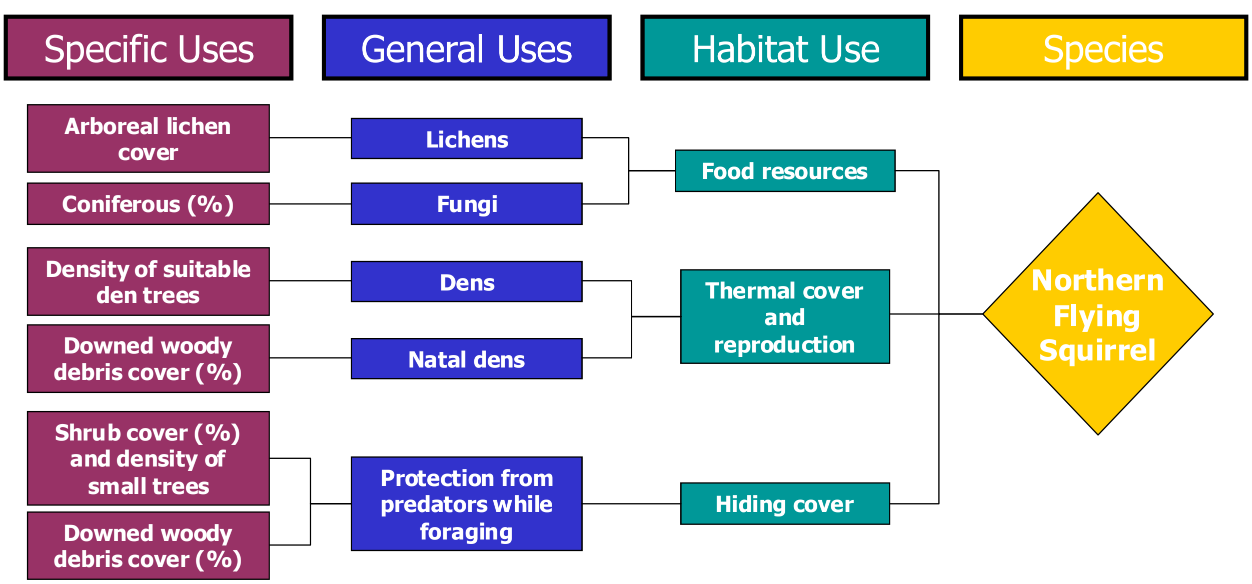


**Figure 2. Envirogram of the Northern Flying Squirrel based on available habitat information for HSM development.**

## 3.3 Model Description

The HSM for Northern Flying Squirrel habitat follows the structure described in the envirogram (Figure 3). As all elements are critical for year-round habitat, no compensation is allowed between them.

The $SI_{food}$ consists of variables indicating the availability of both fungi and lichens to squirrels. Lichen availability can be determined by the SHE variable arboreal lichen cover, while the abundance of mycorrhizal fungi is related to the presence of coniferous trees.

The $SI_{cover}$ uses habitat type to predict the availability of cavity dens. Northern Flying Squirrels commonly den in aspen trees with dbh > 25 cm, height > 7 m, and bark coverage > 80%. Poplar trees with similar characteristics may also be used. As previously mentioned, we estimate that the squirrels require six suitable denning trees per ha. We expect that certain habitat types will provide the squirrels with the desirable supply of denning trees more reliably than others. Therefore, habitat type is used as a variable in the cover equation. Female squirrels may use large downed woody debris in an intermediate stage of decay as denning sites. Unfortunately, the data collected from the TSPs and PSPs from which the SHE models were created were not sufficiently detailed to accurately predict the presence of this material. Therefore, it was necessary to use a simplified SHE variable for the purposes of this HSM: coverage of downed woody debris of any size and in any decay stage.

As hiding cover, the squirrel requires dense shrubs and small trees. Downed woody debris may also be used as shelter from predators.

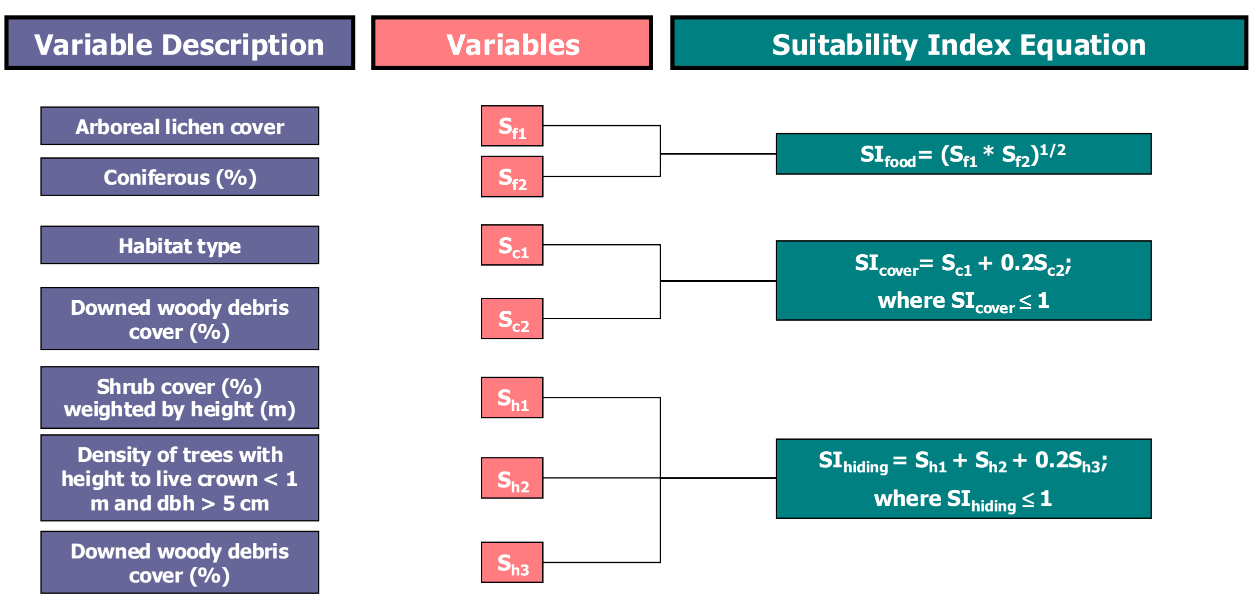


**Figure 3. HSM structure for the Northern Flying Squirrel within Millar Western's FMA area.**

## 3.4 Habitat Variable SIs

### *Food*

The $SI_{food}$ is composed of the availability of arboreal lichens ($S_{f1}$) and the coniferous component of the stand ($S_{f2}$). As shown in Figure 4, suitability increases with arboreal lichen abundance. In mixedwood or coniferous stands, with at least 50% coniferous representation, foraging habitat is thought to be optimal (Figure 5).

### *Cover*

The variables considered in the $SI_{cover}$ are $S_{c1}$, habitat type and $S_{c2}$, presence of downed woody debris. Table 1 shows the suitability ratings applied to each habitat type.

As shown in Figure 6, suitability is optimal in stands with at least 15% coverage of downed woody debris.

### *Hiding Cover*

Figure 7 shows that suitability increases linearly with shrub cover weighted by height to a maximum at 50% cover. Density of trees with low height to crown is thought to be optimal at 12,000 trees per ha (Figure 8). In addition, hiding cover suitability is improved where > 15% of the forest floor is covered with downed woody debris (Figure 4).

**Table 1. Northern Flying Squirrel denning suitability by habitat type.**

| | | Opening | Developing | | Forest | | Old |
|---|---|---|---|---|---|---|---|
| **Broad** | **Specific** | **Clearcut** | **Regenerating** | **Young** | **Immature** | **Mature** | **Old** |
| Hardwoods | Aspen | | | | 0.5 | 1 | 1 |
| | Poplar | | | | 0.5 | 1 | 1 |
| | White birch | | | | 0.5 | 1 | 1 |
| Hardwood Mixed | Aspen-Pine | | | | 0.5 | 1 | 0.5 |
| | Aspen-White spruce | | | | 0.5 | 1 | 0.5 |
| | Aspen-Black spruce | | | | 0.5 | 1 | 0.5 |
| | Poplar-Pine | | | | 0.5 | 1 | 0.5 |
| | Poplar-White spruce | | | | 0.5 | 1 | 0.5 |
| | Poplar-Black spruce | | | | 0.5 | 1 | 0.5 |
| Softwood Mixed | Pine-Poplar | | | | 0.25 | 1 | 0.5 |
| | Pine-Aspen | | | | 0.25 | 1 | 0.5 |
| | White spruce-Poplar | | | | 0.25 | 1 | 0.5 |
| | White spruce-Aspen | | | | 0.25 | 1 | 0.5 |
| | Black spruce-Poplar | | | | 0.25 | 1 | 0.5 |
| | Black spruce-Aspen | | | | 0.25 | 1 | 0.5 |
| Conifers | Pine | | | | | 1 | 1 |
| | White spruce | | | | | 1 | 1 |
| | Black spruce | | | | | 1 | 1 |
| | Larch | | | | | 1 | 1 |

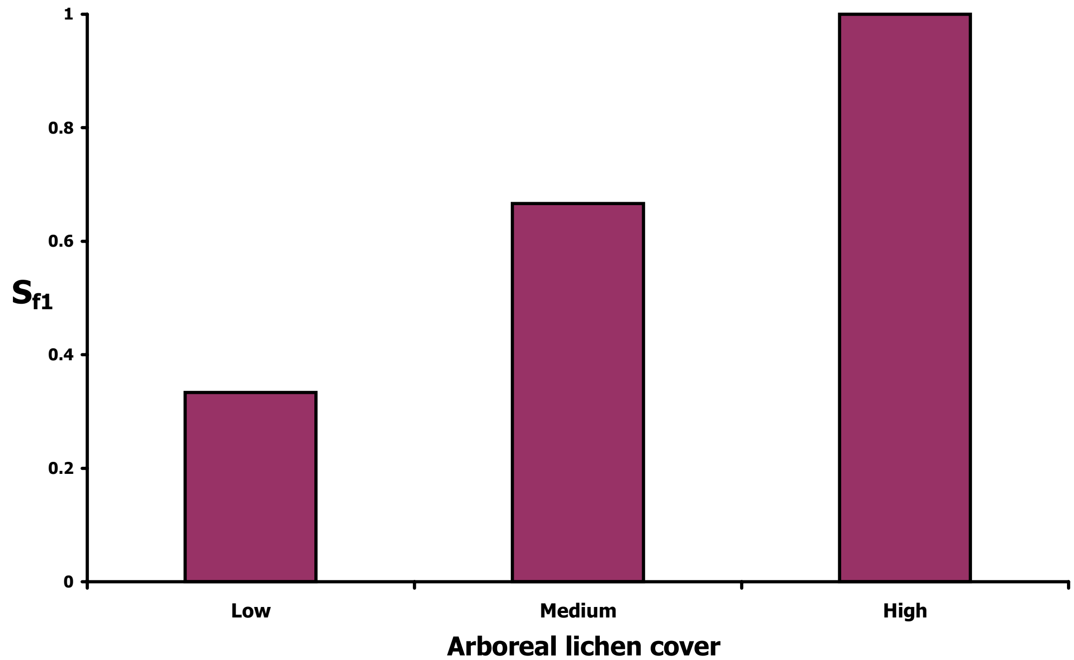


**Figure 4. Northern Flying Squirrel foraging habitat suitability in relation to arboreal lichen cover within Millar Western's FMA area.**

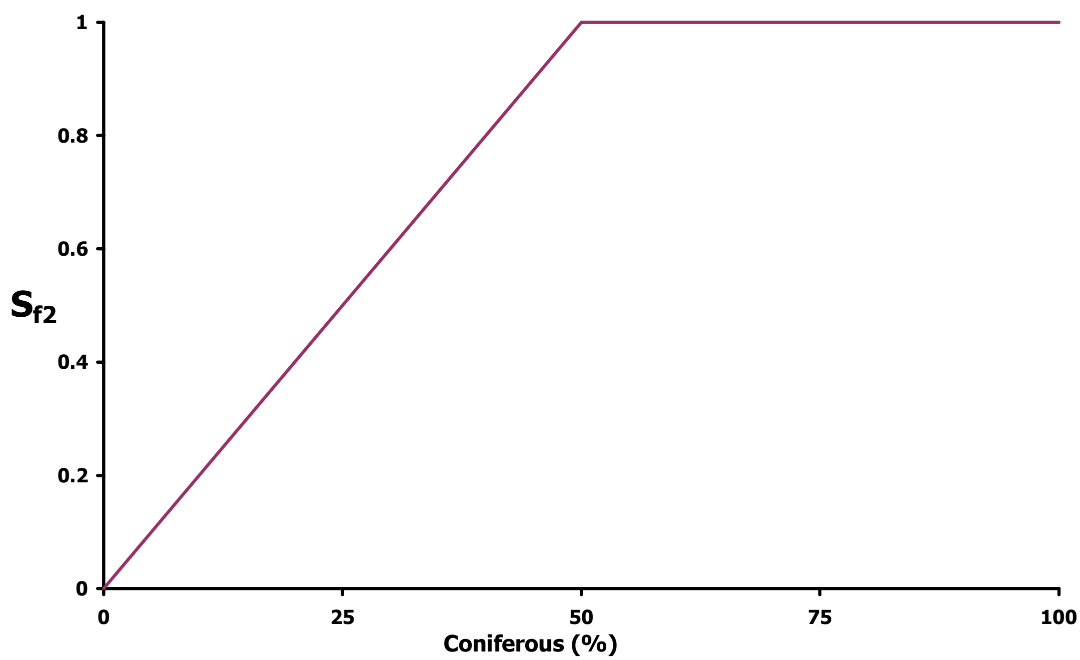


**Figure 5. Northern Flying Squirrel foraging habitat suitability in relation to tree species composition within Millar Western's FMA area.**

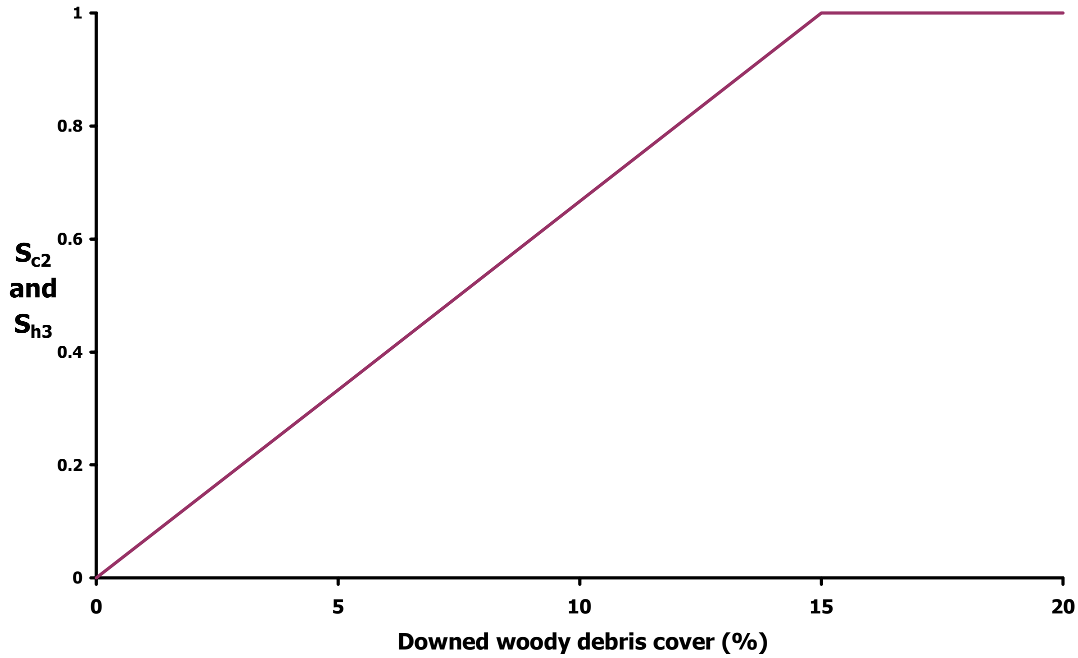


**Figure 6. Northern Flying Squirrel cover and hiding cover habitat suitability in relation to downed woody debris cover (%) within Millar Western's FMA area.**

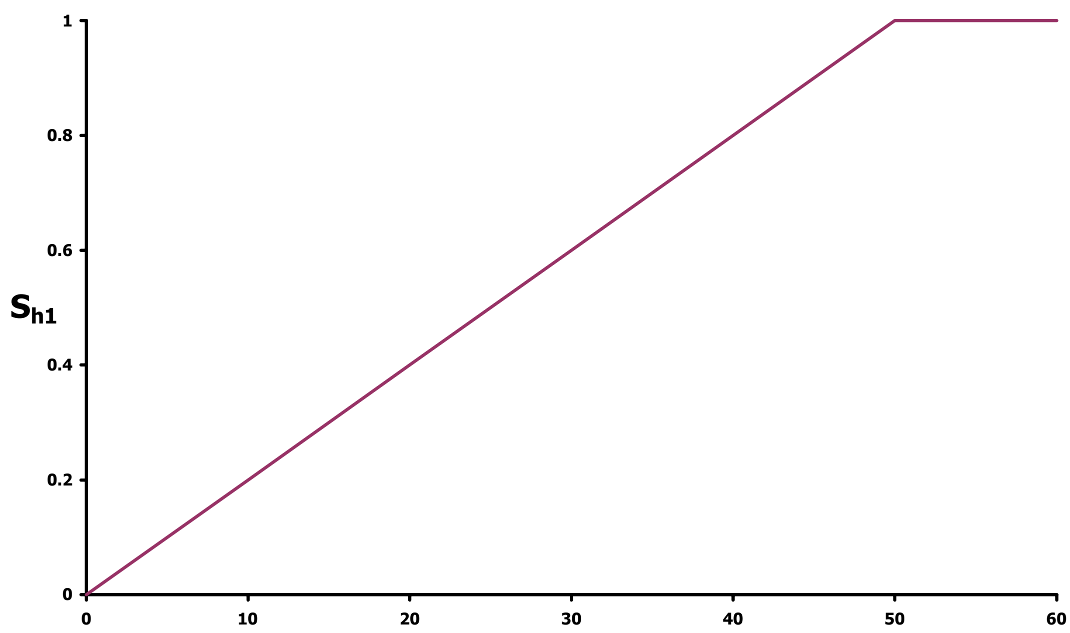


**Figure 7. Northern Flying Squirrel hiding cover habitat suitability in relation to shrub cover weighted by height within Millar Western's FMA area. Weighting = 0 - .25 m = 0, .25 - .5 m = .25, .5 - 1 m = .65, 1 - 3 m = 1, > 3 m = 0.2.**

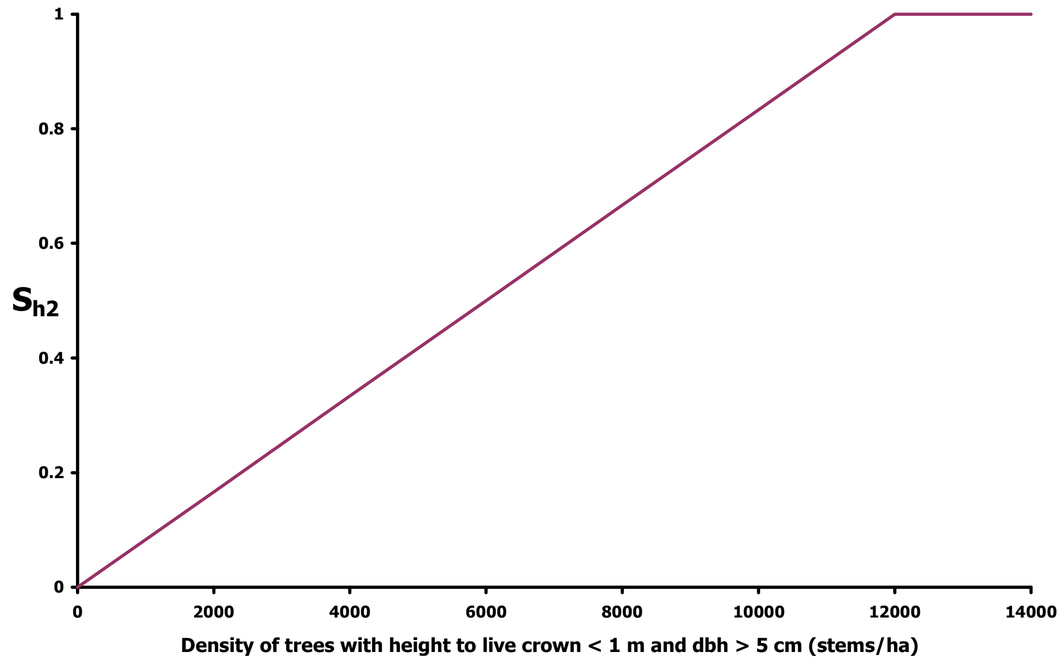


**Figure 8. Northern Flying Squirrel hiding cover habitat suitability in relation to density of trees with height to live crown < 1 m and dbh > 5 cm within Millar Western's FMA area.**

## 3.5 Computation

Our goal is to create HSMs that allow the user to identify the potential impacts of proposed forest management strategies on foraging, cover, and hiding cover habitats. Therefore, the outputs of the $SI_{food}$, $SI_{cover}$, and $SI_{hiding}$ calculations are considered individually to display trends in habitat availability.

### *Foraging Habitat Index*

The value of each pixel as foraging habitat is assessed using the equation:

$$SI_{food} = (S_{f1} * S_{f2})^{1/2}$$

### *Cover Habitat Index*

The suitability of each pixel of forested habitat as cover for the Northern Flying Squirrel is assessed using the equation:

$$SI_{cover} = S_{c1} + 0.2S_{c2};$$

$$\text{where } SI_{cover} \leq 1.$$

### *Hiding Cover Habitat Index*

A suitability rating for each pixel as hiding cover habitat is defined by the equation:

$$SI_{hiding} = S_{h1} + S_{h2} + 0.2S_{h3};$$

$$\text{where } SI_{hiding} \leq 1.$$

### *Home Range Smoothing*

A home range size of 12.6 ha is used for the Northern Flying Squirrel. A circular window of radius 200 m moves over the grid representing Millar Western's FMA area with each pixel, in turn, acting as its centre. The $SI_{food}$ values of each pixel within the window are averaged and recorded as the $SI_{food}$ of the centre pixel. Similarly, the average of the $SI_{cover}$ and $SI_{hiding}$ for all pixels within the window are recorded as the $SI_{cover}$ and $SI_{hiding}$ of the centre pixel.

## 4.0 EXTERNAL REVISION

On May 27, 1999, Arlen Todd, wildlife biologist with Alberta Environment, Fisheries and Wildlife Management Division, in Whitecourt, Alberta provided his comments on an early version of the Northern Flying Squirrel HSM. Since he does not have a great deal of experience with this species, he did not recommend any specific alterations.

A draft version of the Northern Flying Squirrel HSM was reviewed by both Dr. Stan Boutin of the University of Alberta and Larry Roy of the Alberta Research Council on June 16, 1999 and June 21, 1999, respectively. Based on their advice and an additional reference that provided Alberta-specific information that they recommended, the following changes were made:

1) Most of the information cited in the text comes from research done in the Pacific Northwest. Both Roy and Boutin were concerned that we had not specifically stated that Alberta-specific information was lacking. We have included a statement about this in the review.

2) Boutin expressed concern that some of the relationships between habitat suitability and forest characteristics shown in the figures were speculative but have been referred to as fact. We have changed the wording of the model to indicate its speculative nature. Boutin mentioned that he is "strongly opposed to trying to do something like this in the absence of any scientific information". We will proceed with the model, however, but recommend that new research results be incorporated as they become available.

3) Originally, a home range size of 12 ha was used for home range smoothing. Boutin suggested that this area is much too small for Alberta's squirrels. We considered changing it to 38 ha but kept it at 12 ha since we believe that the squirrels only range that far in suboptimal habitat. This portion of the model will need to be updated as additional information becomes available.

4) An over-emphasis on the importance of conifers was identified in the draft model. We have now raised the value of aspen and poplar trees for denning.

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