



**Biodiversity**  
Management Concepts  
in Landscape Ecology

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*“... the rate and pattern  
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habitat ...”*

## Biodiversity and Interior Habitats: The Need to Minimize Edge Effects part 6 of 7<sup>1</sup>

### Introduction

In the depths of many mature and old-growth forests in British Columbia, a specialized range of plant and animal life exists. Some of these species depend on the more stable climatic environment of the forested interior, while others require the snags and decaying woody debris often found there. Some of the animals require large unbroken tracts of such habitat to hunt and breed. However, the amount and quality of this habitat have gradually decreased as human settlement, roads, logging, and agriculture have fragmented the province's forested landscape.

As forests are cut, edges are created. The environmental conditions produced along these edges may modify habitat values that are important to interior forest dwellers. Many landscape ecologists have voiced concern about this habitat disruption and about the potential loss of landscape-level biodiversity that may ensue if interior habitat ecosystems and processes are not sustained. Preserving sufficient interior habitat is therefore important to protect these species and maintain biodiversity.

The Forest Practices Code acknowledges the importance of landscape ecology concepts by enabling district

managers to designate planning areas called “landscape units,” each with specific landscape unit objectives. The *Biodiversity Guidebook* (B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks 1995), a component of the Code, recommends procedures to maintain biodiversity at both landscape and stand levels. These procedures, which use principles of ecosystem management tempered by social considerations, recognize that the habitat needs of most interior forest organisms can be maintained if excessive edge habitat is avoided and if forested areas are of adequate size to preserve interior habitat conditions.

This extension note is the sixth in a series<sup>2</sup> designed to raise awareness of landscape ecology concepts and to provide background for the ecologically based forest management approach recommended in the *Biodiversity Guidebook*. The focus here is on the related topics of forest interior habitat and edge effects. We first define and differentiate between edge environments and forest interior habitats. Then we discuss several general ecological principles concerning edge environments and their effects on interior habitat and the plant and animal life that depends on it. We conclude by examining how excessive edge habitat might be prevented and

- 1 January 2000. Policy direction for biodiversity is now represented by the Landscape Unit Planning Guide. This Extension Note should be regarded as technical background only.
- 2 Conservation Biology Principles for Forested Landscapes (Voller and Harrison [editors] 1998) provides a valuable reference for those wanting an in-depth understanding.

forest interior habitat quality maintained at the landscape level.

### What Are Edge Effects and Interior Forest Habitats?

An “edge” is the boundary, or interface, between two biological communities or between different landscape elements. Edges exist, for instance, where older forested patches border newly harvested cutblocks, or where forests verge on rock outcrops, riparian areas, grasslands, or other different harvest types or seral stages.

An ecotone is the zone of transition along the edges of two adjacent ecological communities (Forman 1995). In ecotones, environmental conditions usually differ from those of the surroundings. For instance, if you were to hike from a heavily forested patch toward a revegetating opening on a sunny summer day you would notice some climatic changes and an associated vegetation gradient. After traveling through the relatively cool, shaded, humid, and windless interior of the forest, the fringe area of diverse edge vegetation would seem brighter, a breeze might become more apparent or stronger, and the air would feel warmer and drier. However, if you were to walk the same route on a rainy day, you might not notice any appreciable differences. The changes in microclimate you experienced define a distinct gradient, or “edge effect.”

Some plants and animals benefit from the microclimatic edge effects of the ecotone, and thus the number of different species is generally high in these areas. However, when these species penetrate an adjacent forested patch, they may compete with plant and animal species that depend on forest interior conditions. Interior species can therefore be harmed through the ecological processes of predation, competition, and parasitism. These processes define “biotic edge effects.”

Interior forest habitat lies beyond the influence of both microclimatic

and biotic edge effects and therefore manages to sustain the viability of the plant and animal communities that depend on its generally stable environmental conditions. This habitat can occur in any forest type (coniferous, deciduous, or mixed stands) and in forests of any age.

The area of interior forest habitat does not remain static; it can grow or shrink over time depending on the surrounding forest matrix. It is generally recognized that fragmenting the contiguous forest into smaller patches diminishes both the quantity and quality of the remaining forest interior habitat. The quantity of interior habitat is reduced as the remaining forested patches become smaller and more isolated. The quality is reduced as the smaller patches are affected by microclimatic and biotic edge effects. Loss of interior habitat in late successional or old-growth forests is of particular concern in British Columbia because this type of habitat is the most difficult to preserve and manage.

### Edge Effects and Interior Forest Habitats: Ecological Principles

#### Types of Edges

The creation of edge effects depends on numerous factors including the type of edge present. Edges are either “inherent” or “induced” (Thomas et al. 1979). An inherent edge is a natural, usually long-lasting, feature of the landscape, which may be related to:

- topographic differences (e.g., the so-called tree line, the boundary where tree growth gives way to alpine conditions on mountains or to grasslands in low-elevation dry valleys);
- soil type (e.g., the shift from boggy, peat soils to upland humus soils);
- presence of open water (e.g., lake or river margins); or
- geomorphic, or landform, factors (e.g., divides, peaks, and ridge crests) (Thomas et al. 1979).

Induced edges are caused by both natural and human disturbances

including fire, flooding, erosion, timber harvest, planting, or grazing (Thomas et al. 1979). This type of edge is usually a relatively short-lived phenomenon, such as the edge between an old-growth forest and a clearcut, which fades with successful regeneration and subsequent tree growth. Induced edges are termed “hard” when they represent abrupt changes between two habitat types. “Soft” edges represent a more gradual transition, such as where partial timber cutting techniques create a feathered interface between habitat types.

### Edge Contrast, Microclimatic Effects, and Depth of Influence

The intensity of edge microclimatic gradients, or the “edge contrast,” depends on how sharply the two adjacent habitats differ. For instance, if you walked away from a shaded river bank to an upland forest you would probably detect less of a microclimatic difference than the pronounced contrast you noticed travelling from the forest interior into a clearcut or recently revegetated opening. The microclimatic influence on surrounding forested habitat depends largely on the opening’s size, shape, orientation, and topography.

Sun and wind are chiefly responsible for the temperature and moisture gradients observed within edge environments. Solar radiation is absorbed by the tree canopy and then dissipated upwards. In the forest interior or in shaded riparian areas, this generally results in relatively cooler and more

stable temperatures. However, along exposed edges and within openings, temperatures may be more extreme, often fluctuating widely between day and night. The orientation of an edge may play an important role in determining the intensity of temperature-related effects, particularly in high-latitude regions such as British Columbia. Research suggests that these effects are strongest at southwest-facing edges and weakest at northeast-facing edges (Saunders et al. 1991; Chen et al. 1995).

Wind speed and turbulence usually vary across an opening, with differing effects on edge microclimates. At higher levels above the ground, the wind may continue unhindered as it blows over the forest canopy. Closer to the ground in smaller openings, a “wake” zone with turbulent air flow patterns may exist, along with “quiet” zones adjacent to the upwind and downwind edges (Figure 1) (Novak et al. 1997). In turn, the air temperature and humidity in these quiet edge zones may be more extreme (Chen et al. 1993). However, when an opening is of suitable orientation and size, winds may penetrate some distance into the forest before diminishing. If the winds are sufficiently strong, they may cause windthrow along the upwind edges. These winds may also decrease humidity and increase evapotranspiration in the forest interior (Saunders et al. 1991).

Soil moisture can also vary along the gradient from the drier, more exposed edge environment to the

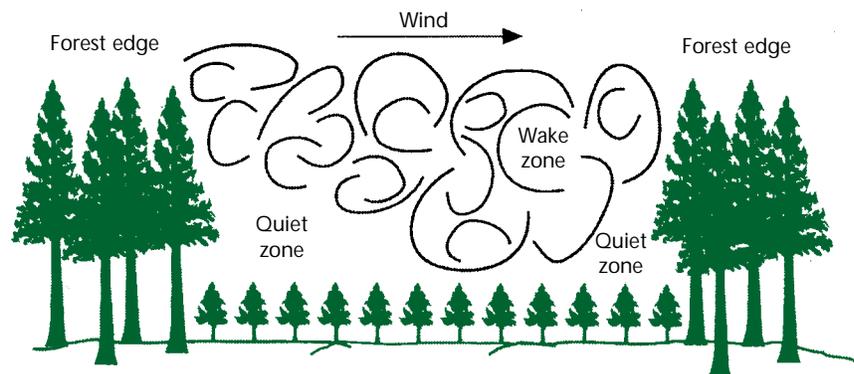


FIGURE 1 Wind and turbulence patterns in a clearing (from Novak et al. 1997).

more humid forest interior. During winter, for instance, the sheltered interiors of old forests often accumulate less snow, but maintain a snowpack longer. Moisture is thus absorbed at an even rate, in contrast to clearcut openings, which can experience irregular soil moisture fluxes (Franklin and Spies 1991).

Plants adapted to the more moderate climatic conditions of interior habitat often cannot survive the effects of drying winds and temperature changes that penetrate from edge environments. Generally, with more abrupt, "harder" edges, the zone of microclimatic edge influence is greater. This effectively decreases the amount of adjacent forest interior habitat. Conversely, with more gradual, "softer" edges, more interior habitat is preserved. For example, the depth of influence for air temperature and humidity extended 120–140 m from a clearcut edge into an old-growth Douglas-fir forest in southern Washington State. For soil temperature and moisture, the range of edge influence was considerably narrower (60–120 m) (Chen et al. 1990). However, if the same old-growth stand is exposed to extreme heat and wind on a southern exposure, the depth of edge influence may reach more than 240 m. Depth of wind influence depends largely on vegetation type, understorey, and stand density (Chen 1991).

### **Biotic Edge Effects**

Edge effects are both positive and negative; they cause some species to thrive and others to perish. For example, the microclimatic regime in the ecotone, plus the proximity of resources from two different habitat types, can support a diverse range of species. Some "edge species," such as deer, moose, and elk, tend to flourish in the edge environments between forests and clearcuts or riparian areas. These habitats contain a wide variety of food resources and cover (Nyberg

and Janz [editors] 1990).

Negative biotic edge effects can occur when the changing mix of habitat characteristics no longer favours species dependent on forest interior conditions. For instance, when certain species migrate or disperse from edge habitat to the interior of a forested patch, they may negatively affect the animal and plant life there as competition increases and existing predator-prey and parasitic relationships are altered. Some hardy weed species, for example, can tolerate the temperature extremes in openings and become major seed dispersers. Winds may deposit these seeds along the gradient from edge to interior, which in the long term can alter the composition of the interior habitat's flora (Alverson et al. 1994).

Trees adjacent to edges may grow more quickly, and regeneration of species such as Douglas-fir and western hemlock can increase, in the first 30–60 m of edge. However, tree mortality also increases along edges of newly exposed clearcuts. Trees can become stressed and weakened if exposed to radical changes in microclimatic conditions and are more prone to diseases, insect attacks, and windfall (Geiger 1965; Saunders et al. 1991; Chen et al. 1992). For example, the Vienna moth, a forest pest, can lay its eggs on trunks of trees located near edges. Because these trees receive more sunlight than in the interior of the patch, the moth larvae hatch earlier than their parasite, which emerges from the cooler forest floor. This effectively upsets the host-parasite cycle, which strengthens the moth population (Geiger 1965; Saunders et al. 1991).

Many terrestrial amphibians require the cool moist conditions of forest floor microhabitats (Davis 1996). Research has shown that these animals may be vulnerable to the drier, warmer, more exposed edges between redwood forests and clearcuts (Bury 1983). In such cases, edges may

temporarily trap these animals within forested patches containing insufficient habitat for their survival. These barriers might also restrict the ability of these species to recolonize sites that have undergone local extinctions (Blaustein et al. 1994).

The richness and density of generalist bird species usually increases along forest edges because of the variety of vegetation and abundance of food. However, migratory bird populations may decline and the numbers of some habitat specialist species may decrease near edges. Increases in nest predation by small mammals, snakes, ravens, and crows are a commonly cited cause of these declines. Edge-related predation may extend as far as 600 m into the forest patch (Wilcove 1987).

### **Interior Habitat Requirements**

In many regions of the province, the natural forests of pre-settlement times persisted because large-scale natural disturbances occurred relatively infrequently. These old seral forests formed important niches for certain "interior species," which seemed to require specific interior habitat conditions.

The importance of the size of these forested interior patches varies depending on the species. For example, area-sensitive, interior forest-dwelling birds such as northern spotted owls and pileated woodpeckers require relatively large tracts of contiguous forest to sustain breeding populations. About 20 000 ha may be required for northern spotted owls, 60% of which should contain suitably contiguous habitat (Lamberson et al. 1994).

However, terrestrial amphibian species may find adequate interior habitat conditions in considerably smaller forest patches or protected riparian areas (Dupuis et al. 1995). On Vancouver Island, salamanders were found to be significantly more abundant in old-growth forests than in younger forests or clearcuts because of the specific microclimatic conditions

and structural attributes found there (Dupuis et al. 1995; Davis 1996). Most salamander species lack lungs and respire through skin, which must be kept moist. Therefore, they may be negatively affected in areas where shade is eliminated, soil surface temperature is increased, and leaf litter or soil surface moisture is reduced (Bury 1983).

Old or late successional forests offer important winter habitat for some large mammals such as deer, elk, woodland caribou, and moose. The tall, large-crowned canopy of the interior forest intercepts snow, which creates thermal cover and reduces snowpacks, and therefore makes winter feeding easier (Nyberg and Janz [editors] 1990). Old forests also provide more abundant and higher-quality forage at this time of year, offering an alternative food supply of arboreal, tree-based lichens and litterfall. While these ungulates are often considered edge species, interior habitat offers important winter refugia, particularly during deep-snow years (McNay 1995).

### **Applying the Concepts: Minimizing Edge Effects**

Past timber harvesting techniques have increased the amount of edge habitat in the British Columbia landscape. These techniques broke up formerly contiguous late successional or old-growth forests into smaller patches. This fragmentation has affected the species, ecosystems, and processes associated with forest interiors by:

- increasing edge effects (e.g., drier, warmer conditions created, with increased risk of windthrow, fire, and disease), which diminishes interior habitat quality;
- reducing the overall quantity of interior habitat available; and
- isolating the remaining interior habitat, which can restrict the exchange of genetic material.

### Minimizing Edge Effects at the Stand Level

At the stand level, certain silvicultural practices and harvesting techniques can minimize edge effects. For instance, during harvesting:

1. Leave feathered or curvilinear edges rather than abrupt, straight edges (Forman 1995). This technique produces edges that more closely resemble those created by natural disturbances. Feathered edges provide a more gradual transition between habitat types and offer animal species more protective cover against predation pressure.

2. Preserve understorey vegetation along feathered boundaries. This practice:

- offers wind resistance;
- minimizes the effects of excessive heat and moisture losses; and
- inhibits edge species from penetrating interior habitat (Chen et al. 1995).

This can decrease the depth of edge influences, thereby enlarging the quantity and improving the quality of interior habitat.

3. Retain more green trees in the clearcut, especially near the edge. By lessening the contrast between a clearcut and an existing stand, this practice reduces microclimatic edge effects in the short term. Over the long term, green-tree retention creates more structural diversity in the stand by offering a source of future wildlife trees, coarse woody debris, and a multilayered canopy (Franklin 1992). In turn, this structural diversity encourages tree regeneration along the edge and decreases the depth of edge influence, allowing more viable interior habitat to be preserved (Chen et al. 1995).

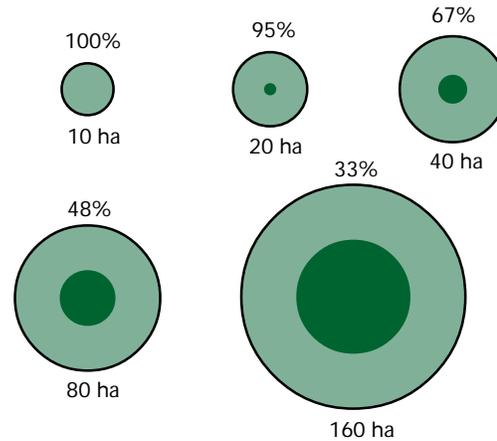


FIGURE 2 An illustration of how edge effects can reduce interior habitat. Shown here are various forest patch sizes and the percentage of interior habitat available, given a 240-m wide section of edge influence (from Franklin 1992).

Many planning and management options exist that will minimize edge effects at both the stand and landscape levels. At the landscape level, careful design will ensure that forest patches contain the maximum amount of viable interior habitat. For instance, when planning forest patches consider the following:

1. **Size:** Given that microclimatic edge influences can extend 200 m or more into the forested patch, a minimum patch width of 600 m should supply a 200-m wide section of interior habitat. Franklin (1992) indicates that, in Douglas-fir forests of Washington and Oregon, patch sizes of 50 ha or more will be required to provide significant amounts of unmodified interior forest (Figure 2). If a high potential for biotic effects exists, aggregate harvest units into clusters. This reduces the total amount of edge and maintains larger patches of old forest, which can circumvent the greater ability of biotic influences to penetrate forest interior habitat (Swanson and Franklin 1992).
2. **Shape:** Given a certain size threshold, compact patch shapes should protect interior habitat against detrimental edge effects because these forms have low edge-to-interior ratios. Conversely, convoluted and elongated patches have high

edge-to-interior ratios (Figure 3) (Forman 1995). However, some linear forest patches, especially in riparian areas, are valuable if they are wide enough to provide landscape connectivity and meet the interior habitat requirements of smaller animals.

3. **Orientation:** When designing optimal patch shapes consider the orientation of the patch to flows in the landscape. For instance, determine prevailing wind directions to minimize the potential for windthrow. Long “hard” edges facing southwest create more pronounced edge effects and result in a greater penetration of microclimatic influences into adjacent intact forests.

While several reserves or forest patches may currently occupy large areas, they may actually contain only a small amount of interior habitat if they are irregularly shaped. To increase the quantity and quality of the interior habitat in these patches, manage adjacent similar (with respect to species composition, age, and structure) areas to complement and increase the overall effective size of the reserve. This approach reduces the edge contrast over the short term. Over the long term, this technique increases the reserved patch’s circularity, eliminates sharp ecotone

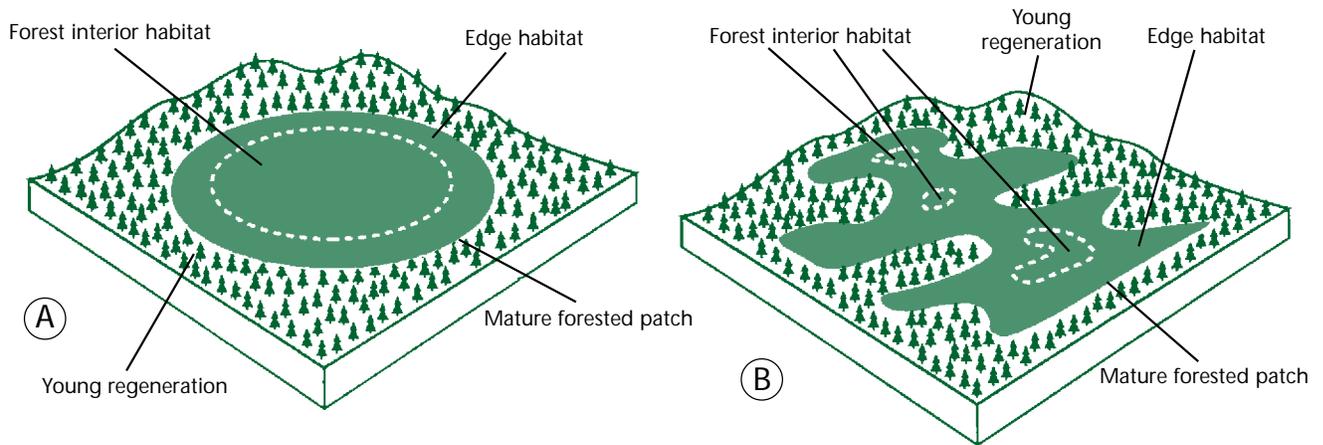


FIGURE 3 An illustration of how patch shape affects the amount of edge and interior habitat. (A) A circular forested patch tends to have a greater amount of interior habitat and less edge. (B) An irregularly shaped patch has more edge and less interior habitat (from B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks 1996).

boundaries, and reduces edge effects (Laurance and Yensen 1991).

The rate and pattern of future harvesting in the province will determine the amount of viable forest interior habitat. At a landscape scale, plan to manage interior habitat as a shifting mosaic. Remember that large patches of late successional forest containing interior habitat may appear and disappear over time, but the total area of forest interior within a given landscape should remain constant.

*Text by Susan Bannerman*

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