Forest Management for Biodiversity in Montane "Islands"

Joan Voller
British Columbia Ministry of Forests, Research Branch
712 Yates Street, Victoria, BC, V8W 3E7, Canada

Andy MacKinnon
British Columbia Ministry of Forests, Research Branch
712 Yates Street, Victoria, BC V8W 3E7, Canada
Andy.MacKinnon@gems1.gov.bc.ca

ABSTRACT

The montane is often considered an "island" habitat surrounded by different and sometimes inhospitable ecosystems, where factors such as area, isolation, and immigration influence species richness and diversity. Until recently, the montane has provided only a small portion (2–3%) of the forest harvest in coastal British Columbia. Montane forests were considered to have relatively inoperable terrain, with wood that had undesirable fibre quality and moderately low productivity. However, as submontane ecosystems are logged, development plans call for timber supply to come increasingly from coastal montane forests. Unfortunately, our knowledge of coastal montane ecosystems is meagre, and most current management practices employed there are based on research and management experience in the submontane. Further, montane ecosystems are more sensitive to disturbance and slower to recover than submontane ecosystems. In order to responsibly manage these habitats we have to understand the differences between montane ecosystems and the lower elevations for which the current management strategies were created. By understanding the species present in the montane, and their habitat associations, we can develop more appropriate management strategies. So far our project has focused mainly on a general inventory of plants, habitat elements, vertebrates, and arthropods found at our site on northern Vancouver Island. We are using our data to investigate species/habitat associations. This information can then be used to better understand habitat needs, and thus develop more appropriate management strategies for both the listed and common species found during our inventory.

Key words: forest management, montane, Vancouver Island.

Coastal montane forests are the transition zone between low (submontane) and high (subalpine) elevation forests, and range from approximately 650 to 1,000 m. The montane and subalpine elevations offer habitat for a large range of plants and animals, as well as providing economic value from recreation and resource extraction such as forest harvesting.

Concern for the preservation of the montane and subalpine forests has increased with the elevated harvest of these areas. Until recently, the montane has contributed only a small portion (2–3%) of the forest harvest in coastal British Columbia. However, the montane and subalpine forests of Vancouver Island actually account for about 30% of the land base (Smith 1992) and represent, for example, 25% of MacMillan Bloedel's future Annual Allowable Cut (Beese 1995). In the past, these areas were considered to have relatively inoperable terrain with wood that had undesirable fibre quality and moderately low productivity. However, as submontane ecosystems are logged, development plans call for timber supply to come increasingly from coastal montane forests. Unfortunately, our knowledge of coastal montane ecosystems is meagre, and most current management practices employed here are based on research and management experience from the submontane.

In order to develop more appropriate management strategies for the montane and subalpine forests we need to understand the differences between these areas and the submontane. Montane ecosystems are more sensitive to disturbance and slower to recover than submontane ecosystems. The montane's greater sensitivity to disturbance is partially due to its harsher climate. The harsher climate of the higher elevations produces lower temperatures, greater snowpacks, greater amounts of annual precipitation, and generally higher winds. This harsher climate also reduces the growing season and thus raises concerns over the survival, growth, and time needed to regenerate the forests (e.g., Koppenaal and Mitchell [1992] for montane forests, and Brett and Klinka [1998] for subalpine forests). As well, the greater snowpacks reduce the time that food and other necessities are available to wildlife, which influences species richness and diversity.

Unlike the submontane, the montane and higher elevations act like "island" habitats surrounded by different and sometimes inhospitable ecosystems. Species richness and diversity are affected by factors such as area, isolation, and

L. M. Darling, editor. 2000. Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Kamloops, B.C., 15 - 19 Feb.,1999. Volume One.
B.C. Ministry of Environment, Lands and Parks, Victoria, B.C. and University College of the Cariboo, Kamloops, B.C. 490pp.

immigration. Because the montane is often considered an "island," a species' ability to survive will greatly depend on the degree to which it has adapted to these factors. Lomolino and Davis (1997) describe montane islands of North America as "complex systems, isolated by a heterogeneous mix of immigration filters." How isolated these systems are for a species depends mainly on the habitat that lies between these "islands" and a species' ability to cross it. This ability to cross an inhospitable habitat will affect a population's potential to avoid local extinction. A certain amount of immigration must occur in order to limit the risk of local extinction (i.e., immigration rate must exceed extinction rate; MacArthur and Wilson 1967, Lomolino and Davis 1997). The degree of isolation between montane islands also depends somewhat on distance, and a species' ability to cover that distance. However, artificially decreasing the amount of isolation between populations can also cause problems for a species (e.g., the Vancouver Island marmot's range has become concentrated by their using clearcuts instead of travelling to the nearest mountain meadow, thus making the whole population more susceptible to mortality factors).

The Coastal Montane Biodiversity (CMB) project on Mount Cain was initiated to help increase our understanding of the montane and subalpine forests of coastal British Columbia. By understanding the species present in the montane and their habitat associations, we can develop more appropriate management strategies. The data presented in this paper are a small subset of data collected so far on this project. The inventory data collected during this project are in the process of being analyzed. In addition, other research projects associated with the CMB project are focusing on cavity nesting birds, bats, and ground and arboreal arthropods of the montane (Joy 2000, Kellner 1999, Fagan and Winchester 1999).

STUDY AREA

The study area is located at Mount Cain (50°3'N, 126°18'W) and Maquilla Peak near the community of Woss, B.C. on the northern part of Vancouver Island. Mount Cain provides the headwaters of the Tsitika River and, through Cain Creek, drains into the Davie River, which is the major drainage separating Mount Cain from Maquilla. The Englewood Logging Division of Canadian Forest Products, Ltd. (CANFOR) manages the area as part of Tree Farm License No. 37.

The landscape consists of a matrix of managed and natural forest stands that are part of 2 biogeoclimatic zones (Meidinger and Pojar 1991). The first and largest portion of the study area is classified as the Montane, Very Wet Maritime Coastal Western Hemlock variant (CWHvm2). This variant occupies an elevation range of about 650–1,000 m (600–900 m at Mount Cain) on the coastal mainland of British Columbia, the Queen Charlotte Islands, and Vancouver Island (Meidinger and Pojar 1991). Cool, short summers, cool winters, high precipitation (mean annual precipitation of 2,787 mm) and substantial snowfall are some of the climatic characteristics of the CWHvm2 variant (Meidinger and Pojar 1991).

The second biogeoclimatic unit in the study area is the Windward, Moist Maritime Mountain Hemlock variant (MHmm1). This variant covers the subalpine regions of coastal British Columbia, Vancouver Island, and the Queen Charlotte Islands, with lower limit elevations between 800 and 1,000 m and upper limits between 1,100 and 1,350 m (Green and Klinka 1994). At Mount Cain this variant occurs between 900 and 1,300 m. The variant is characterized by short, cool, moist summers and long, wet, cold winters with deep accumulations of snow (total mean annual depth of approximately 820 cm; Meidinger and Pojar 1991). The Parkland subzone of the MHmm1 occurs at the upper elevations (MHmm1p), with the nonforested ecosystems of the Alpine Tundra (AT) above that.

At lower elevations, below the study area, the Submontane Very Wet Maritime Coastal Western Hemlock variant of the CWHvm (CWHvm1) occurs.

The CWHvm2 variant supports western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*), interspersed with varying amounts of amabilis fir (*Abies amabilis*). Some drier sites at lower elevations also support small amounts of Douglas-fir (*Pseudotsuga menziesii*), while yellow-cedar (*Chamaecyparis nootkatensis*) is present at higher, moister regions of the zone. Major understory species include Alaskan blueberry (*Vaccinium alaskaense*), five-leaf bramble (*Rubus pedatus*), step moss (*Hylocomium splendens*), lanky moss (*Rhytidiadelphus loreus*), and pipecleaner moss (*Rhytidiopsis robusta*; Green and Klinka 1994).

Mountain hemlock (*Tsuga mertensiana*), yellow-cedar, and amabilis fir dominate the subalpine MHmm1 variant. Both western hemlock and western redcedar are also present in this zone, though at lower elevations. The forest becomes increasingly sparse with increasing altitude and thins into parkland with trees scattered in isolated and irregular clumps (Meidinger and Pojar 1991). As with the CWHvm2 variant, dominant vegetation of this variant includes Alaskan blueberry and pipecleaner moss, in addition to oval-leafed blueberry (*Vaccinium ovalifolium*).

METHODS

The inventory of biodiversity focused on 4 major life-form groups: plants, habitat elements, vertebrates, and arboreal- and ground-associated arthropods. The compilation of data on the invertebrates found during our inventory is unfinished; therefore, they are not listed in this paper (Fagan and Winchester 1999). Whenever possible, inventory techniques were those established by the Resource Inventory

Committee (RIC). Climate data were also collected.

Fifty 750-m-long transects were established through a representation of ecosystem types. Five of the 50 transects were established along an elevational gradient from 650 m to 1200 m. Six square sample plots (20 m^2, 0.04 ha) were established at 150-m intervals along each of the 50 transects. In order to increase independence (>300 m apart), plots 1, 3, and 5, of each transect were established as “biodiversity” plots.

Details of methods used for the inventory may be found in the CMB final report (Joy et al. 1999). Details of methods for the associated research projects may be found in the following: cavity nesting birds (Joy 2000); bats (Kellner 1999); arthropods (Fagan and Winchester 1999).

RESULTS

The species that are most likely to be affected by harvesting in the montane are rare species and species dependent on the higher elevation forests for part or all of their life cycle. Table 1 shows the species at risk that were found during our inventory or that are known to occur in the montane on Vancouver Island. By including those species that are known to occur in the montane but were not found during our inventory, we recognize that either their rarity, or a gap in our methods, may have prevented us from finding them. Through our inventory of the Vancouver Island montane and a Rare Element Occurrence Report compiled by the British Columbia Conservation Data Centre (CDC; CDC 1998), we have noted 3 bryophyte and lichen, 40 vascular plant, 7 bird, and 6 mammal species at risk. Of these species at risk, 14 vascular plant, 3 bird, and 1 mammal species are dependent on the higher elevations for part or all of their life cycles. The following additional bird species that are not at risk, but that are dependent on the higher elevations for part or all of their life cycle, were also found during our inventory: three-toed woodpecker (*Picoides tridactylus*), gray jay (*Perisoreus canadensis*), American pipit (*Anthus rubescens*), and gray-crowned rosy finch (*Leucosticte tephrocotis*).

In addition, we found 321 common vascular plant species, 71 common bird species, and 9 common mammal species during our inventory of Mount Cain; for more specific results on the common species found during the inventory refer to Joy et al. (1999). For results from the associated research projects refer to Joy (2000) for cavity nesting birds, Kellner (1999) for bats, and Fagan and Winchester (1999) for arthropods.

DISCUSSION

Increased concern for the preservation of the higher elevations has initiated an increase in interest in alternative silvicultural systems (e.g., shelterwood, green tree retention, and patch cuts). Projects such as Montane Alternative Silvicultural Systems (MASS; Arnott et al. 1995) and Sicamous Creek (Hollstedt and Vyse 1997) have given us the opportunity to study the potential of these alternatives, both from an economic viewpoint and a biological viewpoint.

The Sicamous Creek project also looks at the effects alternative silvicultural systems have on biodiversity. No coastal project yet addresses these concerns. However, MASS characterizes forest structure and natural vegetation dynamics following a variety of silvicultural treatments (Beese et al. 1995). Combining the lessons of MASS with the lessons from the CMB project on the habitat requirements of various montane forest species, we can evaluate the efficacy of different silvicultural systems in meeting habitat requirements for montane forest species.

For example, Beese et al. (1995) reported that the pre-logging basal area that remained after logging was 18% (206 stems/ha >17.5 cm dbh) for the shelterwood treatment, and 5% (22 stems/ha >17.5 cm dbh) for the green tree retention treatment. On Mount Cain, Joy (2000) found that nest tree characteristics for the red-breasted sapsucker were at least 32.5 m in height and 93.3 cm in diameter, across a range of decay classes. He also found that the red-breasted sapsucker preferred western white pine (*Pinus monticola*), amabalis fir, western hemlock, and mountain hemlock, and suggests that these species should be included in the design of wildlife tree patches. It is widely felt that primary cavity nesters are keystone species in northern forests (Daily et al. 1993, Walters 1996). Joy (2000) therefore suggests that wildlife tree retention in coastal montane forests be based on mean nest tree diameter and height. Combining the findings from these studies will help us meet the habitat requirements of primary cavity nesters such as the red-breasted sapsucker; at the same time we also benefit other species that use the cavities created by these species.

In order to develop effective alternative silvicultural systems for the montane and subalpine forests we also have to understand how the “island” effect may influence species populations. Coastal montane ecosystems are not subject to regular, large-scale, stand-destroying disturbances (e.g., Beese et al. 1995), and so might be expected to harbour some species with poor dispersal abilities. For example, Winchester (1997) reports an unusually high incidence of wingless arthropods in canopies of coastal temperate rain forests on western Vancouver Island. Similar results are anticipated from canopy arthropod work at Mount Cain.

Vertebrates are generally less affected by the isolation factor. Of the 13 listed and 84 common vertebrate species in the Vancouver Island montane, all but 4 (three-toed woodpecker, American pipit, white-tailed ptarmigan, and Vancouver Island marmot) can be found at all elevations throughout the year, and are not dependent on the montane and higher elevations for any of their life cycle; therefore, isolation is not a concern. As well, these 4 vertebrate species that live at least part of their life cycle in the montane are capable of

Table 1. Species at risk that have been noted in the montane on Vancouver Island.

Species	Status[a]	Source[b]	Dependence[c]
Bryophytes and Lichens			
Bryoria nadvornikiana	?	Mt. Cain	
Chaenotheca phaeocephala	?	Mt. Cain	
Pseudocyphellaria rainierensis	?	Mt. Cain	
Vascular Plants			
Allium cremulatum Olympic onion	Red S1 G4	Other	
Anemone drummondii var. *drummondii* Drummond's anemone	Blue S2S3 G4T4	Other	Y
Apocynum sibricum var. *salignum* Clasping-leaved dogbane	Blue S1? G5?T?	Other	
Artemisia furcata var. *heterophylla* Three-forked mugwort	Blue S1? G4T?	Other	Y
Asplenium adulterinum Corrupt spleenwort	Blue S1? GU	Other	Y
Aster paucicapitatus Olympic mountain aster	Blue S2S3 G3?	Other	
Botrychium simplex Least moonwort	Blue S1? G5	Other	
Carex feta Green-sheathed sedge	Blue S2S3 G5	Other	
Disporum smithii Smith's fairybells	Blue S2S3 G5	Other	
Douglasia laevigata Smooth douglasia	Blue S2S3 G3?	Other	
Draba lonchocarpa var. *vestita* Lance-fruited draba	Blue S2S3 G4T3	Other	Y
Dryopteris arguta Coastal wood fern	Blue S2S3 G5	Other	
Enemion savilei Queen Charlotte isopyrum	Blue S3 G3	Other	
Epilobium ciliatum ssp. *watsonii* Purple-leaved willowherb	Blue S2S3 G5T?	Other	
Epilobium glaberrimum ssp. *fastigiatum* Smooth willowherb	Blue S2S3 G5T?	Other	Y
Epilobium leptocarpum Small-flowered willowherb	Blue S2S3 G5	Other	Y
Erysimum arenicola var. *torulosum* Sand-dwelling wallflower	Blue S1? G4G5T?	Other	Y
Erythronium montanum white glacier lily	Blue S2S3 G4	Other	Y
Euphorbia serpyllifolia Thyme-leaved spurge	Blue S2S3 G5	Other	
Galium trifidum ssp. *trifidum* Small bedstraw	Blue S1? G5T?	Other	
Geum schofieldii Queen Charlotte avens	Red S2 G2Q	Other	
Githopsis specularioides Common bluecup	Red S2 G5	Other	
Hedysarum occidentale Western hedysarum	Blue S2S3 G5	Other	Y
Hypericum scouleri ssp *nortoniae* Western St John's-wort	Blue S2S3 G5T?	Other	
Lewisia triphylla Three-leaved lewisia	Blue S1? G4?	Other	Y
Lophochlaena refracta var. *refracta* Nodding semaphore grass	Blue S2S3 G4G5T4	Other	
Myriophyllum quitewse Waterwort water-milfoil	Blue S2S3 G4?	Other	
Nothochelone memorosa Woodland penstemon	Blue S2S3 G5	Other	
Orthocarpus imbricatus Mountain owl-clover	Red S1 G5	Other	Y
Pyrola elliptica White wintergreen	Blue S1? G5	Other	Y
Rubus lasiococcus Dwarf bramble	Blue S2S3 G5	Other	Y
Rubus nivalis Snow dewberry	Blue S2S3 G4?	Other	Y
Rupertia physodes California-tea	Blue S2S3 G4	Other	
Sanguisorba menziesii Menzies' burnet	Blue S2S3 G3G4	Other	
Senecio macounii Macoun's groundsel	Blue S2S3 G5	Other	
Thelypteris nevadensis Nevada marsh fern	Red S1 G4	Other	
Viola biflora ssp. *carlottae* Queen Charlotte twinflower violet	Blue S3 G5T3	Other	
Viola howellii Howell's violet	Blue S2S3 G4	Other	
Yabea microcarpa California hedge-parsley	Blue S1? G5?	Other	
Birds			
Marbled Murrelet *Brachyramphus marmoratus*	Red S2B, SZN G3G4	Mt. Cain	
Northern Goshawk *Accipiter gentilis laingi*	Red S2B G5T2	Mt. Cain	
Northern Pygmy Owl *Glaucidium gnoma swarthi*	Blue S3 G5T3Q	Mt. Cain	Y
Peale's Peregrine Falcon *Falco peregrinus pealei*[d]	Blue S3B, SZN G4T3	Other?	
American Peregrine Falcon *F. p. anatum*[d]	Red S2B, SZN G4T3	Mt. Cain?	
Pine Grosbeak *Pinicola enucleator carlottae*	Blue S3S4B SZN G5T3T4	Mt. Cain	Y
Sandhill Crane *Grus canadensis* (this species only noted above the canopy)	Blue S3B,SZN G5	Mt. Cain	
White-tailed Ptarmigan *Lagopus leucurus saxatilus*	Blue S3 G5T3	Mt. Cain	Y

Table 1. Continued

Species	Status[a]	Source[b]	Dependence[c]
Mammals			
Keen's long-eared myotis *Myotis keenii*[e]	Red S1S3 G2G3	Mt. Cain?	
Roosevelt elk *Cervus elaphus roosevelti*	Blue S2S3 G5T4	Mt. Cain	
Vancouver Island ermine *Mustela erminea anguinae*	Blue S3 G5T3	Mt. Cain	
Vancouver Island marmot *Marmota vancouverensis*	Red S1 G1G2	Other	Y
Vancouver Island wolverine *Gulo gulo vancouverensis*	Red S1 G4T1	Other	
Water shrew *Sorex palustris brooksi*	Red S2 G5T2	Other	

[a] From British Columbia Conservation Data Centre (CDC).
[b] Mt. Cain = found during our inventory; Other = compiled from information on the CDC Tracking Lists (CDC 1999) and Rare Element Occurrence report for montane areas within the CWH and MH zones on Vancouver Island (CDC 1998).
[c] Y indicates species is dependent on higher elevations for all or part of its life cycle.
[d] A peregrine falcon was seen during our inventory, but we were unable to tell which subspecies it was.
[e] Due to the inability to distinguish this species from the western long-eared myotis we can not confirm that this species was present during our inventory.

dispersing the required distance between montane "islands."

As well, of the 40 listed plant species found in the Vancouver Island montane, 14 are found only in the montane. Like the vertebrates, these plant species are thought to be capable of dispersing the required distance between montane "islands" so isolation is not a concern.

The vertebrate and plant species that are dependent on the higher elevations for all or part of their life cycle are more likely to be affected by loss of area or loss of important habitat attributes. For example, Martin (1997) states that habitat loss due to forestry and recreational activities has the potential to impact summer production, winter survival, and dispersal of the white-tailed ptarmigan on Vancouver Island. As well, species such as the northern pygmy owl and the three-toed woodpecker rely on the availability of wildlife trees.

The upper elevations are also important habitat for the more common species. Ogle and Martin (1997) reported that in the alpine, avian species diversity (mostly migratory species) and food resources were high in the late summer and fall. At this same time, they observed that food resources, as well as avian diversity, were on the decline in lower elevation forests (Ogle and Martin 1997), thus noting the importance of higher elevations to migratory birds.

The increased demand on the resources of the montane ecosystem requires special attention. We need to deal with the increasing problem of managing biological diversity, as well as understanding how the principles of biodiversity management interact with the sustainability of all species, including endangered, rare, and regionally significant animals and plants.

ACKNOWLEDGEMENTS

We are grateful for financial, technical, administrative, and logistical support from the British Columbia Ministry of Forests, Research Branch; British Columbia Ministry of Environment, Lands and Parks, Region One; Canadian Forest Products Ltd., Englewood Logging Division; British Columbia Conservation Fund; and Forest Renewal British Columbia. We also thank the University of Victoria and Simon Fraser University for their cooperation and support. We also wish to thank all those involved in this project for their dedication and hard work.

LITERATURE CITED

Arnott, J. T., W. J. Beese, A. K. Mitchell, and J. Peterson. 1995. Montane Alternative Silvicultural Systems (MASS): proceedings of a workshop, June 1995. Can. For. Serv. and B.C. Minist. For., Victoria, BC. FRDA Rep. 238.

Beese, W. J. 1995. Montane Alternative Silvicultural Systems (MASS): introduction and objectives. Pp. 3–8 *in* J. T. Arnott, W. J. Beese, A. K. Mitchell, and J. Peterson, eds. Montane Alternative Silviculture Systems (MASS). Can. For. Serv. and B.C. Minist. For., Victoria, BC. FRDA Rep. 238.

_____, J. Sandford, and J. Toms. 1995. Montane Alternative Silvicultural Systems (MASS): forest structure and natural vegetation dynamics. Pp. 113–122 *in* J. T. Arnott, W. J. Beese, A. K. Mitchell, and J. Peterson, eds. Montane Alternative Silviculture Systems (MASS). Can. For. Serv. and B.C. Minist. For., Victoria, BC. FRDA Rep. 238.

Brett, R. B., and K. Klinka. 1998. A comparison of natural regeneration patterns in old-growth stands and clearcuts in the Mountain Hemlock zone of southern British Columbia. Northwest Sci. 72 (spec. issue 2): 27–29.

Conservation Data Centre. 1998. CDC rare element and occurrence report for montane areas within the CWH and MH BEC zones on Vancouver Island. B.C. Minist. Environ., Lands and Parks. Victoria, BC.

_____. 1999. CDC tracking lists. B.C. Minist. Environ., Lands and Parks. Victoria, BC.

Daily, G. C., P. R. Ehrlich, and N. M. Haddad. 1993. Double keystone bird in a keystone species complex. Proc. Natl. Acad. Sci. 90:592–594.

Fagan, L. L., and N. V. Winchester. 1999. Arboreal arthropods: diversity and rates of colonization in a temperate montane forest. Selbyana 20(1): 171–178.

Green, R. N., and K. Klinka. 1994. A field guide to site identification and interpretation for the Vancouver Forest Region. B.C. Minist. For., Victoria, B.C.

Hollstedt, C., and A. Vyse, eds. 1997. Sicamous Creek Silvicultural Systems Project: workshop proceedings, 24–25 April 1996, Kamloops, B.C. B.C. Minist. For., Res. Branch, Victoria, BC.

Joy, J. B. 2000. Characteristics of nest cavities and nest trees of the red-breasted sapsucker in coastal montane forests. J. Field Ornithol. 71(3).

_____, L. Peterson, N. Winchester, A. MacKinnon, D. Meidinger, M. Kellner, and J. Voller. 1999. Coastal montane biodiversity inventory. B.C. Minist. Environ., Lands and Parks (Reg. 1), Nanaimo, BC.

Kellner, M. 1999. Activity and roost selection of bats in coastal montane forests on northern Vancouver Island. M.Sc. thesis, Simon Fraser Univ., Burnaby, BC. 95 pp.

Koppenaal, R. S., and A. K. Mitchell. 1992. Regeneration on montane forests in the Coastal Western Hemlock zone of British Columbia: a literature review. For. Can. and B.C. Minist. For., Victoria, BC. FRDA Rep. 192.

Lomolino, M. V., and R. Davis. 1997. Biogeographic scale and biodiversity of mountain forest mammals of western North America. Global Ecol. and Biogeogr. Letters 6:57–76.

MacArthur, R. H., and E. O. Wilson. 1967. The equilibrium theory of island biogeography. Princeton University Press, Princeton, NJ. 203pp.

Martin, K. 1997. Vancouver Island white-tailed ptarmigan inventory project: progress report, 1997 summer surveys. For. Sci. Dep., Univ. British Columbia, Vancouver, BC. For. Renewal British Columbia Prog. Rep.

Meidinger, D., and J. Pojar. 1991. Ecosystems of British Columbia. Res. Branch, B.C. Minist. For., Victoria, BC.

Ogle, S. and K. Martin. 1997. The use of alpine habitats by fall migrating birds on Vancouver Island 1996-1997. Minist. Environment, Lands, and Parks, Nanaimo, BC. Unpubl. rep.

Smith, N. J. 1992. Evaluation of silvicultural systems and ecosystem function: assessing the problem and its extent. For. Can., Pacific For. Centre, Victoria, BC. Unpubl. file rep. 7231K.

Walters, E. 1996. Habitat and space use of the red-naped sapsucker, *Sphyrapicus nuchalis*, in the Hat Creek Valley, south-central British Columbia. M.Sc. thesis, Univ. Victoria, Victoria, BC. 87pp.

Winchester, N. N. 1997. Canopy arthropods of coastal Sitka spruce trees on Vancouver Island, British Columbia, Canada. Pp. 151–168 *in* N. E. Stork, J. Adis, and R. K. Didham, eds. Canopy arthropods. Chapman and Hall, London, U.K.