Karen Price, RR2, S23b, C1, Burns Lake, British Columbia, Canada, V0J 1E0

Jim Pojar, British Columbia Forest Service, Research, Postal Bag 5000, Smithers, British Columbia, Canada, V0J 2N0

Audrey Roburn, Lori Brewer, and **Nola Poirier,** Bamfield Marine Station, Bamfield, British Columbia, Canada, V0R 1B0

Windthrown or Clearcut—What's the Difference?

Introduction

Much interest focuses on the ability of managed forests to conserve biodiversity (e.g. Hunter 1990, Province of BC 1995). Management alters habitat by changing a forest's age and structural attributes. At the stand level, studies demonstrate differences in species diversity and abundance between old and young forests. Most of these studies, however, compare young managed forests with old unmanaged stands, thus confounding the effects of age and disturbance type. Teasing apart this confound will help determine the best management strategies to conserve biodiversity (e.g. leaving structure versus long rotations).

Both time and disturbance type affect stand structure. Disturbance intensity determines what structural legacies will be left behind; time allows new structure to develop; and disturbance frequency limits the time available for development. Natural disturbance agents, such as fire and wind, can leave behind considerable structure relative to clearcut harvesting, which removes most of the stand's biomass.

Structure, rather than stand age per se, may be the key factor determining available habitat. Indeed, some studies have found little difference in species diversity and abundance between young and old unmanaged forests (reviewed in Hansen et al. 1991). Acknowledging the importance of stand structure, recent trends in forest management aim to retain some structural elements during harvesting. Will these retained elements still influence mature stand structure, near rotation age? This question is important because, on a managed landscape with few older stands, structurally complex mature stands may provide important old-growth-like habitat.

While studies have examined the differences in structure and species assemblages among different seral stages, few have compared mature stands originating from different disturbance types. Our study focused on hypermaritime forests on the west coast of Vancouver Island and asked two questions: (1) Do mature stands initiated by blowdown contain more structure than mature stands initiated by clearcutting? (2) Do blowdown-initiated stands support different species than logged stands? More specifically, we asked whether stands initiated by blowdown were more similar to old growth, and predicted that blowdown sites would contain greater structural legacy (more large trees and snags, abundant coarse woody debris) and would have greater heterogeneity (in canopy gaps, microtopography, tree spacing and size). We also predicted that, because of differences in structure, the blowdown sites would contain a higher diversity and abundance of epiphytic lichens (e.g. Neitlich and McCune 1997) and a different suite of birds (old-growth specialists and cavity nesters).

Methods

Site Selection

We located six second-growth sites in coastal forest near Bamfield, BC. Three sites had suffered wind disturbance; three had been harvested; all were 60-80 years old and dominated by western hemlock (*Tsuga heterophylla*). In late August 1996, we sampled structural attributes of each forest and looked at two forest-dwelling communities (epiphytic lichens and birds).

Structural Attributes

We recorded coarse woody debris, canopy gaps, and ground surface mounds that intercepted a 90-m triangular transect at each site. We also sampled three randomly located, 20 x 20-m plots within each site, tallying live trees and snags by 10-cm diameter class.

Communities

At each site, we sampled fallen epiphytic macro-lichens in seven or nine 2-m radius plots, 10 m apart. We identified birds detected within five 30-m-radius plots, during two morning surveys at each site. For analysis, we grouped bird species into two sets based on natural history and published studies: the first set requires or uses various old-growth attributes (woodpeckers, Pacific slope flycatcher *Empidonax difficilis*, chestnut-backed chickadee *Parus rufescens*, red-breasted nuthatch *Sitta canadensis*, brown creeper *Certhia americana*, winter wren *Troglodytes troglodytes*, varied thrush *Ixoreus naevius*, golden-crowned kinglet *Regulus satrapa*, pine siskin *Carduelis pinus*, red crossbill *Loxia curvirostra*); and the second set does not require these attributes (common raven *Corvus corax*, northwestern crow *Corvus caurinus*, Steller's jay *Cyanocitta stelleri*, American robin *Turdus migratorius*, Swainson's thrush *Catharus ustulatus*, cedar waxwing *Bombycilla cedrorum*).

Results

Structural Attributes (see Table 1)

More coarse woody debris lay on the ground in the blowdown sites than in the harvested sites. A larger portion of debris volume came from big logs in the blowdown sites: for example, about 20% versus 0% came from logs thicker than 70 cm. Recent debris (decay class 1 or 2) fell in the smallest diameter class (10-30 cm) on all sites. Stands on blowdown sites had more gaps in their canopies than did stands on harvested sites. Transects crossed more mounds in the blowdown sites, and the windthrow mounds tended to be higher. Windthrow stands tended to have more large veteran trees and more snags than harvested stands. No sites had new (decay class 3 or 4) large (>40 cm dbh) snags. All three harvested sites now support stands of trees with a skewed bimodal distribution of diameter classes. Two of the blowdown sites showed the 'reverse J' distribution characteristic of old-growth forests dominated by gap dynamics; the third blowdown site had a unimodal distribution of stem diameters. The windthrow sites tended to have a higher range of diameters and greater variance in diameter. They also had more variation in the number of stems among the three plots per site than did the harvested sites.

Communities

We found more species of arboreal macro-lichens in the forests on the blowdown sites (blowdown: total = 15 taxa, mean = 10.3 ± 0.3 taxa/site; clearcut: total = 10 taxa, mean = 5.3 ± 1.7 taxa/site; MWU = 9, p=0.02). Twelve of thirteen species occurred in more blowdown sites than harvested sites; six species occurred only on blowdown sites whereas only one was restricted to the harvested sites. Total lichen abundance was greater in windthrow sites, and all lichen taxa found on both site types were more abundant on the windthrow sites (Figure 1). The mean number of bird species tended, non-significantly, to be higher in blowdown sites. Three

TABLE 1. Stand structure in coastal forests. 60-80 years after windthrow and after clearcut logging.

Attribute	Blowdown sites (mean ± se)	Harvested sites (mean ± se)	MWU*	p
coarse woody debris (m^3/m^2)	0.086 ± 0.01	0.039 ± 0.01	9	0.03
m of gap/90-m transect	16.8 ± 4.8	2.2 ± 1.6	9	0.03
mounds/90-m transect (no.)	16.0 ± 1.2	11.7 ± 1.5	8.5	0.04
mean height tallest 3 mounds (m)	1.4 ± 0.1	1.0 ± 0.2	8	0.07
veteran trees (> 60cm dbh)/1200m^2 (no.)	10.7 ± 2.9	4.3 ± 1.3	8	0.06
snags (> 20cm dbh)/1200m^2 (no.)	19.7 ± 6.7	5.3 ± 2.6	8	0.07
dead sticks (< 20cm dbh)/1200m^2 (no.)	27.0 ± 7.0	38.8 ± 16.6	5	0.8
range of dbh (cm)	127 ± 23	80 ± 10	8	0.06
variance in dbh (cm)	22.7 ± 2.8	17.1 ± 1.5	8	0.07
mean difference, no. trees in each of 3 plots/site	28.7 ± 9.7	5.8 ± 2.7	9	0.03

* Mann-Whitney U test (one-tailed).

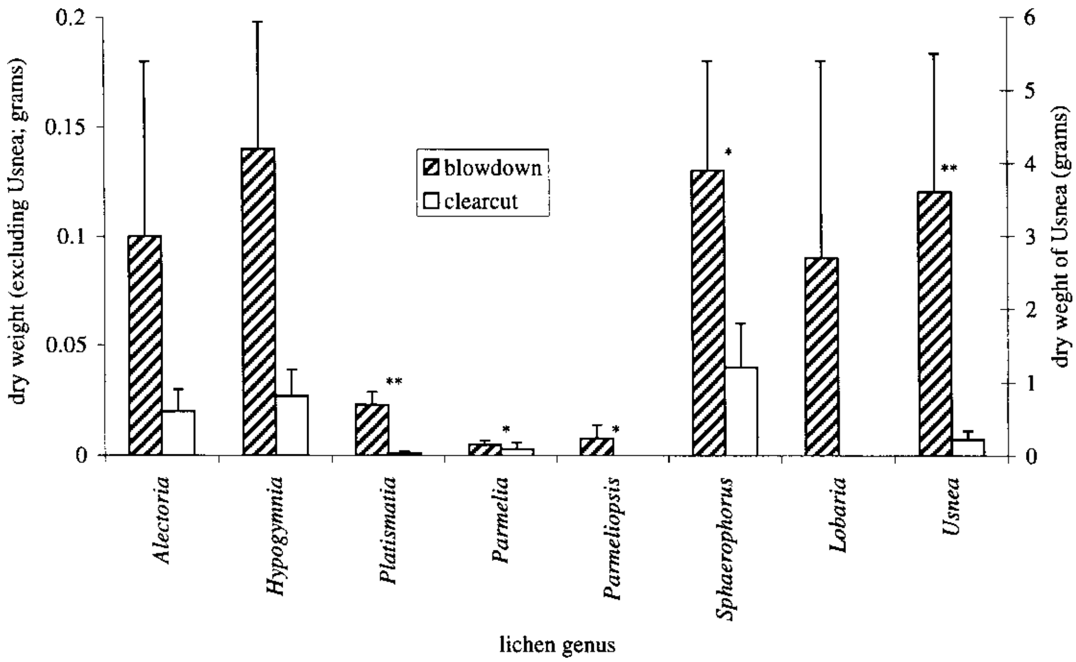

Figure 1. Abundance of epiphytic lichens (by genus) in blowdown and harvested sites (mean ± se; * $p<0.1$, ** $p<0.05$; MWU, one-tailed).

species (pileated woodpecker *Dryocopus pileatus*, varied thrush, and pine siskin) were detected only in blowdown sites; no species were restricted to harvested sites. Of the 12 'old-growth' species, 11 were detected in more blowdown sites, or more often in blowdown sites; of the six 'non-old-growth' species, three were detected more often in harvested sites, and three more often in blowdown sites.

Discussion

This study shows that, near Bamfield, 60-80-year-old stands initiated by blowdown have more structural heterogeneity than do similarly aged stands initiated by clearcutting. With respect to structural attributes, naturally disturbed, secondary, coastal forests resemble old growth more closely than do similarly aged harvested forests—and the wild forests provide habitat for more epiphytic lichens and for a specialised suite of birds.

As well as the obvious link between forest structure (e.g. large snags) and function (e.g. nesting habitat), more subtle connections may exist. Pettersson et al. (1995) found higher variety and numbers of invertebrates in natural boreal forests with rich epiphyte communities than in mature selectively cut forests with few epiphytes, and linked epiphyte abundance with bird abundance.

We caution that our data, while suggestive, are preliminary (due to small sample and short sampling period). Sites did not appear biased by proximity to ocean or by size. However, blowdown sites tended to be surrounded more completely by old growth than did harvested sites, introducing a landscape-level confound potentially influencing both lichen and bird distribution.

Disturbance severity varied among sites within disturbance type. One of the harvested sites had some remnant trees, a higher volume of debris, and a more open canopy than the other two. One of the windthrow sites had a unimodal diameter distribution, lower within-stand variability and a more closed canopy than the other two, likely reflecting a different disturbance regime.

Implications for Forest Management

Structure is very important in forested ecosystems, creating heterogeneity and complexity, and housing a variety of organisms. Harvesting methods, silvicultural systems, and stand-tending practices that retain or lead to recruitment of structural attributes make ecological sense (Lertzman et al. 1997). But a one-time gift does not necessarily bestow a lasting legacy, especially in forests with ecological rotations on an order of magnitude longer than the timber rotation, and with natural disturbance gaps on an order of magnitude smaller than conventional cutblocks. Although the blowdown sites contained more of the structure characteristic of old growth, they did not contain many of the massive live trees, snags, or coarse woody debris found in nearby old stands. The harvested stands had not developed structural heterogeneity over 60-80 years, raising the question of how long it takes to develop structure, or old-growth equivalence.

We conclude that, although leaving structure at the time of disturbance provides legacies that last for 60-80 years, and provides habitat for some lichens and birds, structure alone may not be sufficient. First, we cannot eliminate the landscape-level confound with surrounding old-growth forest. Second, managers may not be able to duplicate (or even approximate) 1000-year old patterns of structure in a harvested stand. A combination of structural retention and long rotations, modelled after the natural disturbance patterns of the region, may be the best option.

Acknowledgements

We thank the rainforest ecology classes of 1995 and 1996 (students and guest lecturers) and Andy MacKinnon for their hard work and enthusiasm, and staff of Bamfield Marine Station for their support.

Literature Cited

Hansen, A.J., T.A. Spies, F.J. Swanson, and J.L. Ohmann. 1991. Conserving biodiversity in managed forests: lessons from natural forests. BioScience 41:382-392.

Hunter, M.L. 1990. Wildlife, Forests, and Forestry: Principles of Managing Forests for Biological Diversity. Regents/Prentice Hall, New Jersey.

Lertzman, K.P., T. Spies, and F. Swanson. 1997. From ecosystem dynamics to ecosystem management. *In* P.K. Schoonmaker, B. von Hagen, and E.C. Wolf (eds.). The Rain Forests of Home. Island Press, Washington DC. Pp. 361-382.

Neitlich, P. N., and B. McCune. 1997. Hotspots of epiphytic lichen diversity in two young managed forests. Cons. Biol. 11:172-182.

Pettersson, R.B., J.P. Ball, K-E. Renhorn, P-A. Esseen, and K. Sjoberg. 1995. Invertebrate communities in boreal forest canopies as influenced by forestry and lichens with implications for passerine birds. Biol. Cons. 74:57-63.

Province of British Columbia. 1995. Forest practices code of British Columbia. Biodiversity Guidebook. BCMOF. Victoria, BC.