Life After the Beetle

Salvage Harvesting of MPB Pine and Green-Tree Retention

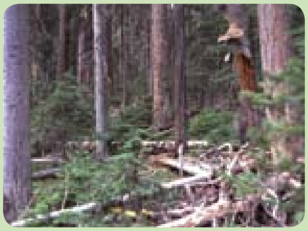
A 30-year Vision into the Future

Variable retention harvests (green-tree retention; GTR) are designed to maintain some aspects of mature forest habitat, maintain biodiversity, and provide an alternative to clearcut harvesting of temperate and boreal forests. Long-term response data are lacking regarding effectiveness of these treatments in conserving biodiversity. We report on a retrospective investigation of the impacts of salvage harvesting of lodgepole pine, killed by an outbreak of mountain pine beetle (MPB) in the 1970s, with variable retention of Douglas-fir as major stand-level structures to maintain biodiversity over time. This approach provided an inference to biodiversity by using ecological indicators of coniferous stand structure and an array of mammal species. Examples of these potential "keystone" species are the southern red-backed vole and common shrew on the forest-floor, the red squirrel and northern flying squirrel in the arboreal mammals, and the snowshoe hare and mule deer in the larger mammals.

A MPB outbreak in the mid-1970's in the southern interior of B.C. resulted in relatively widespread salvage logging of lodgepole pine from mixed pine – Douglas-fir stands. In pine-leading stands, fir were left as residual standing trees. This seed-tree silvicultural system leaves a variable number of wind-firm seed trees standing singly (dispersed retention), or in groups (aggregated retention), to provide a source of fir regeneration as a secondary species to lodgepole pine, which regenerates naturally from abundant cone slash.

Seed-tree stand with overstory Douglas-fir and understory pine

Seed-tree stand



Uncut old-growth forest

This is a relatively widespread practice that has been in place since the early to mid-1970's when lodgepole pine became an important commercial timber species. Because of this history, it is possible to do a retrospective investigation of the responses of stand structure and biodiversity 30 years after salvage harvesting of beetle-killed timber. Stands with residual green trees, composed of dispersed to aggregated Douglas-fir with understory lodgepole pine, cover several landscapes in the southern interior, having arisen from harvesting over the past 30 years.

Major Question

How do these stands compare to those uncut in terms of stand structure and development of late seral forest conditions?

This question has direct relevance to sustainable forest management for wildlife habitat and biodiversity.

Green-Tree Retention

- Dispersed to Aggregated Douglas-fir and Understory Pine
- Comparison to Uncut Forests → Stand Structure & Late Seral Conditions, Sustainability & Biodiversity

How To Proceed?

- Stand Structure & Responses of 6 Mammals → Ecological Indicators of Sustainability & Biodiversity
- Time → Studies lasting decades?
- Or can we do a retrospective study, and look back 30 years to an earlier outbreak of MPB?

Mammals

Common Shrew

Red-Backed Vole

Flying Squirrel

Red Squirrel

Snowshoe Hare

Mule Deer

We predicted that, at 30 years after salvage harvest of beetle-killed lodgepole pine trees,

(1) abundance (basal area and density of coniferous trees and amount of vegetation) and diversity (species diversity and structural diversity of the herb, shrub, and tree layers) of various aspects of stand structure, and

2) abundance (population density or relative habitat use) of these mammal species,

will decline with lower levels of Douglas-fir tree retention.

Stand structure attributes and selected mammals were sampled during 2005-2008 in replicated units of 30-year-old stands of lodgepole pine, with a ***range of GTR as seed-trees (none, dispersed, and aggregated Douglas-fir), and uncut mature/old-growth stands,*** *near Summerland in south-central B.C., Canada.*

Continued from previous

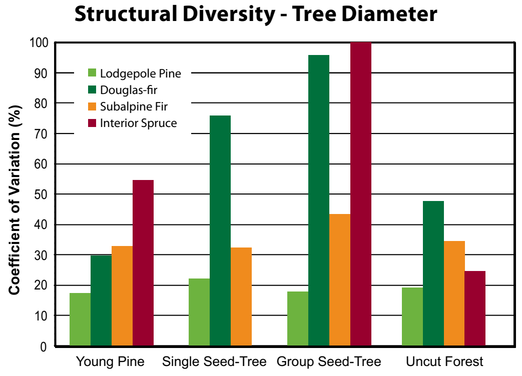
Response in Stand Structure

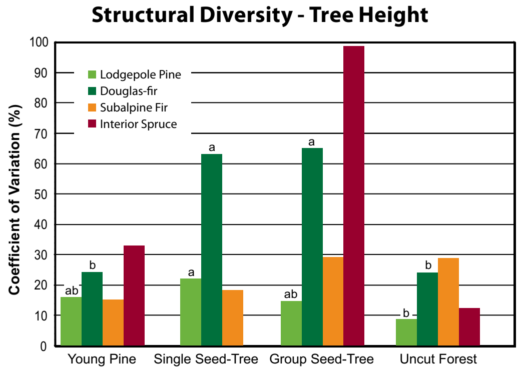
Mean basal area of overstory trees was significantly higher in the uncut forest (71 m^2/ha) than in all three harvested sites (mean of 34 m^2/ha), but mean density was similar ranging from 1401 to 2303 stems/ha. Mean species diversity of total conifers and structural diversity of five height classes were similar among stands.

Parameter	Young Pine	Single Seed-Tree	Group Seed-Tree	Uncut Forest
Overstory Conifers				
Basal Area (m^2/ha)	31^{b}	30^{b}	40^{b}	71^{a}
Density (stems/ha)	1965	2303	1941	1401
Species Diversity	0.81	0.77	0.84	1.36
Understory Conifers				
Total Conifers (stems/ha)	2678	3230	2914	2092
Lodgepole Pine	1973^{ab}	2784^{a}	1878^{b}	380^{c}
Douglas-fir	258	213	762	655
Subalpine Fir	145	143	142	1015
Interior Spruce	302	90	132	42
Species Diversity	1.14	0.81	1.18	1.30
Structural Diversity	1.17	1.42	1.43	1.59

Mean basal area, stand density, and diversity of overstory (> 3 m height) coniferous trees, and abundance, species composition, and diversity of understory (< 3 m height) conifers. Within a row, values followed by different letters are significantly different.

Mean coefficient of variation for diameters and heights of Douglas-fir were greatest in seed-tree stands.





Mean crown volume index of herbs was similar among treatments, but for shrubs was significantly different among stands with the young pine and group seed-tree stands having higher amounts of shrub biomass than the single-seed tree and uncut forest stands. Mean total species richness and species diversity of vascular plants were similar among stands.

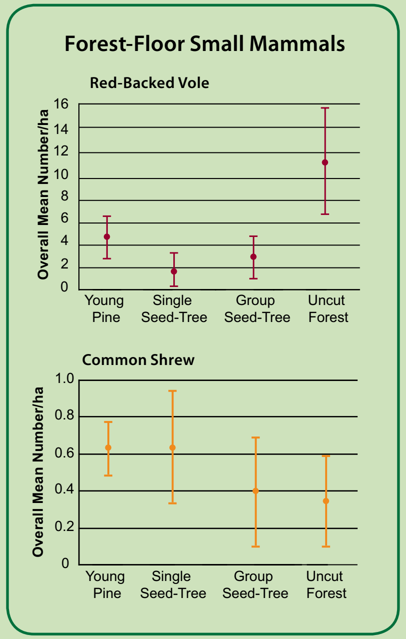
Parameter	Young Pine	Single Seed-Tree	Group Seed-Tree	Uncut Forest
Abundance				
Herbs	6.95	13.01	6.81	8.88
Shrubs	64.75^{a}	9.73^{b}	74.65^{a}	2.08^{b}
Mosses	2.99	0.83	0.90	2.68
Terrestrial Lichens	0.36	0.39	0.33	0.28
Total Species Richness	24.4	20.1	19.8	15.1
Total Species Diversity	1.27	0.88	1.05	1.29

Mean abundance (m^3/0.01 ha) of herbs, shrubs, mosses, and terrestrial lichens and total species richness and total species diversity of vascular plants. Within a row, values followed by different letters are significantly different.

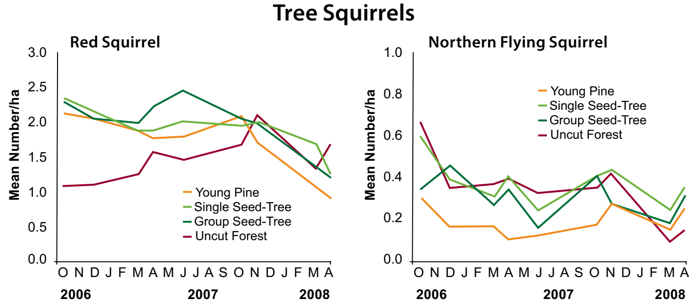
Response of Mammals

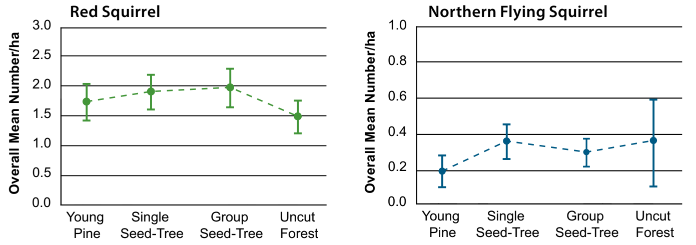
Mean total abundance, species richness, and species diversity of forest-floor small mammals were similar among stands.

Overall mean abundance (± 95% confidence intervals) of the red-backed vole was consistently higher (2.3 to 6.4 times) in the uncut forest than other stands. Overall mean abundance of the common shrew was similar among stands.

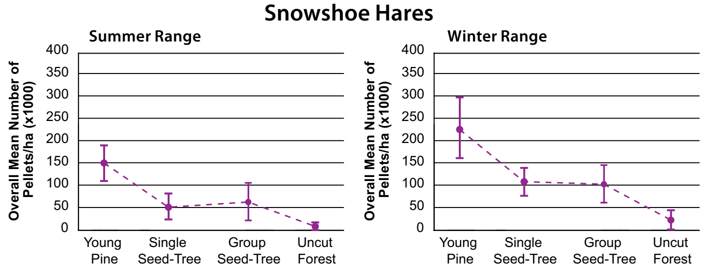


There were higher numbers of red squirrels in the young pine and seed-tree stands than uncut forest stands during fall 2006, with no difference in other seasons. Mean numbers ranged from 1 to 2.5 squirrels per ha. Mean abundance of flying squirrels was similar among stands, ranging from 0.1 to 0.7/ha. Overall mean numbers of red squirrels seemed higher in the seed-tree than uncut forest stands. The pattern of overall mean abundance for flying squirrels was similar among stands, although the young pine seemed to support fewer animals.

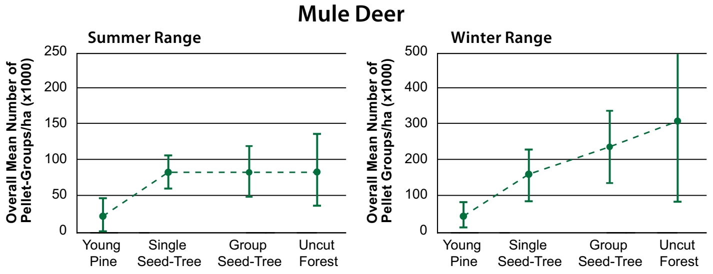




Overall mean relative habitat use by snowshoe hares, based on counts of fecal pellets, was highest in the young pine than seed-tree stands, with all three stand types higher than the uncut stands, in both summer and winter seasons.

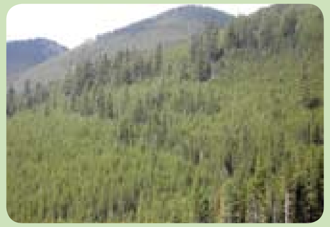


For mule deer, overall mean relative habitat use was higher in seed-tree stands than young pine in both summer and winter. Habitat use was similar in seed-tree stands and uncut forest in both seasons.



Management Implications

Is there life after the beetle?



Natural disturbance regime with overstory Douglas-fir and understory lodgepole pine.

Salvage logging alters: (1) populations of organisms, (2) stand structure, and (3) ecosystem processes and functions. However, what are the long-term consequences of this practice, particularly where green-tree retention occurs at the time of harvest?

This study is the first investigation of the long-term (3 decades) effects of salvage logging of beetle-killed timber, and the subsequent influence of green-tree retention, on biodiversity via inferences from ecological indicators of stand structure and mammals. Retention of green trees can (1) maintain some species and ecological processes from the original forest, (2) provide stand structure in the regenerating forest stand, and (3) provide some connectivity in the commercial forest landscape. These attributes are particularly enhanced by retention of aggregated or group seed-tree patterns of residual trees. This harvesting approach emulates a natural disturbance regime whereby some residual Douglas-fir survive amidst fire- or MPB-regenerated stands of lodgepole pine.

At 30 years after salvage harvesting, we have an indication of how close we are to managing forests sustainably by comparing wildlife habitat and biodiversity, in forests with and without residual fir trees, to those in uncut mature/old-growth forests. Using measurements of stand-level structures, mammals, and inferences to biodiversity, we have examined past disturbance to provide a **vision of forest conditions 3 decades into the future.** An overall summary of response variables indicated that the seed-tree stands had the same or higher value than the uncut forest in 25 of 31 cases. In 6 of 31 cases the uncut forest was higher than the seed-tree stands for mean diameters of the major conifers (Douglas-fir and lodgepole pine), BA of total conifers, and mean abundance of red-backed voles.

Habitat heterogeneity (structural diversity) and animal species diversity, so-called "keystone structures" of a given vegetation complex, seem to have profound implications for biodiversity management. Individual legacy trees provide important habitat for wildlife in managed stands. Several other studies have noted the importance of green-tree retention for maintenance of mycorrhizal fungal networks for tree nutrition and sporocarp food sources for a variety of species such as red-back voles, red squirrels, and flying squirrels.

Flying Squirrel

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Red Squirrel

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