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OLD-GROWTH ATTRIBUTES IN INTENSIVELY MANAGED FORESTS: INTEGRATION OF STAND PRODUCTIVITY WITH MAMMAL DIVERSITY

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ABSTRACT

Management of forested landscapes for biological diversity is a major objective across North America. Perhaps the greatest potential to diversify future forests lies in the vast areas of young second-growth stands which may be managed silviculturally to accelerate ecosystem development. Lodgepole pine (*Pinus contorta*) is the dominant tree species comprising these young forests across the interior lands of the Pacific Northwest. Heavily thinned pine stands appear to develop some old-growth structural attributes such as large diameter trees, crowns, and structurally diverse vegetative communities. Three study areas near Penticton, Kamloops,and Prince George B.C. cover three forest ecological zones and are unique in that thinning treatments were conducted at operational scales relevant to wildlife habitat and population dynamics. Each replicate study area had three stands thinned to densities of 500 (low), 1000 (medium), and 2000 (high) stems/ha in 1988, with an unthinned young pine and old-growth pine stand for comparison. Crown volume index (biomass) of herbs was highest in the thinned stands, but there was no difference among stands for shrubs and trees. Mean species richness and diversity of herbs, shrubs, and trees were similar among stands. Total species diversity of vascular plants was highest in the low- and high-density stands. Mean structural diversity, in terms of richness of height classes (or layers of vegetation), of shrubs and trees tended to be greatest in the thinned stands. Mean abundance of southern red-backed voles (*Clethrionomys gapperi*) was significantly different among stands, with highest numbers of this microtine in old-growth stands. Mean abundance of red squirrels (*Tamiasciurus hudsonicus*) was similar among stands overall, but at Penticton and Kamloops was highest in the old-growth. Northern flying squirrels (*Glaucomys sabrinus*) were at higher numbers in the high-density than unthinned or old-growth stands; and abundance of this sciurid was lowest in the low-density stands.

INTRODUCTION

Managing and conserving forests for biological diversity has become a major objective for forested landscapes in North America and elsewhere (Carey 2000). This objective may be achieved by a combination of practices that provide a variety of forest successional stages (including old-growth), tree species, and stand structures in a mosaic of habitats across a landscape (Hunter 1990). Perhaps the greatest opportunity to diversify forests for the future lies in the vast areas of young second-growth stands which are amenable to silvicultural practices to accelerate ecosystem development (Carey and Curtis 1996; Hayes et al. 1997). As discussed by Hayes et al. (1997), most young seral stands are structurally simple with a single canopy layer, limited number of tree species, relatively little understory vegetation, and variable numbers of standing or fallen dead trees. Young lodgepole pine forests are a classic example of stands with these attributes. A silvicultural practice which could help diversify these simple stands and contribute to both volume and quality increases in wood fiber is the use of precommercial thinning or stand density management (Johnstone 1985).

The abundance and diversity of small mammal communities may provide measures of the integrity of ecosystem function within temperate coniferous forests (Aubry et al. 1991; Carey and Johnson 1995; Carey et al. 1999; Sullivan et al. 2000). These roles include distribution of beneficial mycorrhizal fungi , consumption of invertebrates, aeration of soil and distribution of nutrients, consumption of plants, seeds, lichen, and fungi, and prey for a wide variety of avian, reptilian, and mammalian predators. Thus, small mammals, as a group, may serve as indicators of change in forest structure.

In an investigation of pre-commercially thinned stands at 10 years post-thinning, heavily thinned lodgepole pine stands appear to develop some old-growth structural attributes such as large diameter trees, crowns, and structurally diverse vegetative communities (Sullivan et al. 2001). Forest floor small mammal communities seemed to reflect the compositional and structural diversity of these managed stands (Sullivan et al. 2001). However, what is the response of those mammal species which may act as ecological indicators of old-growth structural features? Examples of these species are the southern red-backed vole (*Clethrionomys gapperi*) on the forest floor and the red squirrel (*Tamiasciurus hudsonicus*), and northern flying squirrel (*Glaucomys sabrinus*) in the forest canopy. Both flying squirrels (Carey 1995) and red-backed voles feed primarily on hypogeous fungi in older stands, and act as prey species for predators such as goshawks and marten. If these mammals can use old-growth structural attributes that develop in young stands, there are clear implications for old-growth dependent wildlife. In addition, stand productivity will be enhanced in terms of fiber production and this relationship may have considerable significance to the harvesting of old-growth forests and annual allowable cut levels.

Thus, this study was designed to determine the population responses of red-backed voles, red squirrels, and flying squirrels to low, medium, and high densities of lodgepole pine compared with unthinned young pine and old-growth pine. Specific hypotheses, phrased as predictions, were that development of old-growth structural attributes in thinned stands: (1) will be enhanced in the heavily than lightly thinned stands; (2) will provide suitable habitat for red-backed voles, red squirrels, and northern flying squirrels as determined by population dynamics; and (3) diversity of forest floor small mammals in heavily thinned stands will be comparable to that in old-growth forest.

STUDY AREAS AND METHODS

Three study areas acted as regional replicates in three different ecological zones: Penticton Creek (Interior Douglas-fir), Kamloops (Montane Spruce), and Prince George (Sub-boreal Spruce). At each area, three stands were thinned to densities of 500 (low), 1000 (medium), and 2000 (high) stems/ha in 1988, with an unthinned young pine and old-growth pine stand for comparison. All installations were at operational scales relevant to population dynamics and habitat measurements. The three small mammal species were live-trapped intensively from May to October 2000, 2001, and 2002 in all stands. Stand structure (herb, shrub, and tree layers) was sampled in all stands. Statistical analysis used ANOVA and comparison of means with 95% confidence intervals.

RESULTS

Understory Vegetation

A total of 53 species of herbs, 27 species of shrubs, and 7 species of trees were sampled in this study. Mean total crown volume index of herbs was significantly different among treatment stands over the 3-year period 2000-2002. The thinned stands had a higher crown volume index of herbs than that of either of the unthinned or old-growth stands. Prominent herb species in these stands included fireweed (*Epilobium angustifolium*), grasses, Arctic lupine (*Lupinus arcticus*), wild strawberry (*Fragaria virginiana*), heart-leaved arnica (*Arnica cordifolia*), white-flowered hawkweed (*Hieracium albiflorum*), showy aster (*Aster conspicuus*), bunchberry (*Cornus canadensis*), and one-sided wintergreen (*Orthilia secunda*).

Mean total crown volume index of mosses was highest in the old-growth stands with no difference among the other four stands. Abundance of terrestrial lichens was similar among stands.

Mean total crown volume index of shrubs was similar among stands over the three years. However, shrub volume (m^3/0.01 ha) appeared lowest in the old-growth stand averaging 11.16. Mean crown volume index ranged from 37.09 to 72.19 m^3/0.01 ha in the four stands of young lodgepole pine. Shrub layers in these stands were composed primarily of Sitka alder (*Alnus sinuata*), twinflower (*Linnaea borealis*), willow (*Salix* spp.), wild rose (*Rosa* sp.), black twinberry (*Lonicera involucrata*), and various species of *Vaccinium*.

Mean total crown volume index of deciduous and coniferous trees was similar among stands in 2000 to 2002. This index of tree biomass followed a predictable trend from a higher volume in the unthinned stands to a lower volume in the low-density stands. Prominent trees, in addition to lodgepole pine, included aspen, interior spruce, Douglas-fir, and subalpine fir.

Species and Structural Diversity

Mean species richness and diversity of herbs, shrubs, and trees were similar among treatment stands. However, total species richness and diversity of vascular plants appeared high in the low-density and high-density stands. Mean structural richness of shrubs was significantly different among stands with the old-growth stands having fewer shrub layers than any of the four young pine stands. Richness of tree layers (both deciduous and coniferous species based on crown volume index) was significantly different among stands with the low-density and old-growth stands having the highest number of tree layers. Although mean total structural diversity of all vegetation was similar among treatment stands for the combined layers of herbs, shrubs, and trees, a pattern of higher structural diversity in the heavily thinned stands was apparent.

Abundance of Forest Floor Small Mammals

A total of 1,116 individual red-backed voles was captured during 2000 to 2002. Overall mean abundance of red-backed voles per ha was similar among stands. However, based on mean abundance and 95% confidence intervals, numbers of red-backed voles were higher in the old-growth than other

stands at Penticton, and higher in the old-growth than low-, medium-density, and unthinned stands at Kamloops. Mean numbers of red-backed voles were similar in all stands at Prince George.

Species Diversity of Forest Floor Small Mammals

Mean total abundance of forest floor small mammals was similar among stands. Mean species richness and diversity also followed this pattern. Species diversity of small mammals appeared highest in the low- and medium-density stands.

Abundance of Arboreal Small Mammals

A total of 587 individual red squirrels was captured during the study. Mean abundance of red squirrels per 9 ha was similar among stands. However, their abundance among treatment stands varied between sites. Red squirrels were at similar numbers among stands in Prince George, while at Penticton there were greater numbers of red squirrels in the old-growth stands than in the other stands. Mean abundance of red squirrels ranged from 0.40 to 23.38 individuals per 9-ha study site.

A total of 187 individual flying squirrels was captured during the study. Mean abundance of flying squirrels per 9 ha was significantly different among stands. Overall, numbers of flying squirrels were lowest in the low-density and unthinned stands and higher in the high-density than medium-density or old-growth stands. This same pattern was evident in the analysis of flying squirrel numbers at each study area. Mean abundance of flying squirrels ranged from 0.27 to 6.00 individuals per 9-ha study site.

DISCUSSION AND MANAGEMENT IMPLICATIONS

A new paradigm in forest management is managing second-growth forests to accelerate the development of structural characteristics associated with late-seral forests. A key uncertainty is whether those wildlife species associated with these structural characteristics will respond positively to their development in thinned, young seral forests. Our results showed that population dynamics of northern

flying squirrels and red squirrels would be enhanced in young thinned stands to levels recorded in old-growth forests. In fact, habitat quality for flying squirrels, based on abundance and population dynamics, in high-density, pre-commercially thinned stands exceeded that in old-growth stands.

Our results also supported the hypothesis that abundance and diversity of forest-floor small mammals and the demographic attributes of red-backed vole populations would be enhanced in young thinned stands to levels recorded in old-growth forest. The late successional forest species, such as the red-backed vole, dominated the small-mammal communities with the early successional generalist species such as the deer mouse (*P. maniculatus)* and northwestern chipmunk (*T. amoenus)* being less prevalent in our treatment stands than recorded in an earlier study (Sullivan et al., 2001). This change in relative species composition likely balanced abundance and diversity attributes in these small mammal communities across the stand types. Our overall study represents a 15-year vision of the results of pre-commercial thinning of young lodgepole pine stands to a range of densities and comparing the relatively long-term responses to those in unthinned and old-growth stands. The three study areas, in three different ecological zones, acted as regional replicates thereby extending our inferences on responses of forest-floor small mammals to lodgepole pine stands across the interior of British Columbia.

The results of our study suggest that abundance and diversity of forest-floor small mammals will be similar among thinned and unthinned stands of young lodgepole pine and old-growth forests at 12- to 14-years after thinning. Inherent in this community similarity will be comparable productivity of red-backed vole populations, at least in terms of reproduction, recruitment, and survival among stands. Abundance of red-backed voles should also be reasonably similar among stands except in years of high numbers. This latter difference will likely decline with time as the heavily thinned stands approach structural and compositional similarity to old-growth forest. Thus, appropriate thinning regimes that provide a variety of stand structures, either within (variable-density thinning) or between stand treatments (conventional thinning) should help manage for plant and animal diversity across forest landscapes. Old-growth attributes may be produced in perhaps decades in intensively managed young stands rather than waiting centuries with the alternative of no management intervention. This relationship has clear

implications for sustainable management and landscape diversity, annual allowable cut levels, and related harvest schedules and plans.

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REFERENCES

Aubry, K. B., M. J. Crites, and S. D. West. 1991. Regional patterns of small mammal abundance and community composition in Oregon and Washington. Pages 285-294 *in* Wildlife and Vegetation of Unmanaged Douglas-Fir Forests. USDA Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-285.

Carey, A. B. 1995. Sciurids in Pacific Northwest managed and old-growth forests. Ecol. Applica. **5**:649-661.

Carey, A. B. 2000. Effects of new forest management strategies on squirrel populations. Ecol. Applica. **10**:248-257.

Carey, A. B., and R. O. Curtis. 1996. Conservation of biodiversity: a useful paradigm for forest ecosystem management. Wildl. Soc. Bull. **24**:610-620.

Carey, A. B., and M. L. Johnson. 1995. Small mammals in managed, naturally young, and old-growth forests. Ecol. Applica. **5**:336-352.

Carey, A. B., J. Kershner, B. Biswell, and L. D. DeToledo. 1999. Ecological scale and forest development: squirrels, dietary fungi, and vascular plants in managed and unmanaged forests. Wildl. Monogr. No. 142.

Hayes, J. P., S. S. Chan, W. H. Emmingham, J. C. Tappeiner, L. D. Kellogg, and J. D. Bailey. 1997. Wildlife response to thinning young forests in the Pacific Northwest. J. For. **95**:28-33.

Hunter, M. L., Jr. 1990. Wildlife, forests, and forestry. Prentice Hall, Englewood Cliffs, N.J.

Johnstone, W. J. 1985. Thinning lodgepole pine. Pages 253-262 *in* D. M. Baumgartner, R. G. Krebill, J. T. Arnott, and G. F. Weetman, editors. Lodgepole pine: the species and its management. Washington State University Cooperative extension, Spokane, Washington, USA, and Vancouver, British Columbia, Canada.

Sullivan, T. P., D. S. Sullivan, and P. M. F. Lindgren. 2000. Small mammals and stand structure in young pine, seed-tree, and old-growth forest, southwest Canada. Ecol. Applica. **10**:1367-1383.

Sullivan, T.P., D.S. Sullivan, and P.M.F. Lindgren. 2001. Stand structure and small mammals in young lodgepole pine forest: 10-year results after thinning. Ecol. Applica. **11**:1151-1173.