available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/biocon

Management strategies to increase stand structural diversity and enhance biodiversity in coastal rainforests of Alaska

*Robert L. Deal**

USDA Forest Service, Pacific Northwest Research Station, 620 SW Main Street, Suite 400, Portland, OR 97205, USA

ARTICLE INFO

Article history:
Received 9 January 2007
Accepted 12 March 2007
Available online 3 May 2007

Keywords:
Biodiversity
Forest management
Old-growth forests
Stand structure
Partial cutting
Red alder
Southeast Alaska
Sitka spruce
Western hemlock

ABSTRACT

Coastal rainforests of southeast Alaska have relatively simple species composition but complex structures with high diversity of tree ages, sizes and forest canopy layers, and an abundant understory plant community. Wildlife and fisheries resources also play an important role in the ecological functioning of forest and aquatic systems. Clearcutting has greatly altered these forest ecosystems with significant decreases in structural diversity of forest stands and greatly reduced wildlife habitat. This paper synthesizes information on management options in older forests that have never been actively managed, and in younger forests to increase diversity of stand structures and their associated effects on biodiversity. Light to moderate levels of partial cutting in old-growth forests can maintain the original diversity of overstory stand structures and understory plant communities. In younger forests that develop after clearcutting, mixed alder-conifer stands provide more heterogeneous structures and significantly higher understory biomass than in pure conifer forests. Research has shown that red alder increases diversity and abundance of understory plants, and provides forage for deer and small mammals. Results also show a clear linkage between alder and improved invertebrate diversity in aquatic systems. A combination of light partial cutting in older forests along with inclusion of red alder in conifer-dominated forests could provide the greatest amount of diversity and maintain the complex stand structures that are an important component of these forest ecosystems.

0. Introduction

Southeast Alaska is a coastal temperate rainforest region with steeply rising coastal mountains and densely forested islands. This region contains large areas of old-growth forests and these forests are renowned for their scenic quality, fish and wildlife-habitat and timber resources. The Tongass National Forest encompasses most of this region with nearly 7 million hectares and is the largest national forest in the United States. The Tongass recently completed a more than decade long management planning effort that identified five focus issues including wildlife viability, fish habitat, alternatives to clearcutting, socio economic considerations and karst and cave resources (TLMP, 1997). Thus, forest managers in the region have been working to develop management strategies that will provide wood resources to the local economy without compromising scenic quality, or aquatic and wildlife habitat. Forest managers are interested in developing silvicultural solutions to enhance options for multiple resource management. Forest practices that could maintain or increase biological diversity are crucial for forest management.

* Tel.: +1 503 808 2015; fax: +1 503 808 2020.
E-mail address: rdeal@fs.fed.us
0006-3207/$ - see front matter
doi:10.1016/j.biocon.2007.03.014

The coastal rain forests of southeast Alaska have simple tree composition but complex forest age and tree size structure. The two predominant tree species, Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), contain more than 90% of the total forest volume (Hutchison, 1967). Abundant annual precipitation (1500–5000 mm) occurs throughout the year along with occasional hurricane force winds. The significance of this climate for the forest is that moisture is generally not a limiting factor for tree regeneration, wildfire is rare, and tree windthrow is common (Harris et al., 1974; Harris, 1989; Deal et al., 1991; Nowacki and Kramer, 1998; Kramer et al., 2001).

Multi-aged stands have been created by high-frequency, small-scale natural disturbances such as windthrow, landslides and endemic tree disease (Deal et al., 1991; Kramer et al., 2001; Hennon and McClellan, 2003). These multi-aged stands contain complex forest structures with many forest canopy layers, abundant understory vegetation, large trees and snags, heartrot cavities in live trees, large woody debris, and other important ecological characteristics of old-growth forests (Franklin et al., 1981; Alaback and Juday, 1989; Franklin and Spies, 1991). These forest structures contain many habitat features important for a variety of terrestrial wildlife. The understory vegetation is also very important as food for herbivores and as cover for ground foraging and nesting birds and small mammals.

Since the 1950s, clearcutting has been the dominant timber management practice in southeast Alaska forests (Harris and Farr, 1974). Forest development following stand-replacing disturbances such as clearcutting is different than typical forest development following natural small-scale disturbances. Post-harvest conifer regeneration is frequently abundant (>10,000 trees ha^{-1}) with the development of a dense new cohort of western hemlock and Sitka spruce trees. The forest canopy closes in 20–30 years followed by a dense, long-lasting stage of stem exclusion (Alaback, 1982; Deal et al., 1991). Canopy closure eliminates most herbs and shrubs (Alaback, 1982) and attempts to reestablish understory plants through thinning dense young-growth stands has led mostly to conifer regeneration (Deal and Farr, 1994) with little success in herbaceous plant colonization (Tappeiner and Alaback, 1989). This stage of stem exclusion is long lasting in southeast Alaska and can persist for 100 years or longer (Alaback, 1984). These dense young-growth stands have relatively uniform tree height and diameter distributions, and notably lack the multi-layered, diverse forest structures and shrub/herb layers found in old-growth or multi-aged stands (Alaback, 1984; Deal, 2001; Hennon and McClellan, 2003).

This long-lasting stage of stem exclusion has significant implications for understory plants and wildlife such as Sitka black-tailed deer that depend on these plants as forage (Wallmo and Schoen, 1980; Schoen et al., 1988; Hanley, 1993). For the first 15–25 years after clearcutting, these young-growth stands provide greater understory plant biomass than old-growth stands (Alaback, 1982); however, snow accumulation makes them much less useful for deer habitat in the winter (Kirchhoff and Schoen, 1987; Schoen and Kirchhoff, 1990). Following canopy closure, the resulting dense stands are recognized as having broadly negative consequences for wildlife habitat (Wallmo and Schoen, 1980; Hanley, 1993; Dellasala et al., 1996; Schoen et al., 1981, 1988; Thedinga et al., 1989). Subsequently, there is increasing interest in developing forest management practices that maintain or enhance biodiversity and assure long-term sustainability of forest products, wildlife, and aquatic resources.

Stand development of partially cut stands appears different than young-growth stands that develop after clearcutting. In a study that assessed several stands that were partially cut between 1900 and 1950, results indicated that stand structural diversity and plant diversity and abundance were much greater in these partially cut stands than in young-growth stands developing after clearcutting (Deal, 2001; Deal and Tappeiner, 2002). Recent forest management plans have prescribed forest practices using a variety of silvicultural systems including even-aged, two-aged, and uneven-aged management (TLMP, 1997) even though there is little information available on their silvicultural or ecological effects. A large scale alternatives to clearcutting (ATC) study has been established in the region (McClellan et al., 2000) to assess the long-term effects of experimentally manipulated forests but it will be many years before results are available.

Another management option to potentially mitigate some of the problems with clearcutting involves the role of red alder in these predominantly conifer forests. Recent studies of mixed alder-conifer stands in southeast Alaska indicate different successional pathways following clearcutting than the previously described development patterns of pure conifer stands. These mixed alder-conifer stands generally appear to have lower tree stocking and stand density than pure conifer stands of a similar age (40–50 years), with more open forest canopies and more heterogeneous stand structures (Deal, 1997; Deal et al., 2004). Other studies in mixed alder-conifer stands have reported increases in plant species richness and highly productive understory vegetation with biomass similar to that of old-growth stands of the region (Hanley and Hoel, 1996; Hanley and Barnard, 1998; Hanley et al., 2006). Habitat quality for small mammals in even-aged alder-conifer stands may be equal to that of old-growth forests (Hanley, 1996; Hanley and Barnard, 1999a,b). Red alder may convey additional benefits in riparian forests. Riparian forests with some red alder appear to produce more prey biomass and food for fishes than conifer riparian forests (Wipfli, 1997; Piccolo and Wipfli, 2002). If similar processes occur in upland forests, the presence of red alder may increase invertebrate production, providing more food for animals such as birds, small mammals, and fish, in turn affecting their abundance.

There is increasing interest in developing forest management practices that maintain or enhance biodiversity and assure long-term sustainability of forest products, wildlife, and other forest resources. The overall objective of this paper is to summarize and synthesize current information on management options in older forests that have never been actively managed, and also to assess management strategies for young-growth forests that have developed following clearcutting. I will synthesize results from two large recent studies in the region, and using these case studies as examples, discuss some potential forest management strategies for increasing stand structural diversity in both older and younger forests. My specific objectives are to assess the effects of overstory stand structure on forest plant communities in managed old-