Seeking a balance between forestry and biodiversity – the role of variable retention silviculture

Insights from western USA and Canada
Seeking a balance between forestry and biodiversity – the role of variable retention silviculture

Insights from western USA and Canada

Prepared for
Forest & Wood Products Australia

by
S. Baker

This report has not been peer reviewed
Publication:
Seeking a balance between forestry and biodiversity – the role of variable retention silviculture

Insights from western USA and Canada

Project No: PGD167-0910

© 2011 Forest & Wood Products Australia Limited. All rights reserved.

Forest & Wood Products Australia Limited (FWPA) makes no warranties or assurances with respect to this publication including merchantability, fitness for purpose or otherwise. FWPA and all persons associated with it exclude all liability (including liability for negligence) in relation to any opinion, advice or information contained in this publication or for any consequences arising from the use of such opinion, advice or information.

This work is copyright and protected under the Copyright Act 1968 (Cth). All material except the FWPA logo may be reproduced in whole or in part, provided that it is not sold or used for commercial benefit and its source (Forest & Wood Products Australia Limited) is acknowledged. Reproduction or copying for other purposes, which is strictly reserved only for the owner or licensee of copyright under the Copyright Act, is prohibited without the prior written consent of Forest & Wood Products Australia Limited.

This work is supported by funding provided to FWPA by the Department of Agriculture, Fisheries and Forestry (DAFF).

ISBN: 978-1-921763-24-3

Principal Researcher:
Susan C. Baker

World Forest Institute
4033 SW Canyon Road
Portland, Oregon USA 97221

Forestry Tasmania
GPO Box 207
Hobart, Tasmania Australia 7001

School of Plant Science
University of Tasmania
Private Bag 55
Hobart, Tasmania Australia 7000

Final report received by FWPA in June, 2011 (This report has not been peer reviewed)

Forest & Wood Products Australia Limited
Level 4, 10-16 Queen St, Melbourne, Victoria, 3000
T +61 3 9927 3200  F +61 3 9927 3288
E info@fwpa.com.au
W www.fwpa.com.au
Executive Summary

Variable retention (VR) is a harvesting system that is increasingly being used worldwide to achieve improved biodiversity and social outcomes compared to clearcutting and other traditional silvicultural systems. VR was initially developed in the Pacific Northwest (PNW) of USA and Canada, where it is applied in a broad variety of forest types, ages and land tenures. VR has recently been implemented in wet old-growth forests in Tasmania, and there is scope for broader implementation in both Tasmania and mainland Australia. Hence, insights from the PNW about operational experience, research, adaptive management, and efforts to improve relationships between timber industry and environmental groups are of broad relevance to forest management in Australia.

This report covers three main topics. Chapter 2 presents the results from surveys of twelve organizations that are currently implementing VR across western USA and Canada. These surveys explored motivations for using VR, variation in implementation, adaptive management and monitoring, and perceived success of the system. Chapter 3 of the report discusses research and formalized adaptive management programs relating to improving conservation outcomes from silvicultural practices. This includes descriptions of some of the large silvicultural trials investigating biodiversity and silvicultural outcomes of VR and clearcutting. Two emerging areas of research are discussed: the importance of early-seral forests for biodiversity, and the role of ‘forest influence’ in facilitating recolonisation of harvested areas by biodiversity from nearby mature forest. Chapter 4 provides examples of successful collaborations that have settled long-term conflicts between timber industry and environmental groups, resulting in improved conservation outcomes and continued timber production.

The development and implementation of VR in the PNW has been an excellent example of adaptive management. Although the desire for improved social acceptability was often a primary driver for using VR along with the desire for improved ecological outcomes, organizations clearly embraced the ecological objectives of the system. There was a lot of variability in VR implementation across the region. The system was used in a wide variety of forest types, including old-growth, second and third-growth forests; and a variety of land tenures including those managed by industrial companies on both public and private lands, State governments, small private ownerships and First Nations people.

Most organizations used one or more of the three main harvesting patterns: aggregated retention where uncut forest is left in groups, dispersed retention where scattered trees are retained, and mixed retention which combines the previous two approaches at the one site. Aggregated retention and mixed retention were most widely used. This related to a combination of operational, social and ecological factors. Research trials are showing that aggregates are able to maintain a broader variety of species than are dispersed trees, although some species are advantaged by the more uniform distribution of trees with dispersed retention. Windthrow monitoring has shown that with the exception of some wind-firm species, windthrow is reduced with aggregated retention. Large aggregates are less prone to windthrow than small ones. Organizations using VR were adapting their practices in response to operational experience and the results of research and monitoring. Those organizations with direct links to research trials appeared to be making the most informed changes. Good training programs, strong leadership and organizational cultures supportive of ecologically sustainable forestry practices were important to success. Using VR had generally achieved the social and ecological objectives, and organizations were planning on continued implementation.
However there was uncertainty over long-term ecological outcomes, emphasising the need for long-term biodiversity research.
There are a large number of long-term silvicultural trials in western USA and Canada that compare silvicultural and biodiversity outcomes of a range of harvesting approaches. Many of these include variable retention treatments (e.g. DEMO, MASS, VRAM, EMEND, Roberts Creek, STEMS) and results are already influencing operational practices. These trials demonstrate the ability of VR to maintain biodiversity, structures and habitats from the previous stand within harvesting areas. Comparisons of different retention-levels, patterns and locations of retention will be important for future refinement of VR to maximise the biodiversity benefits. PNW scientists are increasingly recognising the importance of healthy early-seral habitats for biodiversity. Since intensive forest management practices may not provide adequate early-seral habitat conditions for many species, there are important consequences for biodiversity conservation. Forest managers should consider the ecological impacts of site preparation practices, and much more research is required. This subject is relevant to all silvicultural methods including variable retention. Another area requiring more research is ‘forest influence’, the concept that proximity to mature forest facilitates recolonisation of harvested areas by mature-forest biodiversity. There are forest influence targets for VR implementation in both Tasmania and Vancouver Island, but the concept is poorly understood outside these regions. The strength and distance of forest influence varies from species to species, although there is currently very little research showing exactly what scale is relevant, and how this might vary depending on forest type or other factors. Better understanding of forest influence will assist forest managers in designing harvest layouts to balance trade-offs between the retention and influence objectives of variable retention.

Native forest harvesting is subject to a large amount of public scrutiny, and environmentalists have the capacity to shut down the forest industry if these conflicts are not resolved. Canada appears particularly successful at brokering agreements between the timber industry and environmental groups. A variety of approaches have been used successfully, and may provide guidance for resolving similar conflicts in Australia and elsewhere.

Operational experience and research in western USA and Canada have proven that variable retention is a useful approach for balancing the social, economic and ecological objectives of timber harvesting. These experiences support wider implementation of VR in North America, Australia and elsewhere.
Contents

1. Introduction ............................................................................................................................ 1
   1.1 Ecologically sustainable forest management ................................................................. 1
   1.2 Variable retention .......................................................................................................... 3
   1.3 Adaptive management and research ............................................................................ 5
   1.4 Scope and aim of this report ........................................................................................ 5
2 An overview of variable retention practices in the PNW: objectives, implementation, and adaptive management ................................................................. 6
   2.1 Introduction .................................................................................................................. 6
   2.1.1 Hypotheses .......................................................................................................... 6
   2.2 Methods ..................................................................................................................... 7
   2.3 Results ....................................................................................................................... 8
   2.3.1 Drivers for using VR .......................................................................................... 8
   2.3.2 Use of VR compared to other silvicultural systems .............................................. 10
   2.3.3 VR Implementation ......................................................................................... 11
   2.3.4 Adaptive management ....................................................................................... 13
   2.3.5 Success, challenges and uncertainty .................................................................. 14
   2.3.6 Future changes ................................................................................................. 15
   2.4 Discussion ............................................................................................................... 16
   2.4.1 Study findings compared to initial hypotheses .................................................... 16
   2.4.2 General discussion ............................................................................................ 20
   2.5 Conclusions .............................................................................................................. 21
   2.6 Lessons for Australia ............................................................................................... 21
3. Improving conservation outcomes through silvicultural research and adaptive management ............................................................................................................. 23
   3.1 Adaptive management in the PNW .......................................................................... 23
   3.2 Researching alternative silvicultural systems ........................................................... 25
   3.2.1 DEMO ............................................................................................................. 25
   3.2.2 STUDS .......................................................................................................... 27
   3.2.3 MASS ......................................................................................................... 28
   3.2.4 STEMS ....................................................................................................... 29
   3.2.5 VRAM ......................................................................................................... 29
   3.2.6 Roberts Creek .............................................................................................. 30
   3.2.7 EMEND .................................................................................................... 31
   3.3 Effects of forest influence on biodiversity ................................................................. 32
   3.4 Importance of early-seral forests for biodiversity ..................................................... 38
   3.5 Lessons for Australia ............................................................................................... 40
4 Resolving conflicts between the timber industry and environmental groups ................. 42
   4.1 The NW Forest Plan ............................................................................................... 42
   4.2 The Glaze Forest Restoration Project ....................................................................... 43
   4.3 Examples of resolving conflicts in Canada ............................................................... 44
   4.3.1 BC Coastal Forest Project ................................................................................. 44
   4.3.2 Canadian Boreal Forest Agreement .................................................................. 45
   4.3.3 Other Canadian agreements ............................................................................. 46
   4.4 Use of variable retention silviculture ...................................................................... 46
   4.5 Lessons for Australia ............................................................................................... 47
5 Conclusions .......................................................................................................................... 50
Acknowledgements ............................................................................................................... 51
Literature References ........................................................................................................... 53
Appendix 1. Interview Questions ........................................................................................ 58
1. Introduction

1.1 Ecologically sustainable forest management

Variable retention (VR) was initially developed in the Pacific Northwest of USA and Canada. It was developed as an alternative to clearcutting, that aims to retain structural elements at the time of harvesting, thereby allowing working forests to be managed for multiple (economic, social and ecological) objectives. The VR silvicultural system was developed in recognition that stand-level approaches are required to supplement networks of large and smaller reserves in order to ensure persistence of forest biodiversity. Variable retention has often been used in response to public pressure to stop clearcutting, based on both its potential to provide improved biodiversity outcomes as well as improved visual and social-acceptability outcomes.

The importance of ‘managing the matrix’ (Lindenmayer and Franklin, 2002) is being increasingly well understood. For example, in Tasmania, 39% of forest is in the large permanent reserve network; nevertheless these reserves are inadequate to protect all species, since there are many whose habitat is poorly represented (Munks et al., 2004; Munks et al., 2009). Although managed forests tend to contain some areas that will not be harvested (e.g. because of requirements under forest practices or threatened species legislation, or because they are unsuitable to harvest), formal and informal reserves are generally not considered adequate on their own to maintain functional populations of species that require mature forest conditions. For example, narrow riparian buffers are a common reserve type within managed forests, yet these may be edge-effected (Baker et al., 2009a), not provide ‘upslope’ habitat conditions for those species that are disadvantaged in riparian areas (Baker et al., 2006; MacDonald et al., 2002), and may not be distributed in a spatial arrangement to make the overall landscape suitable for occupation, depending on the home-range requirements and dispersal patterns of particular species’ (Lindenmayer and Franklin, 2002). According to Franklin et al. (1997), most organisms probably do not respond to a corridor-based conservation strategy; rather, conditions in the matrix or dominant patch type will be most important in controlling landscape connectivity for biodiversity. Effective conservation of forest biodiversity requires a combination of strategies at a range of spatial scales, which in practice requires planning for conservation at the landscape-level, the regional-level, the stand-level, and the individual species level (e.g. for threatened species) (Hunter, 1999; Lindenmayer and Franklin, 2002). In the PNW, the need for integrated conservation planning across land ownerships can be illustrated with the forest land tenure map for Oregon (Figure 1). Forest management practices are vastly different amongst land tenures, meaning that there are large areas of very intensively managed industrial forests in some parts of the landscape and vast areas of National forest in other areas that receive only minimal management intervention.
Ecologically sustainable forest management therefore requires that the working forest ‘matrix’ should be managed for conservation of biodiversity as well as for timber production. This is not only important for those listed threatened species which receive detailed planning and attention, but for *all* native forest inhabiting species. After all, forest managers do not wish to be responsible for additions to the threatened species list! Temperate native forests are incredibly biodiverse ecosystems, providing habitat for thousands of species of birds, mammals, vascular plants, bryophytes, lichens, fungi, invertebrates and bacteria. Many of these species have specialized habitat requirements. For species which require conditions provided by mature or old-growth structural conditions, traditional harvesting with repeated clearcutting rotations may mean that the forest never regains a condition suitable for many species. Forest management is already considered to be a potentially threatening process for several of Tasmania’s listed threatened species (http://www.dpiw.tas.gov.au/inter.nsf/WebPages/SJON-58E2VD?open). It is therefore of critical importance to ensure that Australia and the PNW, where forest management is relatively recent, do not follow in the footsteps of countries where long histories of intensive forest management have resulted in either the extinction or threat of extinction of large numbers of forest species (Berg et al., 1994; Eriksson and Hammer, 2006). For example, in Sweden, threatened species are frequently associated with old-growth forest structures and conditions; with old living trees, snags and logs being particularly important for vertebrates, invertebrates and non-vascular plants; while the age, density and abiotic conditions associated with old forest were especially important for vascular plants (Berg et al., 1994).
1.2 Variable retention

Modern efforts towards ecologically sustainable forest management often focus on natural disturbance dynamics for guidance. Forests have evolved under natural disturbances such as wildfire and wind, and forest biodiversity has therefore evolved to be adapted to conditions that fall within the natural range of variability. Certain characteristics of natural disturbance regimes, and forest harvesting, will determine whether an area provides suitable habitat for forest species: the intensity and severity of disturbance, the spatial and temporal scales of disturbance, and the specific habitat conditions that result from these (Baker et al., 2004; Lindenmayer and McCarthy, 2002; Turner et al., 1998).

Understanding natural disturbance regimes (e.g. wildfire, wind) that result in regeneration of forest ecosystems are important to guiding implementation of variable retention. The harvesting system was developed in recognition that the structural legacies that remain at the stand-scale following wildfire and other natural disturbances were being lost following clearcutting, with negative impacts on biodiversity (Franklin et al., 1997). Investigations of the effects of natural disturbances, and ecosystem recovery following them, highlighted the importance of structural and biological legacies. Unlike clearcutting, natural fires and wind events leave behind live and dead standing trees, intact undisturbed patches at the stand-scale, and large volumes of coarse woody debris (Franklin et al., 2002; Lindenmayer and McCarthy, 2002; Turner et al., 2009). Naturally regenerated forests are therefore much more structurally complex than forests regenerated following clearcutting, and this complexity in structural conditions and greater variety of habitats have been demonstrated to be critical to ecosystem functioning and maintenance of biodiversity (Franklin et al., 1997). Research in these natural landscapes, including following the Mt. St. Helens Volcano eruption in 1980, highlighted the importance of these biological legacies (or ‘lifeboats’) in facilitating ecosystem recovery (Franklin et al., 2002), with rapid re-establishment of ecosystems with high levels of structural, functional and biological diversity (Franklin et al., 1997).

Variable retention is a flexible approach to forest harvesting that may retain individual trees, snags, logs, or small patches of forest within harvested areas, usually for at least the full rotation (Franklin et al., 1997). It is therefore used to either maintain or restore environmental values associated with structurally complex forests. Franklin et al. (1997) propose three main purposes for the VR harvest approach.

1. **Lifeboating (refugia and inocula):** to provide refugia for ‘lifeboating’ species, structural elements and processes over the regeneration phase: refugia provide inocula for re-establishment of species into the harvested area once conditions become suitable.
2. **Structural enrichment of established forest stands:** to enrich new forest stands with structural features so that conditions suitable for late-successional species are re-established earlier in the rotation: forests with greater structural diversity provide more habitat niches and thus greater carrying capacity for biodiversity, as well as possibly ameliorating local microclimatic conditions.
3. **Enhancing connectivity:** structural retention moderates habitat conditions and provides ‘stepping-stones’ to facilitate movement of organisms within the managed forest landscape.

What is and is not classified as variable retention can be hard to define, since implementation varies greatly. Variation in implementation across western USA and Canada will be discussed in detail in Chapter 2 of this report. However, retention levels with VR are usually beyond the minimum requirements for retained green trees, snags and coarse woody debris under regional forest practices legislation. The main spatial patterns for VR implementation are dispersed...
retention, aggregated retention, or a mixture of the two on the one site (mixed retention). With aggregated (or group) retention, patches of forest are retained undisturbed, whilst with dispersed retention individual trees (usually dominant and codominants) are evenly distributed over the site. There are relative advantages and disadvantages to each approach, hence mixed retention is increasingly being used to gain the ecological benefits of both clumped and dispersed trees. By retaining patches of forest intact, aggregates have the advantage of retaining not only the overstorey trees, but also the multiple canopy levels of vegetation and undisturbed soil and leaf-litter conditions. In this way, they are generally able to retain a broader variety of species on-site than scattered overstorey trees with dispersed retention. The advantage of dispersed retention lies in the closer distribution of trees. These can act as refugia or hosts for many organisms (e.g cavity-using species, epiphytic plants, fungi including mycorrhizae, invertebrates), and will eventually also provide snags and coarse woody debris. Snags can be retained at the time of harvest, but more easily and safely with aggregated rather than dispersed retention.

One concept associated with VR silviculture, ‘forest influence’ (Keenan and Kimmins, 1993; Mitchell and Beese, 2002), relates to the ‘lifeboating’ objective (see above). Thus structural retention is not only intended to retain species and structures within the harvested stands, but this retention is further expected to influence species composition in harvested areas. According to Franklin et al. (1997), “Use of structural retention to sustain biological diversity assumes that refugia will provide the inocula for re-establishing species in the harvested area once the new forest stand and other suitable habitat conditions are re-established”. In some regions (e.g. Tasmania, Vancouver Island) forest influence rules distinguish variable retention from clearcutting. For example the majority of the harvested area (Tasmania, Forestry Tasmania, 2009) or stand (Vancouver Is., Mitchell and Beese, 2002) may be required to be within one co-dominant tree height of long-term retention. These rules are based on ecological theory as well as being a practical approach to distinguishing variable retention from clearcutting, based on Keenan and Kimmons’s (1993) definition. This definition is based on the understanding that adjacent unharvested forest maintains a “shadow of forest influence some distance into the cutover”. The extent of this forest influence will vary amongst species and processes. While the concept of forest influence is very important to implementation of variable retention silviculture, its ecological effects on different types of biodiversity are still poorly understood.

Variable retention has been applied operationally in the USA from as early as the late 1980s, and has received widespread use on some land tenures in the USA and Canada since the 1990s. This operational implementation has been backed up by several large-scale silvicultural experiments (see Chapter 3.2) that investigated alternative harvesting systems, in relation to both silvicultural and biodiversity assessment criteria. By contrast, the first research sites at the Warra Silvicultural Systems Trial (SST, Hickey et al., 2006) looking at aggregated retention (the form of variable retention now applied operationally in Tasmania) were established in 2004, and operational implementation started around the same time. Another silvicultural experiment (Lindenmayer, 2009) was established in Victoria, Australia between 2005 and 2009. Variable retention is not currently used operationally in Australia outside of Tasmania. However, similarities in forest types and natural disturbance regimes mean that variable retention has potential to be used much more broadly in Australia, in particular in Victoria’s wet forest ecosystems.
1.3 Adaptive management and research

Adaptive management is a process of management, planning and decision-making in the face of uncertainty, to acquire and use knowledge as this is created, learn from successes and mistakes, and modify practices to better achieve management goals (Lindenmayer and Franklin, 2002; Stankey et al., 2005; Walters and Holling, 1990). Although adaptive management can work as an informal ‘trial-and-error’ approach, a more formalized approach increases the likelihood that new knowledge will be generated and incorporated into management practices (Lindenmayer and Franklin, 2002).

Development of VR in both the PNW and in Tasmania has been an example of adaptive management. This adaptation has in part led to the variability in implementation amongst forest growers. For example, in Tasmania, research at the Warra SST found that dispersed retention, which is commonly practiced in the PNW, was unsafe in old-growth wet eucalypt forests. Further adaptation occurred to overcome difficulties with regeneration burning (Forestry Tasmania, 2009).

Variable retention approaches have been trialed in a number of long-term silvicultural experiments in the USA and Canada, including the Variable-Retention Adaptive Management (VRAM) experiments of MacMillan Bloedel and its successors in coastal British Columbia (Beese et al., 2005), the Montane Alternative Silvicultural Systems (MASS) trial in Vancouver Island (Beese and Arnott, 1999), the replicated Demonstration of Ecosystem Management Options (DEMO) study in Oregon and Washington (Aubry et al., 2004; Aubry et al., 2009) and the Ecosystem Management Emulating Natural Disturbance (EMEND) project in north-western Alberta (Work et al., 2004). These trials usually compare clearcutting to several alternatives, and have guided forest managers implementing variable retention on topics including biodiversity, social acceptability and tree regeneration.

1.4 Scope and aim of this report

Variable retention may take many forms and be used for a variety of objectives. This has led to wide variation in the details of how it is practiced. This report will highlight how and why variable retention varies in its implementation, thereby providing a better understanding of scope for using this silvicultural system. Longer and more widespread use of VR in the PNW means that this region provides a great depth of experience that is relevant to forest managers in Australia. The report will describe some of the PNW biodiversity research that is relevant to ecologically sustainable forest management, including research directly focused on VR. The report will also discuss the importance of managing for early-seral biodiversity, since there is emerging work suggesting that intensively managed forests may not actually provide adequate early-seral forest habitats for some species. Development of variable retention is an excellent example of adaptive management, which may provide guidance for using adaptive management in other areas of forest management. The report will therefore discuss some of the different adaptive management approaches taken by forest growers in western USA and Canada, with varying degrees of success. Western USA and Canadian forests have also been the subject of controversy between timber industry and environmental groups, analogous to current disputes and negotiations over continued harvesting of publicly owned native forests in Australia. Canada appears to have been particularly successful at resolving such conflicts in a way that has allowed continued native forest harvesting. Their approaches may therefore be relevant to ongoing negotiations about the future of forest management in Australia.
2 An overview of variable retention practices in the PNW: objectives, implementation, and adaptive management

2.1 Introduction

Although variable retention silviculture is used by many forest growers across western USA and Canada, there is wide variability in practices. Semi-structured surveys of twelve PNW growers were conducted with the aim of understanding the motivations for using VR, variability in operational aspects, and the role and success of adaptive management in guiding application. Variability in these aspects amongst forest management organizations has important implications for biodiversity conservation. Although improved ecological outcomes are likely to be an important motivation for using VR, many practical and social aspects of an organization’s particular approach could impact on ecological outcomes.

Synthesizing information about VR practices in the US and Canada should provide insights about how to successfully integrate silvicultural and conservation objectives, and how adaptive management has shaped VR practices. Although some information about individual organization’s VR practices can be found on the internet, or, rarely, in other publications (e.g. Beese et al., 2003), these information sources do not facilitate easy comparison of specific aspects of VR implementation. One previous paper by Work et al. (2003) compared various western Canadian companies’ approaches to timber production practices as they pertain to conservation of biodiversity. Although this paper addresses use of variable retention/green tree retention, the focus and scope differs from the survey presented here, making the two studies complementary. The broader regional scope and range of land tenure classes of the present study is expected to portray greater variation in practices. These findings should provide useful guidance for growers considering using VR methods or modifying their current practices. The survey questions relate to the following twelve hypotheses.

2.1.1 Hypotheses

Drivers behind using VR

1. Use of VR silviculture in place of clearcutting will relate to ethical, aesthetic and social drivers defined within organizations, such as response to public pressure or the desire for improved ecological sustainability rather than external constraints or incentives such as legislative and/or certification requirements. This will result in flexibility in implementation.

2. Loss of timber revenue will be the primary constraint in not using VR more broadly in place of clearcutting.

3. VR silviculture will be used more often in mature and old-growth forests than in regrowth forests. This will relate to a higher priority given to maintaining conservation values provided by older forests rather than restoration of landscapes that are depauperate in old-growth.

4. Risk and uncertainty about perceived advantages and disadvantages of VR silviculture will be a factor influencing decisions about its implementation.

VR Implementation

5. VR practices, although variable, will generally meet the definition of ‘The Retention System’ in Mitchell and Beese (2002). Rules about retention and influence will be quite
variable amongst forest growers. Retention rules will be the primary guidance for site layouts rather than an influence threshold.

6. Differences in VR implementation amongst growers, and choice of VR system (aggregated vs. dispersed vs. mixed retention), will relate more to operational and silvicultural constraints (e.g. getting successful regeneration, minimizing windthrow) than to characteristics of the forest such as disturbance regime, land tenure, perceptions about outcomes for biodiversity, or other factors.

7. VR will be used as one of several silvicultural systems applied by an individual grower. It will be used in forest types that would conventionally have been clearcut, rather than subject to partial cutting systems.

Adaptive Management

8. Organizations with an active adaptive management process for VR will have modified practices to a greater degree than other growers.

9. Government organizations will be more likely to invest in research and monitoring programs to ensure that VR practices are meeting ecological objectives than private or tribal growers.

10. Changes to VR implementation will relate more to overcoming economic or operational constraints than to improving outcomes for biodiversity.

11. Formalized objectives relating to desired ecological outcomes will facilitate achieving perceived benefits for biodiversity.

12. Most organizations that have used VR will, on balance, consider it a successful silvicultural system for achieving multiple objectives (e.g. timber production with improved ecological outcomes), and will plan for ongoing implementation.

2.2 Methods

Semi-structured surveys were conducted with representatives from twelve organizations using VR. These were interviews, based on forty-eight questions relating to the above hypotheses (Appendix 1). Interviews were conducted with a single representative (ten organizations) or two representatives (two organizations), and hence the study findings may be biased somewhat by the knowledge and interests of the people interviewed. Organizations surveyed included six Canadian companies, of which two were in Alberta and four were in British Columbia. One of these was a First Nations company. In USA, the six interviews included one Californian company, three Oregon growers, and two from Washington. The US interviews included state forest management agencies, small private landowners and an industrial company. Public and private land tenures were represented in both USA and Canada. Hence the surveys included the range of land tenure sizes, ownership classes and forest practices legislation across the region.

Organizations using VR were identified based on a combination of ‘snowball sampling’ – i.e. word of mouth, and responses to requests for information. I telephoned any organizations that I thought may use VR, and also asked them if they knew of other organizations that might do so. In addition I contacted the Small Woodlands Association and the Society for American Foresters (SAF). Requests for information about organizations using VR were included in SAF’s ‘E-Forester’ and ‘Western Forester’ newsletters. Although not all organizations using
VR were included, the majority of those operating in western USA and Canada were included. All organizations currently implementing VR that I approached agreed to be interviewed. Ten of twelve interviews were conducted in person, and two over the telephone. I also arranged field visits with eight of these organizations to view their practices on the ground.

Because interpretation of what constitutes variable retention was found to be variable, as a criterion for whom to include in the study, I only interviewed forest managers that considered that they were doing VR. Other similar harvesting approaches (e.g. clearcutting with retention, variable density thinning, shelterwood) were not included unless the organization felt that these methods fell within the VR umbrella. Likewise, two organizations whose silvicultural approach would generally be considered to be VR were not surveyed because they did not identify themselves as using VR. Taking this approach as to who to survey means that the study can objectively document and describe the range of practices that are interpreted to constitute variable retention, rather than being biased by my pre-conceived perceptions about the silvicultural system. It became apparent that while the variable retention approach was generally well known in western Canada, many western USA forestry professionals were not familiar with it. VR appeared not to be in current practice in interior BC, as companies there were salvaging mountain pine beetle impacted areas. Hence interior BC was not represented in the surveys. VR was rarely if ever used by large industrial companies, TIMOs or REITs in Oregon and Washington.

Interviews were conducted between June and November 2010. They took between one and two hours (average 1.5 hours) each. All interviews were voice recorded and transcribed in full. Relevant information relating to each survey question from the twelve organizations were collated into a single Microsoft Word file, and then results were further summarized for each question using Microsoft Excel.

The survey responses will be somewhat biased by the interest and expertise of the individual/s within each organization that I interviewed, and therefore may not necessarily be a perfect representation of that organization’s practices. In most cases, numerical statistics were estimates rather than precise actual figures, and may be inaccurate. These are intended to illustrate broad similarities and differences in implementation. For calculating statistics, if I was given a range, I used the midpoint of the range for calculations. In a few instances estimates could not be provided. In many cases results were summarized based on factors that were mentioned during interviews. Just because a factor was not mentioned in relation to a specific question does not necessarily imply that it is not relevant for that organization; hence results should be interpreted as being indicative rather than all-inclusive. In some cases the responses to a particular question were also relevant to other questions, and were used accordingly. Numbers in brackets in the Results section indicate the number of organizations (out of a total of twelve) that mentioned each factor in the interview.

2.3 Results

2.3.1 Drivers for using VR

- Initial drivers included improved social acceptability (5 organizations), improved environmental outcomes (6), government policy (2) and certification (2). Motivations internal to organizations (social acceptability and ecological outcomes) were the primary drivers for seven organizations, external drivers (government or certification) were primary drivers for three organizations, and both internal and external drivers were important in two cases.
• Objectives were generally related to the environment and biodiversity (11 organizations), although social factors were important in seven cases. Restoration was a goal in three cases.

• Ten of twelve organizations were certified, often with more than one scheme. Certification schemes included Forest Stewardship Council (FSC) (9), ISO14001 (3), Canadian Standards Association (CSA) (1), Sustainable Forest Initiative (SFI) (3), and American Tree Farm System (1). In four cases FSC certification was only for a certain area of a larger land base.

• Four organizations considered that certification encouraged use of VR silviculture compared to other harvesting systems while six organizations felt that it did not play a major role. Certification had resulted in changes to management for all but two of the certified organizations, although these changes did not usually relate specifically to VR silviculture. However, one US small private grower embarked on VR silviculture at the request of FSC. However, this organization’s VR approach was unique, and did not follow the general pattern of implementation by other organizations, perhaps because they were being pushed towards practices they were uncomfortable with. Changes to management that arose from certification included: more checks, balances and auditing, that potentially resulted in changes to on-ground practices (6 organizations), better organization, record keeping and reporting (4), improved ecological and/or harvesting outcomes (4), improved monitoring (3), improved stakeholder engagement (2), encouragement for adaptive management (1), and encouragement to minimize herbicide use (1).

• A number of incentives and constraints influenced choices by organizations regarding use of VR, although they generally varied widely. Incentives included requirements for retention (5 organizations), either by government, certification or self-imposed schemes. The requirement to manage forests for ‘public good’ was mentioned by both US state agencies interviewed. Other incentives, each mentioned once, were Government compensation for additional costs, a premium price on timber sales in recognition of well managed forests, and removal of a government ‘green-up’ rule for adjacent stands. For constraints, government or conservation easement limitations on opening sizes in relation to retention levels was mentioned twice. All other constraints were mentioned only once: the government looks unfavourably upon unsalvaged windthrow, but it is uneconomic to salvage it; reduced timber supply; government stocking standards that were developed for clearcutting and are difficult to achieve with VR; increased reporting and other requirements impact staffing requirements; it is technically illegal to plant anything but conifers (not enforced); specific requirements for desired structural conditions; government safety branch discourages leaving retention trees and snags, which makes VR harvesting more difficult; certification discourages herbicide use which slows growth of regeneration; prescriptive forest practices legislation.

• A number of areas of risk and uncertainty were considered relevant to decisions about which silvicultural system to implement. These were: windthrow (6), ecological outcomes (5), regeneration success (4), visual and social outcomes (3), invasive species and diseases (3), safety (2), risk of legal action if windthrow affects adjacent properties (1); fire risk (1), economic risk (1), and uncertainty over future ability to sell or harvest large logs, either if mills are no longer geared to take them, or if changes are made to legislation, e.g. for threatened species or old-growth definitions (e.g. large trees as potential Spotted Owl habitat) (1).
2.3.2 Use of VR compared to other silvicultural systems

- Eleven organizations provided estimates of the proportion of VR used on their land tenure as opposed to other silvicultural systems. These ranged widely from 3-100% (average = 50% ± 30% SD) of managed land area, whilst the twelfth organization stated only that VR was used in the majority of cases. VR was used across less than 50% of the land area in five of twelve cases, and two organizations use 100% VR. Other silvicultural systems used included clearcutting (4), clearcut with reserves (2), thinning and/or selection silviculture (5) and understorey protection (1). All organizations said that VR was used in place of some form of clearcutting (either traditional clearcut, clearcut with reserves or two-pass clearcut), although two Oregon-based organizations also use VR in place of thinning in some cases and the Californian organization also uses it in place of ‘alternative prescription’.

- For the ten organizations that use more than one silvicultural system on their land tenure, a broad variety of factors were considered to influence which sites VR silviculture is employed. These were: certain forest types (5), certain landscape or management zones or intended stand conditions (4), windthrow risk (3), site constraints requiring habitat retention under legislation (3), timber yield (3), certain disturbance regimes (2), harvesting practicalities, e.g. terrain influence on cable versus ground-based harvesting (2), costs or revenue (2), the need for restoration (2), growth of shade-intolerant regeneration (2), problems with invasive species or diseases (2), importance of public perception (1), land tenure (private vs. public) (1), uncertainty over long-term ecological benefits (1), wanting to encourage regeneration of certain tree species (1), size of property (1), and pre-harvest stand condition (1). Overall, environmental, management, and logistical factors appeared to be much more important than social ones in determining which sites to use VR.

- Although forest type was in some cases indicated to be a factor influencing the choice of silvicultural system for a site, ten of twelve organizations use VR on all the forest types on their land tenures. One BC organization largely uses VR in temperate rainforest sites and the Californian organization uses it in hardwood dominated sites with specified conifer basal area. Likewise, forest age was not an important determinant of silvicultural system, with only a single organization, an Oregon-based small private forest, using VR in younger forests and selection in older forests. Five organizations manage a mixture of older and younger forests. With the exception of the Oregon property where some old-growth trees are harvested, all other organizations harvesting old-growth forests were Canadian.
2.3.3 VR Implementation

- With the exception of an organization that claims to have been doing VR since the mid-1970s, because they have been leaving scattered old-growth trees on sites since then, implementation of VR with the other organizations started between 1992 and 2003, with the mid-late 1990s being common (Figure 2).

![Bar chart showing the number of organizations commencing use of VR silviculture over time.](chart.png)

Figure 2. The number of organizations commencing use of VR silviculture over time.

- There was a huge range amongst growers in the land areas where VR has or will be employed, from less than one hundred hectares for a small private forest up to approximately two million hectares for a Canadian private company (average = 473,163 ha ± 667,339 SD). This translates into a big variation in the approximate current annual VR cut, which ranged from 0 to 7,500 ha (average = 2,405 ha ± 2,417 SD).

- Harvest unit sizes were also rather variable, ranging from two hectares to more than one hundred hectares. There was a trend for somewhat larger harvest unit sizes in Canada than USA, and for smaller sizes on small private forests.

- Four organizations did not have particular intended rotation periods for VR, while the approximate rotations amongst other growers varied from 55 to 110 years (average = 79 years ± 20 SD). Eight organizations plan that retention is generally for the entire rotation or longer, while other organizations have not specified the length of retention. The Californian company may harvest a proportion of their VR retention after twenty years as part of their ‘restoration VR’ practices under special approval from the Director of Forestry to harvest retention trees at less than a 50 year rotation (as is the usual case under the California Forest Practice Rules for VR).

- Seven organizations considered that implementation of VR was varied greatly among sites, three indicated some variability, and two considered practices to be generally similar among sites.

- A wide variety of factors were mentioned as being important in guiding VR implementation. These fell into four broad categories; logistical (4), management (7), societal (4) and environmental (9). Logistical factors mentioned were windthrow (3), logging system (cable vs. ground-based vs. heli) (2), general harvesting logistics (present or future) (2). Management factors were: corporate philosophy and management objectives (3), economic and market considerations (3), legislation (1), training and
ensuring personnel understand objectives (1), and monitoring and reporting (1). Societal factors were: visual constraints (3), archaeology and cultural issues (1), and public values (3). Environmental factors included ecological and wildlife values (5), initial or desired stand conditions (3) and scientific knowledge (1). These results suggest that while environmental factors were important in guiding the details of VR implementation, other management factors in particular, as well as societal and logistical aspects were also very important.

- Ten of twelve organizations said that social considerations influence VR harvest designs or other aspects of VR implementation in the following ways: practices were altered in viewsheds (9) such as through higher retention levels (3), affected choice of harvesting system (5), retention levels or locations were influenced by input from public or trappers (4), strategic location of retention (2), more dispersed trees (1), improved social license to harvest (1), use of buffers along roads (1), and planting randomly rather than in rows (1).

Retention and Influence

- Estimates of the proportion of VR harvest area cut using the three main patterns—aggregated retention, dispersed retention or mixed retention—were available for nine organizations. Overall, aggregated and mixed retention were more common than dispersed retention. Five organizations used dispersed retention, but this was in a minority of the land area with the exception of a small Oregon private forest where it was the most common form of VR used. Two Canadian organizations restricted VR implementation to a single pattern, either mixed or aggregated retention. Four organizations used all three patterns, one used a mix of aggregated and dispersed, and two used a combination of aggregated and mixed. Hence retention patterning varied broadly amongst organizations.

- A variety of factors were mentioned as influencing decisions over whether to leave retention in aggregates compared to dispersed trees. These included site-specific ecological and biodiversity factors (7), logistical factors relating to ease of operations such as topography for cable versus ground-based harvesting (cable yarding is more common on steep ground) (6), wind (aggregates are commonly used in windy areas) (4), guided by natural disturbance (either regime dynamics or existing legacies) (4), aesthetic outcomes (2), size of opening (2), tree species (dispersed trees can be retained for windfirm species) (1), forest health problems such as root disease or mistletoe (1), growth impacts on regeneration (1), site sensitivity for cultural or biodiversity values (1), harvest economics (aggregates cost less) (1), logistical ease of mapping aggregates for auditing of retention levels (1), choice of species to regenerate (aggregates for shade-intolerant Douglas-Fir) (1). Factors relating to ecological outcomes and logistics were more commonly cited than factors related to management or societal outcomes.

- There was a wide range of targeted retention levels, from 0% to approximately 45% or more for individual sites. More than 15% retention was typical, although one organization considered itself to practice VR without any retention beyond legislative requirements, and another company in Alberta had a 5% retention target for merchantable trees. There was a range of approaches to retention targets, including site-level targets, targets that varied according to landscape zones or harvest unit sizes, average targets established for the entire land tenure but no specific site-level targets, targets for numbers of retained trees and snags, and no retention targets.

- Aggregate sizes were also variable (from as small as 0.1 ha up to more than 10 ha), and commonly also varied significantly within an organization. Average aggregate sizes were generally smaller in the USA (usually 0.1 or 0.2 ha) than in Canada where average
aggregate sizes for three organizations were approximately 0.25 – 0.375 ha while the other three organizations commonly had aggregates 2 ha in size or greater along with smaller aggregates.

- All organizations anchored at least a proportion of their aggregates and retained trees on areas of ecological importance. Six organizations considered that more than 50% of their retention was anchored for specific ecological reasons. Features mentioned for anchoring retention included: specific wildlife features such as bear dens and nest trees for at-risk birds (11), snags (8), riparian areas (7), bogs, wetlands and springs (6), big veteran trees (5), culturally important areas or archaeological sites (3), sensitive soils or geology (3), representativeness (2), coarse woody debris accumulations (2), species diversity, for example retaining hardwoods (2), screening of visual features (1), and genetic legacies for good regeneration (1). All organizations said that snag retention was encouraged. Five organizations had specified snag retention and/or creation guidelines. Two organizations did some snag creation and another five organizations specifically retain live recruitment trees as future sources of snags. Six organizations mentioned snag retention as a potential safety concern that limited their ability to retain them.

- The concept of forest influence (*sensu* Mitchell and Beese, (2002), i.e. that harvested areas will be, on average, closer to retention than in clearcut sites, thereby facilitating recolonisation by biodiversity) appeared only to be understood by seven of twelve organizations, including all four from BC. Six of these organizations considered forest influence in their management, and four had specified forest influence rules relating to 1-tree-height proximity to retention. Another four organizations had other guidelines relating to maximum distances between retention.

- The ‘retention’ goal was usually considered more important than the ‘influence’ goal of VR, although three organizations considered retention and influence equally important (two from BC and one from Oregon).

### 2.3.4 Adaptive management

- All organizations cited multiple sources of information for learning about VR silviculture (average = 3.6 information sources ± 1.2 SD). Books and articles commonly referenced about VR included those on ecology, introduction to the VR approach and natural disturbance (10 organizations). Individual scientists appeared particularly important in disseminating information (mentioned in 11 interviews), either from their written work or by working directly with organizations. Jerry Franklin was mentioned in 10 of 12 interviews, Malcolm Hunter twice, and several other scientists by a single organization. This highlights the important role that individuals can play in shaping ecologically sustainable silvicultural practices. Neither directly funded nor external science were particularly available sources of information for smaller organizations, who did not have easy access to scientific journals, and tended to rely more on more readily accessible information sources and workshops. Four organizations mentioned learning from the experiences of other organizations. Five of six Canadian organizations specifically mentioned learning from USA science and operational experience as well as other Canadian work, while no USA organizations specifically mentioned Canadian work. Other sources of information included major enquiries (the Clayoquot Scientific Panel and the FEMAT Report) (3 organizations), direct collaborations with external scientists and consultants (3), in-house research and expertise (2), VR workshops (2), word of mouth including discussions with other foresters at association meetings (2), certification bodies and auditors (2), adaptive management (2), newsletter-type articles (1), and the internet (1).
Six of twelve organizations had a formalized adaptive management process, although one was only being set up, and another existed more in theory than in practice because of funding cuts. Nine organizations considered implementation of VR to be an example of adaptive management, and the other three partially so, if not necessarily in a formalized sense. The evolution of VR could be described as active (as opposed to passive) adaptive management for seven of the twelve organizations. For example, practices had changed in direct response to research and monitoring outcomes. However there was some monitoring of operations in ten cases. Although there are silvicultural trials investigating different variable retention patterns and retention levels in Oregon and Washington (DEMO), BC (MASS, VRAM and other trials) and Alberta (EMEND), only three of the organizations had direct relationships with these experiments. Adaptive management programs were done in collaboration with other organizations in five cases.

Seven organizations employ biologists, seven contract them, and one relies on volunteers. Only one of the organizations, a small private forest, does not utilize the expertise of biologists. Biologists were most commonly employed to provide general site-level advice, with specific involvement with VR in only five cases, and strategic-level work and research in only four cases. Six organizations had research programs, and in four cases these were directly related to VR. Ten organizations had monitoring programs, and in five of these cases the monitoring specifically related to VR. Nine organizations have had collaborations with external experts to facilitate their VR practices. Seven of these cited the collaborations as being very helpful, and two as helpful.

A variety of factors were mentioned for how adaptive management has resulted in changes to how VR is implemented. Retention pattern has shifted in five cases; with either a move to more aggregated/mixed retention away from dispersed retention (3), a move to mixed retention from aggregated retention (1), or a move to more mixed or dispersed retention from aggregated retention (1). Other changes to implementation have included the use of fewer, larger aggregates (3), better anchoring of retention (3), relaxing or removing a forest influence target (2), introducing specific numerical targets for desired stand structures or retention levels (2), a shift to using less VR (2), a shift to using more VR (1), more flexibility in implementation (1), better avoidance of windthrow (1), higher retention levels (1), and longer rotations (1). Seven organizations considered that the results of research and monitoring played a role in making these changes. Reasons for changes related to improving biodiversity outcomes (6), minimizing windthrow (3), corporate philosophy (3), improving visual outcomes (1), minimizing invasive species spread (1), and economics (1).

2.3.5 Success, challenges and uncertainty

VR Implementation was considered successful by ten of twelve organizations (one answered “no”, one “don’t know”) and eleven organizations definitely planned to continue to implement at least some VR in the medium to long-term, with one “maybe”.

Factors that were mention as being influential to success of VR were: corporate philosophy and support from upper management (4), training (2), positive public opinion (2), improved ecological sustainability (2), interaction with research community or external experts (2), weeding out detractors (1), support from personnel and contractors (1), catering practices to particular sites (1), timber production is still economically viable (1), the ability to use VR to restore conifer-dominated forests (1). Factors mentioned relating to uncertainty or decreased use of VR included: uncertainty over future biodiversity outcomes (4), the approach being too prescriptive and lacking flexibility (2),
There were a number of factors that were mentioned as major challenges with VR compared to other harvesting systems. These were: windthrow (5), VR is more costly (5), educating and gaining the support of the workforce (3), government regulations (2), operational challenges (2), maintaining timber production volumes (1), seedling growth (1), ability to positively change public perceptions (1), monitoring requirements (1), refinement based on new information (1), uncertainty over long-term ecological benefits (1), and accessing research results (1).

Nine organizations considered that the ecological objectives for VR were clearly stated and understood by all relevant personnel. However, there was some uncertainty over whether VR had met objectives (six “yes” and six qualified responses). The qualifications related to being unable to predict long-term outcomes. In only two cases had the initial primary objectives for VR changed; in one case to place greater emphasis on ecological aspects, and in the other, there are no longer specific objectives.

VR was generally considered successful at maintaining structural complexity and biodiversity at the stand-level in the short-term, with only one organization commenting that retention levels were too low to ‘maintain’ biodiversity, although there was some uncertainty over long-term outcomes.

All twelve organizations considered that using VR had resulted in improved social acceptability.

2.3.6 Future changes

Organizations mentioned a number of aspects of VR implementation that could possibly benefit from being changed in the future, although one organization said “don’t know” and another, “nothing in particular”: landscape-scale planning (3), retention pattern (aggregated vs. dispersed) (2), more flexibility (2), more formalized adaptive management and monitoring systems (1), better catering to individual sites (1), use of more clearcutting in place of VR (1), changed retention levels (1), larger patch sizes (1), and longer rotations (1).

A number of areas were mentioned where new information could facilitate VR practices: long-term biodiversity outcomes such as in relation to different retention patterns (8), long-term impact on tree growth (2), optimal practices for biodiversity at the landscape-scale (2), ecological response to forest influence (2), validation that practices qualify as VR (1), and knowledge of natural disturbance in relation to biodiversity (1). Nine organizations considered that such information might be obtained from the results of research and monitoring.

Several potential incentives were mentioned that, if instigated, might facilitate future implementation of VR: government stumpage or tax breaks in recognition of ecological benefits and added costs (3) or government cost-share program for added costs (1), premiums on timber sales, e.g. via certification bodies (2), a system of payment for ecosystem services (biodiversity credits) along the lines of carbon credits (1), change disincentives into incentives, such as payments for creating habitat for threatened species (there is currently a perception of being punished for creating spotted owl habitat) (1), incentives for academics to disseminate research results in more accessible forms to forest
managers (1), and less hassle or faster processing time by forest regulating body in recognition of certification for ecologically sustainable forest management (1).

2.4 Discussion

Variable retention silviculture was found to be implemented across western USA and Canada, on a variety of property sizes and land tenures, forest ages and forest types. There were many similarities in how VR was implemented by different organizations, as well as with their motivations for using VR, and their approaches to adaptive management. However there were also a number of differences, highlighting the flexibility of this silvicultural system. The results of the surveys will be discussed in relation to the twelve study hypotheses.

2.4.1 Study findings compared to initial hypotheses

Drivers behind using VR

1. Use of VR silviculture in place of clearcutting will relate to ethical, aesthetic and social drivers defined within organizations such as response to public pressure or the desire for improved ecological sustainability rather than external constraints or incentives such as legislative and/or certification requirements. This will result in flexibility in implementation.

Although the initial motivations for using VR were more commonly internal to organizations (social acceptability or ecological outcomes) external drivers (government policy and certification) were also important in several cases. The desire for improved social acceptability or impetus from government or certification bodies appeared as important as motivations relating to ecological outcomes as an initial driver for starting to use VR. However, once the decision to use VR had been made, all but one organization’s stated objectives for using the system related to ecological outcomes, although social factors (social licence, societal values, visuals, market access, certification) were a primary objective along with ecological objectives for another six organizations. Implementation was found to be very variable, although in a few cases legislative requirements were thought to reduce flexibility.

2. Loss of timber revenue will be the primary constraint in not using VR more broadly in place of clearcutting.

Reduced timber supply was only mentioned once as a constraint for using VR, and increased costs or reduced revenue were mentioned twice as factors that may influence whether or not to use VR in place of other harvesting systems on a particular site. Environmental and logistical factors were most commonly mentioned as affecting choice of silvicultural system for a site. A number of government constraints, often relating to unwieldy regulations, impacted choices about using VR. Hence ecological, logistical and regulatory factors appear to be more important constraints impacting use of VR than economic factors.

3. VR silviculture will be used more often in mature and old-growth forests than in regrowth forests. This will relate to a higher priority given to maintaining conservation values provided by older forests rather than restoration of landscapes that are depauperate in old-growth.

Except for two organizations which used VR in particular forest types, the system was used across the range of ages and forest types that were available for harvesting on each land tenure. This included old-growth (primarily in Canada), second and third-growth forests. Restoration of structural complexity or productive species composition was a
specific goal for using VR by three organizations. VR was also applied in a wide range of forest types. Hence conservation priorities for particular forest types or ages appeared not to be an important driver for using VR.

4. Risk and uncertainty about perceived advantages and disadvantages of VR silviculture will be a factor influencing decisions about its implementation

A number of areas of risk and uncertainty were mentioned in relation to VR implementation. Windthrow appeared to be a problem in many situations, and in some cases had resulted in reduced use of VR. However in most cases implementation had been adapted to minimize windthrow risk, and there was acceptance of a certain level of blowdown. Eleven organizations said they would continue to use VR in the future, while the twelfth was uncertain. This uncertainty related to the long-term ecological outcomes of VR silviculture which are currently unknown, as well as problems with invasive species. Uncertainty about future ecological outcomes was mentioned by five organizations, although usually in the context of the need for continued research and monitoring, and postulating that dispersed retention may be shown to have more advantages compared to aggregated retention in the longer-term compared to current research which tends to favour aggregates for most species. Uncertainty over visual and social outcomes and safety were also mentioned along with a few other factors, although these did not appear to be major constraints.

VR Implementation

5. VR practices, although variable, will generally meet the definition of ‘The Retention System’ in Mitchell and Beese (2002). Rules about retention and influence will be quite variable amongst forest growers. Retention rules will be the primary guidance for site layouts rather than an influence threshold.

The retention system is defined as “a silvicultural system that is designed to retain individual trees or groups of trees to maintain structural diversity over the area of the cutblock for at least one rotation, and leave more than half the total area of the cutblock within one tree height from the base of a tree or group of trees, whether or not the tree or group of trees is inside the cutblock” (Mitchell and Beese, 2002). Variable retention practices were extremely variable. Although implementation by three of the four BC companies interviewed generally met the definition of ‘The Retention System’, this was not the case outside of BC. The fourth BC company had backed away from the prescriptive approach of the retention system, to apply VR in a more loosely defined context without rules for forest influence et cetera.

The concept of forest influence (defined as the biophysical effects of forests or individual trees on the environment of the regenerating stand), where the majority of a cutblock is within a tree-height of retention, was poorly understood outside of BC. With the exception of one small private forest in Oregon which applied a one-tree-height guideline (although retained trees were allowed to be harvested within the rotation), there were not forest influence rules in either Alberta or the USA. In some cases there were rules for maximum distances between retention trees, although the intention was about distributing the retention rather than facilitating recolonisation of the harvested areas.

Although the forest influence component of the BC definition was not generally applied elsewhere, the first part of the definition relating to long-term retention of trees or patches of forest was broadly implemented. In all but one case, variable retention was implemented as one of the three common patterns: aggregated (group), dispersed, or...
mixed retention. The requirement for long-term retention was generally applied, with eight of twelve organizations planning that retention is generally for the entire rotation or longer. In one unusual example, a small private company cut a proportion (e.g. one fifth) of each property approximately every ten to fifteen years, resulting in a range of age-classes up to approximately 75 years before the trees were harvested. No long-term retention was required beyond that imposed under forest practices legislation. This example did not appear to fit the generally accepted interpretation of VR, involving additional retention within sites over the long-term.

Retention levels were found to be extremely variable, both within and between organizations, ranging from 0 - >40% at the site-level, although >15% was fairly typical. Eight of twelve organizations had some form of retention target, although there were a wide range of approaches for this. Retention rules were generally more important to shaping implementation than influence rules, although three organizations considered retention and influence equally important (two from BC and one from Oregon).

As well as variation in approaches to retention-levels, time-period for retention, and forest influence, a number of other factors varied widely amongst the various organizations. These included retention pattern, aggregate sizes, harvest unit sizes, rotation periods, and anchoring strategies for retention. As well as variability amongst organizations, most of them considered that there was a wide variety of implementation of VR within their land-tenure. Hence VR appeared to be resulting in both variability in structural and habitat conditions within sites, and varied practices at the landscape-level.

6. **Differences in VR implementation amongst growers, and choice of VR system (aggregated vs. dispersed vs. mixed retention), will relate more to operational and silvicultural constraints (e.g. getting successful regeneration, minimizing windthrow) than to characteristics of the forest such as disturbance regime, land tenure, perceptions about outcomes for biodiversity, or other factors.**

A wide variety of factors influenced how VR was implemented by the various organizations. The relative proportions of the three main VR patterns varied widely, even within similar forest types, although aggregated and mixed retention were generally more common than dispersed retention. Land tenure did not appear to be a major influence on implementation. Characteristics of the natural disturbance regime did impact implementation in some instances, e.g. guiding retention levels or retention pattern. For example, natural legacies following wildfire-disturbance in boreal forest in Alberta was used to justify a 5% retention target by one company (the other Albertan company had a 15% target), while retention levels were generally higher in Vancouver Island old-growth forests subject to wind disturbance. Use of aggregates rather than dispersed trees was commonly employed as a strategy to minimize windthrow of susceptible species (e.g. western hemlock). General implementation was influenced by a very wide variety of factors, and ecological, logistical, societal and management factors were all important. Likewise, a wide variety of factors were mentioned as influencing decisions over whether to leave retention in aggregates compared to dispersed trees. In this case, factors relating to ecological outcomes and logistics were commonly cited, rather than factors relating to management or societal outcomes, although these were mentioned in a few instances.

7. **VR will be used as one of several silvicultural systems applied by an individual grower. It will be used in forest types that would conventionally have been clearcut, rather than subject to partial cutting systems.**
Only two of the twelve organizations interviewed used 100% VR, although another two had moved away from previous 100% use for practical reasons. VR was used in all of the commercially available forest types across the study region. In all cases, VR was an alternative to some form of clearcutting, although in three cases it was also practiced as an alternative to thinning or alternative prescription. The proportion of VR compared to other silvicultural systems varied widely across organizations, from 3 - 100% of cut by area. More than half the organizations used >50% VR. Factors affecting choice of silvicultural system were most commonly environmental and management, as opposed to logistical or societal factors.

Adaptive Management

8. **Organizations with an active adaptive management process for VR will have modified practices to a greater degree than other growers.**

The evolution of VR could be described as active (as opposed to passive) adaptive management for seven of the twelve organizations. However, various aspects of VR implementation have changed since initial implementation for all organizations. Seven organizations considered that the results of research and monitoring played a role in guiding changes to VR practices. Organizations actively engaged in ecological research more commonly cited research results as having influenced changes to practices to improve ecological outcomes.

9. **Government organizations will be more likely to invest in research and monitoring programs to ensure that VR practices are meeting ecological objectives than private or tribal growers.**

This was not the case. Several of the large private companies invested extensively in research and monitoring programs related to VR implementation, whilst one of the three small private owners relied on volunteers to conduct biodiversity monitoring of all silvicultural systems on their properties. The two state government management agencies interviewed funded little or no research and monitoring relating to VR, although one of them supported research by an external organization on State forest.

10. **Changes to VR implementation will relate more to overcoming economic or operational constraints than to improving outcomes for biodiversity.**

Improving biodiversity outcomes was the most common reason for changes to VR practices, followed by minimizing windthrow. Improving visual and economic outcomes were each only mentioned once.

11. **Formalized objectives relating to desired ecological outcomes will facilitate achieving perceived benefits for biodiversity.**

Nine of twelve organizations considered that the ecological objectives for VR were clearly stated and understood by all relevant personnel. However, there was some uncertainty over whether VR had met these objectives. This perception did not appear to relate to how clearly the objectives were stated. Rather, many organizations expressed some uncertainty over the long-term ecological outcomes of using VR silviculture, since implementation and research has been for a relatively small proportion of a full silvicultural rotation.
12. Most organizations that have used VR will, on balance, consider it a successful silvicultural system for achieving multiple objectives (e.g. timber production with improved ecological outcomes), and will plan for ongoing implementation.

Almost all organizations considered that VR implementation had been successful, although one thought disagreed because of problems with windthrow, and one was unsure. Eleven of twelve organizations are planning to continue using at least some VR in the medium to long-term, although one organization was uncertain.

2.4.2 General discussion

The evolution of VR in the PNW is a good example of adaptive management, with changes to harvesting approaches and retention practices in response to both logistical challenges and the results of research and monitoring. To a certain extent it appears that VR co-evolved separately in USA, Alberta and BC around the same time. Jerry Franklin’s work and encouragement was initially formative in all regions. However, more recently, practices appear to have diverged somewhat in different directions, with little follow-up collaboration outside of local regions.

Implementation is extremely varied, both within organizations, among companies within a region, and among regions. Most organizations outside of BC did not understand the concept of forest influence, and recolonisation of harvested areas was not always a major objective for VR silviculture. Not all organizations designated retention as being for the long-term.

Worker safety was found not to be a greater problem with VR than clearcutting, and greater emphasis on safety has led to improved safety records in some cases. The main safety issue that was mentioned was that worker safety discourages retention of snags, although aggregates were large enough to safely retain snags of all decay stages in most cases.

Ongoing research and monitoring will continue to be important for VR implementation. One large private company mentioned that the research results supporting the ecological benefits of VR was probably central to continued use of the approach even following two major buy-outs and organizational restructuring. Several organizations mentioned uncertainty over long-term ecological outcomes, and that this hindered choices about retention patterns among other things. Hence ongoing monitoring of the long-term research into VR (e.g. at EMEND, MASS, VRAM and DEMO experiments) will be important along with other research and monitoring. In some cases more active engagement between managers and research into VR might be beneficial, and researchers should be encouraged to ensure relevant results are readily accessible to the forest management community. Future research at operational sites could capitalize on the wide variability in VR implementation.

Training of staff also appears to encourage optimal practices, so that all personnel understand how and why VR can be used to improve ecological outcomes. Some Canadian companies train all staff about ecological objectives and how to achieve them, including contractors such as fallers and machine operators. In several cases it was mentioned that contractors came to prefer VR to clearcutting, finding it more interesting, and becoming actively engaged in choosing the best retention trees for biodiversity habitat. Ecological objectives of the system have been widely embraced, and are resulting in benefits to biodiversity compared to clearcutting. VR is successfully meeting its objectives for improved biodiversity and social outcomes.
2.5 Conclusions
Variable retention is a very flexible silvicultural system, applied across a variety of forest types, ages and land-tenures of western USA and Canada. Companies using VR generally felt that it was a successful system, and were planning ongoing implementation. Investment in research and monitoring has been important in guiding the adaptive management process. In some cases increased emphasis on staff training, and greater collaborations amongst organizations implementing VR, and with the research community, may be beneficial.

2.6 Lessons for Australia

- Improved social acceptability for forest harvesting was an important motivation for several PNW organisations, and implementing VR was considered by them to have successfully met this objective. Hence broad application of VR has the potential to help diffuse ongoing conflicts over harvesting native forests in Australia. Ecological objectives for VR had been clearly embraced by PNW organizations. Strong support from upper management, continued input from ecological research, and good training programs appeared important to success. Greater focus on these aspects could be beneficial in some cases with Australian native forest management, and as noted above, would likely have the additional benefit of improving social acceptability.

- VR implementation in Tasmania is similar to PNW implementation, in particular to that on Vancouver Is., perhaps because scientists and practitioners from that region provided advice during the Tasmanian phase-in of VR. Main differences appear to relate to operational challenges: regeneration burning is the main challenge in Tasmania while windthrow is a major challenge in the PNW. Dispersed retention was not possible in Tasmanian old-growth wet eucalypt forest because of concerns for worker safety with tree falling, meaning that aggregated retention is the only form of VR applied. Safety has not been found to be a problem in the PNW, and dispersed retention and mixed retention are widely used.

- VR is an adaptable approach which could be applied in other forest types and ages in both Tasmania and mainland Australia. For example it is used in a wide variety of forest types in the PNW, including dry ponderosa pine forests. Although PNW implementation of VR was usually as an alternative to clearcutting, VR is also a useful alternative to selection silvicultural approaches, and is implemented as part of selection silviculture in eastern USA (Brian Palik, personal communication). With these forests, unless some patches or trees are specifically designated for long-term retention, the forests face similar problems with loss of habitat diversity and late-successional structures as can occur with clearcutting. Maintenance of some forest cover does not equate to providing the range of structural and habitat characteristics as a forest that has regenerated following natural disturbance. Hence there is scope for much broader application of VR in wet, dry and high altitude forests in Australia.

- Research and monitoring was important to validate the choice of VR silviculture, and to guide changes to management. Several PNW organizations mentioned uncertainty over long-term ecological outcomes, in particular with regards to the relative benefits of aggregated and dispersed retention patterns. The role of research and monitoring in shaping VR, and encouraging continued use, emphasises the importance of funding for long-term research. Maintaining, and preferably increasing, funding for long-term research into the ecological and silvicultural outcomes of variable retention and other harvesting systems should be given high priority in Australia. Collaborations with external experts helped companies embark on using VR silviculture, but for organizations without strong direct ties to research programs, accessing research results was sometimes difficult. Likewise in Australia, communication between researchers and managers can be problematic, so efforts to forge stronger working relationships, and to disseminate results
in forms accessible to the forest industry as well as in academic journals, would be beneficial.
3. Improving conservation outcomes through silvicultural research and adaptive management

3.1 Adaptive management in the PNW

The biodiversity impacts of many forest management practices are poorly understood. Since management for timber production is known to have potentially negative impacts on some species and processes, adaptive management in the face of uncertainty is very important to ensure that practices continue to evolve and improve. Lindenmayer and Franklin (2002) define adaptive management as “the acquisition of additional knowledge and the utilization of that information in modifying programs and practices so as to better achieve management goals”. Approaches to adaptive management are variable, and a variety of factors are important in assisting success. A formalized active adaptive management strategy incorporating, research, monitoring and careful documentation is generally considered more effective than passive adaptive management (Lindenmayer and Franklin, 2002; Walters and Holling, 1990).

Successful adaptive management can be applied on forest land tenures of any size. The family-owned forest ‘Hyla Woods’ provides an example of adaptive management on a small land ownership (Peter Hayes, personal communication). Their monitoring program, which has been ongoing for fourteen years, includes biodiversity surveys (e.g. birds, amphibians, aquatic macroinvertebrates) and responses to harvesting. They engage with university scientists and other volunteers, making the monitoring program possible, for example by assisting with the design of the program, and carrying out parts of it (e.g. bird surveys) that require specialized expertise. This engagement has been possible because of community support for the type of forestry being implemented by Hyla Woods, with a strong emphasis on conservation. A wide variety of silvicultural practices have been tested on the three Hyla Woods properties, and the responses to these have influenced future management. For example, monitoring that identified problems with invasive plants has contributed to a current preference for less intensive silviculture. They also asked the Department of Fish and Wildlife to review their practices and provide advice during the re-write of their stewardship plan. This resulted in changes to slash management practices on the advice of a wildlife biologist who recommended piling some slash to provide cover for mammals. As a result they pile some and broadcast some so that they also ensure good distribution of coarse woody debris. They also found that planting Western Red Cedar into slash piles can minimize the impact of browsing by elk and deer.

MacMillan Bloedel (since bought out by Weyerhaeuser and now Western Forest Products) on Vancouver Island provides an excellent example of a successful formalized adaptive management strategy. Their BC Coastal Forest Project is described below (Chapter 4.3.1) as a Canadian example of resolving conflicts in the timber industry. Keys to success included effective strong leadership which included direction about importance of biodiversity, sufficient funding, excellent long-term research and monitoring programs, staff training programs, and bringing in outside expertise. As an example, one operational challenge on Vancouver Is., as well as other PNW forests, is managing the risk of windthrow in sites utilizing retention silviculture. Windthrow monitoring identified very high levels of windthrow in some instances, resulting in an adaptive management process to develop harvest unit designs that take this into account. This involved monitoring of windthrow, research and development of wind risk models (e.g. Scott and Mitchell, 2005) and learning from experience. It was found that whilst site layouts need modification in forests with high risks of windthrow, it should still be possible to retain late-successional species and structures within
sites. Certain trees are inherently more windfirm, and thus make good candidates for dispersed retention trees. Careful planning of aggregate locations, shapes and sizes is minimizing the extent of windthrow. As a result of adaptive management, there is a tendency now to use larger aggregates and use dispersed retention less often than when variable retention was initially implemented. Other organizations such as the Washington Department of Natural Resources have also adapted practices to help manage windthrow risk.

Currently there is a lot of focus on minimizing the negative impacts of forestry practices on biodiversity. This has lead to development of alternative silvicultural systems such as variable retention, and resulted in setting up large silvicultural experiments (see Chapter 3.2) to research impacts on silvicultural and biodiversity outcomes. However, research into fundamentals of forest biodiversity and ecosystem function is equally vital. Two excellent examples of long-term ecological research sites in the PNW are the HJ Andrews experimental forest in Oregon and the Wind River Canopy Crane in Washington. Research into a diverse array of topics at these sites has made an enormous contribution to the field of forest ecology.

However not all examples of adaptive management have been entirely successful. Funding for research and monitoring has been drastically reduced in most forest management organizations in Western USA and Canada in response to the economic downturn. This has often resulted in staff retrenchment as well as withdrawal of funding for field trips, external consultancies and collaborations. This has had a detrimental impact on adaptive management, research and monitoring of the biodiversity impacts of timber harvesting.

One example is the Oregon Department of Forestry (ODF), which has a formalized adaptive management strategy that is legislated under their forest management plan. http://www.oregon.gov/ODF/STATE_FORESTS/docs/management/nwfmp/17-5-Implement_prn.pdf. Although there are a couple of success stories with application of the adaptive management process (swiss needlecast, young stand management), for the most part the research timelines have meant that information is not yet available to guide management. In the last year, budget cuts of ~90% mean that there is really only sufficient funding to pay for contributions to research co-operatives, and these may not be conducting research of most relevance to ODF. ODF has good relationships with university researchers, and can still encourage research into questions relevant to adaptive management. However, without the funding to back this up, timelines for delivering results become even longer, thus compromising the adaptive management process. Previously ODF was able to directly fund university researchers to investigate questions of mutual interest, and this approach was taken rather than having an in-house research team, with the exception of a few monitoring staff. This process was considered to have worked well, as the funding agreements were fairly specific about deliverables. Forest management on ODF lands is also benefitting from passive adaptive management, with flexibility under their Forest Management Plan to utilize a range of silvicultural methods. However one forester noted that while many different harvesting approaches had been tried, lack of record keeping and staff turnover meant that people did not always know either the initial objectives or the final outcomes of various management practices. This emphasizes the need for defining objectives and careful documentation to ensure feedback to guide future practices. In general, while there have been some successes, the ODF example illustrates that having a formalized adaptive management process does not necessarily ensure success, and is particularly hindered by insufficient funding.

Under the Northwest Forest Plan, approximately 6% of forests were allocated to adaptive management areas, which were intended to allow experimentation and studies to evaluate different approaches aimed at achieving the overall objectives of the Plan (United States Department of Agriculture and United States Department of Interior, 1994). However, these
and other regional monitoring programs did not fully live up to expectations (Stankey et al., 2003), and the capacity to experiment with innovative forestry practices was in reality very limited since harvesting was not allowed because of public pressure and constraints imposed by legislation such as the Endangered Species Act. Lack of funding and short time-frames for studies were additional limitations (McAlpine et al., 2007). One example is the Blue River project, where excellent science provided a framework for management guided by natural disturbance (Cissel et al., 1999). However implementation of this framework was limited by public opposition to regeneration harvesting. A certain amount of uncertainty and risk is inherent to adaptive management, but if stakeholders are uncomfortable with these, then it can hamper the process (McAlpine et al., 2007).

The economic recession has had a strong impact on the ability of forest management agencies to conduct adaptive management. Some of the long-term silvicultural experiments in the PNW have been hampered by the difficulty in finding funding for ongoing biodiversity monitoring. It is possible that it is harder to find grant funding and attract doctoral students to ongoing projects compared to establishing new projects. Funding agencies appear not to recognize that the longer such trials have been running the more value they will be to guide industry. Often there is a huge investment in establishing trials and sampling over the first few years, and then funding is discontinued and interest wanes. It may be that the most important findings from research into variable retention will be in coming decades. For example ecological processes are likely to change following canopy closure and stem exclusion phases, and recolonisation of harvested areas by late-successional species from retained aggregates and edges (forest influence) is likely to occur gradually once habitat conditions become suitable. Ongoing funding for research, as well as trial maintenance (e.g. maintaining tracks and signs) is therefore very important.

3.2 Researching alternative silvicultural systems

There are a large number of silvicultural experiments in western USA and Canada that are helping guide ecologically sustainable forestry practices. Several will be briefly described here, and the following website provides links to others in Oregon and Washington: http://www.fs.fed.us/pnw/research/lsse/index.shtml. Many of these research trials share similar aims, and sometimes include quite similar treatment applications. This not only benefits synthesis and drawing broad inference from findings (e.g. Wilson et al., 2009), but because they are located in a range of forest types, findings can also be catered to the appropriate ecosystem and environmental conditions.

3.2.1 DEMO

The Demonstration of Ecosystem Management Options (DEMO) study http://www.cfr.washington.edu/Research.demo/ was established in 1994-1995 to investigate alternatives to clearcutting within the range of the northern spotted owl. There are six replicates in Oregon and Washington, providing a broad region of inference. For example tree growth in the southern Oregon sites was much lower than at the Capitol Forest site in Washington. The study design included six treatments (Figure 3).
A number of biodiversity studies were initiated at DEMO (Aubry et al., 2009), although most of these were sampled soon after harvesting and have not been resurveyed.

Synthesis of the early biodiversity findings allows comparisons of treatment effects on different biodiversity groups (Figure 4). This illustrates that responses to harvesting treatments are quite variable amongst biodiversity groups. Not surprisingly, responses vary with the level of removal, with lower levels of removal having species assemblages more similar to controls. But Figure 3 also illustrates that biodiversity responses vary between aggregated and dispersed spatial patternings of retention. Whilst aggregated retention had less impact on some taxonomic groups (e.g. small mammals, birds, herbs) dispersed retention had less impact on others, although this appeared to vary with retention levels (e.g. truffles and mushrooms with 40% retention). This illustrates the benefits of using a mixture of aggregated and dispersed retention to cater for biodiversity overall; either at different sites, or using mixed retention within sites.
Figure 4. Responses of various biodiversity groups to different levels and arrangements of retention at the Demonstration of Ecosystem Management Options (DEMO) study in Oregon and Washington. The graph illustrates difference in the percentage similarity of assemblages, where numbers closer to zero on the Y-axis are more similar to species composition in unlogged controls. On the X-axis, the numbers indicate the percentage retention (uncut, 75%, 40%, and 15% retention), and D indicates that retention is dispersed across the block while A indicates that it is in the form of 1 ha aggregates. Data are from the first two years following harvest. This figure was provided by Doug Maguire from Oregon State University.

3.2.2 STUDS
The Siuslaw Thinning for Understorey Diversity Study (STUDS) http://www.fs.fed.us/pnw/research/lsse/siuslaw-thinning.shtml in the southern Oregon Coast Range is examining growth response to thinning of planted and natural regeneration of five tree species. The study is examining whether thinning and underplanting is a useful tool in Douglas-fir forests to increase heterogeneity in stand structure and composition, vegetative diversity, and productivity. The trial was established in 1992, and two of the treatments have recently had a second thinning entry. The most intense initial treatment (30 trees per acre, no second entry) has performed surprisingly well. Planted trees all died in the unthinned control, and have grown poorly in the least intense thinning, but have survived and grown well in medium and intense thinning treatments (Maas-Hebner et al., 2005). Thinning increased understorey plant species diversity without the loss of any shrub species (Chan et al., 2006).
3.2.3 MASS

The Montane Alternative Silvicultural Systems Trial (MASS) at http://cfs.nrcan.gc.ca/subsite/mass/home was established in 1993 in the coastal western hemlock zone on Vancouver Is., Canada (Beese and Arnott, 1999). It is therefore one of the older trials investigating alternatives to clearcutting, with fifteen-year measurements for some projects. Treatments (Figure 5) included unharvested control, clearcut, patchcut (1.5 - 2 ha patches), green tree retention of scattered dominants and co-dominants (25 trees per ha, ~5%), and shelterwood where trees representing the entire stand profile and 25-30% of the basal area (~200 stems per ha) were left throughout the stand as both clumps and individual trees. Recent salvage was conducted following a large windstorm which affected approximately one third of the green tree retention treatment, and also impacted the patches such that salvage and a second-pass harvest removed 2/3 of the patch area, with 1 ha groups remaining. Overall, the patchcuts were best at retaining biodiversity associated with mature forest, followed by the shelterwood system because of the clumpy arrangement of some of the retention. In general terms, the biodiversity research indicated that for 25% retention, it was better to leave retention as aggregated rather than dispersed trees from the point of view of biodiversity, costs and impact on growth and yield of the new cohort of regenerating trees. However there was evidence that dispersed trees had advantages for certain types of biodiversity, e.g. ectomycorrhizal fungi or foraging by woodpeckers (although clumps were better for nesting). Regeneration was much better in the green tree retention than the shelterwood treatment.

Figure 5. The MASS trial, illustrating trial layout, and recent photographs, from top to bottom, of green tree retention, inside a retained patch, and the shelterwood treatment.
3.2.4 STEMS
The Silviculture Treatment for Ecosystem Management in the Sayward (STEMS) trial on Vancouver Is. http://www.for.gov.bc.ca/hre/stems/ consists of three site installations in 40-60 year-old second-growth Douglas-fir in the Sayward forest on Vancouver Is. (Figure 6). It compares forest productivity, economics, and public perception of seven silvicultural systems or extended rotation treatments (one of each per site): uncut control, group selection, patch cut, extended rotation with commercial thinning, aggregated retention, dispersed retention and clearcut with reserves. STEMS 1 was established in 2001, STEMS 2 in 2005, and STEMS 3 quite recently. STEMS has the same study design as the Capitol Forest Study in Washington, USA, to allow for broader comparison and inference. The STEMS trial is unusual in having cut tracks, signs and leaflets to allow self-guided tours. With the dispersed retention treatment, approximately half the trees were windthrown in a one in one hundred year wind event. Within this treatment, those trees that had been pruned to minimise the risk of windthrow were the ones that tended to remain standing. Large dominants with a lot of taper were also more windfirm. Regeneration near the retained trees tended to be shorter than regeneration away from that immediate influence. Group selection was found to have a big impact on growth of regeneration, and was not considered to be feasible operationally except perhaps for woodlots.

Figure 6. STEMS 1. The left-hand photo shows dispersed retention with pruned trees, the middle photo shows an aggregate in the aggregated retention treatment, and the right-hand photo is an example of a group selection cut.

3.2.5 VRAM
The Variable Retention Adaptive Management Experiment (VRAM, Beese et al., 2005) was established on Vancouver Is. between 2001 and 2005 to provide information to further refine VR silvicultural practices. Between one and three replicates were established of experimental blocks that compare a range of retention levels and patterns (Figure 7). Each 100 ha installation contains a number of variations of the treatment of interest. These are: group retention level (0%, 10%, 20%, 30%, and 100% retention; Figure 8), group retention size (clearcut, small, medium and large groups, uncut), group retention location (0%, 15% and 50% riparian-aligned and uncut control), dispersed retention (0%, 5%, 10%, 30% retention and uncut control), and group removal (short cycle versus long-cycle and clearcut and control). The aim is to monitor short- and long-term effects on forest growth, structural attributes and selected plant and animal species.
3.2.6 Roberts Creek

The Roberts Creek Study Forest (Figure 9) was established in ~1997 in Douglas-fir dominated forest on the Sunshine Coast of mainland British Columbia. The demonstration forest aims to test and compare a range of approaches for harvesting and managing lower-elevation Douglas-fir dominated ecosystems [http://www.for.gov.bc.ca/rco/research/silv/roberts_creek.htm](http://www.for.gov.bc.ca/rco/research/silv/roberts_creek.htm). Treatments include unharvested control, conventional clearcut with reserves, two dispersed retention treatments, variable retention (with groups and dispersed trees) strip shelterwood and extended rotation (thinning). Retained trees were found to have a strong influence on establishing regeneration, with much better height growth in the clearcut. Dispersed retention enhanced natural regeneration, especially of western hemlock, even though only Douglas-fir and Western Red Cedar were retained. There was approximately 30% windthrow in the dispersed retention treatment in the first three years. Trees on wetter soils were especially sensitive to windthrow. In the extended rotation treatment, orienting yarding corridors at right
angles to dominant wind assisted minimizing windthrow (D'Anjou, 2002). Results have not yet been published from biodiversity surveys.

Figure 9. The Roberts Creek Study Forest in 2010. The left-hand photo shows regeneration following clearcutting in 2006, and the right-hand photo shows dispersed retention (harvested 2007).

3.2.7 EMEND

The Ecosystem Management Emulating Natural Disturbance (EMEND) trial in Alberta [http://www.emend.rr.ualberta.ca/index.asp](http://www.emend.rr.ualberta.ca/index.asp) is a 4 x 8 factorial experiment comparing a range of harvesting intensities (2% (clearcut), 10%, 20%, 50%, 75% and 100% (uncut control) of original stand volume) across four forest cover-types that represent an undisturbed boreal mixedwood successional chronosequence:

1) canopy >70% deciduous trees (early-successional);
2) canopy >70% deciduous with a white spruce understory;
3) mixed-wood stands with 40-60% spruce and aspen cover in the canopy; and
4) canopy >70% spruce (late-successional).

In addition, each harvested stand contains one small (0.2 ha) and one large (0.46 ha) aggregate, thus enabling comparisons to be made between aggregated and dispersed retention forms of VR. Each cover-type by treatment combination is replicated three times over the 1000-ha experiment. EMEND also employs fire treatments, including 10% retention with distributed slash burns and unlogged control compartments burned with prescribed ground fires as well as unburnt controls. In this way, EMEND is in a much better position to draw comparisons between silviculture and natural disturbance than the other silvicultural trials. Another advantage of the EMEND trial is the strong partnerships between university, government and industry.

Annual research programs and plot measurements by the EMEND Core Team are conducted to assess long-term silvicultural and biodiversity outcomes. As well as the core studies, the numerous biodiversity studies conducted by university academics and post-graduate students are leading to a good understanding of biodiversity responses to harvesting and burning, with numerous publications in the international literature. EMEND research is influencing government policy, and strong links with industry partners such as the company DMI are also influencing the management practices of industrial partners.

Studies are indicating that higher levels of dispersed retention maintain more species from the unlogged forest in the early years post-harvest (Caners et al., 2010; Craig and Macdonald, 2009; Harrison et al., 2005; Work et al., 2010). Carabids (Work et al., 2010), spiders (Jaime Pinzon, personal communication) and understorey plants (Craig and Macdonald, 2009) responded to increasing retention levels of dispersed retention, although threshold levels for plant cover was generally between 10% and 20% retention, while higher retention levels
 (>50%) were required to maintain late successional beetles and spiders. Threshold levels for maintaining understorey plants appeared to shift between the second and eighth growing seasons, with the 20% retention treatment becoming more like the 50% treatment over time, suggesting faster recovery towards mature forest condition (Craig and Macdonald, 2009; Macdonald and Fenniaik, 2007). Results vary among biodiversity groups, with saproxylic beetles responding more to quantity and decay class of coarse woody debris than to the level of overstorey retention (Jacobs et al., 2007). The density of natural Populus sucker regeneration (Gradowski et al., 2010) and growth and survival of planted white spruce (Gradowski et al., 2008) is inversely proportional to the density of retained trees. In the burnt control stand (Figure 10), Populus regeneration levels were lower because the hot burn killed tree roots limiting suckering, although there was good spruce regeneration from seed. In these forests, burning is important for certain pyrophylic species such as some beetles and woodpeckers. The aggregates have also been shown to benefit biodiversity (e.g. Hogberg et al., 2002), with even the small aggregates being better than dispersed retention for spiders (Jaime Pinzon, personal communication). Larger aggregates (1.8-4.4 ha) were better for maintaining carabid and staphylid beetles characteristic of mature forest (Pyper et al., 2010). The ability of small aggregates to lifeboat rare invertebrates was reduced with increasing distance from stand edges (Pyper, 2009). Variability in aggregate sizes is recommended, although aggregates larger than 2 ha have some benefits further from edges (Matthew Pyper, personal communication).

Figure 10. EMEND treatments. The left-hand photo (J. Pinzon, 2006) shows a 2% retention site containing 0.2 and 0.46 ha ellipses retained within the clearcut area. Regeneration consists of natural aspen and planted spruce. The middle photo shows the conifer control stand that was experimentally burnt. The right-hand photo shows the unburnt conifer control.

There is a cover-type and harvesting treatment interaction, where the effects of harvesting appear to be greater in the later-successional forest types. This is because the conifer forest regenerates to early-successional vegetation after harvest, in contrast with aspen forest which regenerates back to aspen. Uncommon species are the most likely to be removed from sites with harvesting, for example a small patch of conifer trees within an aspen stand.

3.3 Effects of forest influence on biodiversity

Variable retention silviculture aims to facilitate recolonisation of harvested areas by biodiversity from the uncut aggregates and/or dispersed trees once conditions become suitable. Recolonisation of harvested areas by late-successional biodiversity is assumed to be related to proximity to colonisation sources in undisturbed forest. Hence forest, or residual tree, ‘influence’ is defined as the biophysical effects of forests or individual trees on the environment of the surrounding land (i.e. the harvested area in the context of VR) (Keenan and Kimmins, 1993; Mitchell and Beese, 2002). The degree and distance of forest influence will be inherently variable, e.g. between individual species or microclimatic variables, and with site slope, aspect, and latitude (Keenan and Kimmins, 1993). In general, mature forest influence is considered to diminish significantly at distances greater than one tree length from
edge (Mitchell and Beese, 2002). Currently this concept is largely theoretical and untested, however, which limits understanding of the spatial and temporal scales of recovery following disturbance. The relatively young age of silvicultural trials and operational variable retention sites is one limitation, since species with preferences for mature forest may be less likely to recolonise harvested areas when microclimatic and other conditions are considerably different, as is the case in the initial years following harvest before canopy closure. Further, recolonisation of harvested areas is likely to be a gradual process, thus forest influence effects are likely to be more pronounced in older silvicultural regeneration. Perhaps because of these challenges, much of the research focus on VR silviculture to date has been on the ability of the system to retain species and structures within sites, and the degree to which forest influence functions in practice for various biodiversity groups is still very poorly known. Better understanding of forest influence will be of broad relevance to managing forest landscapes, including predicting recovery following wildfires.

![Forest Influence Diagram](image)

Figure 11. The concept of forest influence. Variable retention (left) and traditional clearcut (right) cutblocks are used to illustrate this process. The variable retention site contains unharvested aggregates which are expected to provide recolonisation sources for seeds, spores and animals from old forest to more recently harvested patches. The rate of movement should depend on the proximity of regenerating forest to old forest – areas within 1-tree-height of retained forest are assumed to be within ‘forest influence’. The figure shows that VR sites with uncut aggregate have greater areas of influence - retaining 23% of the area in aggregates results in 51% influence, compared to only 6% in the clearcut site. Figure produced by Robyn Scott.

With variable retention in Tasmania, areas within one co-dominant tree height of long-term retention are defined as being under forest influence, and more than 50% of the harvested area is required to be under forest influence for a site to qualify as variable retention silviculture (Figure 11). A ‘forest influence calculator’ GIS tool assists planners with site planning to meet the forest influence target (Scott, 2008) and aggregates and other adjacent areas of ‘forest providing influence’ are mapped into the GIS to ensure that they are retained for the entire rotation. On Vancouver Island, the forest influence target is defined slightly differently, in that aggregates are able to ‘influence themselves’ so that >50% of the cutblock, including aggregates, needs to be within one tree height of long-term retention (Beese et al., 2003). Perhaps because the ecological understanding of forest influence is rather poor, the concept is not widely understood or applied in US application of VR, although in some cases there are guidelines for maximum distances between retention trees or aggregates (see Chapter 2.3.3).

The use of one-tree-height from codominant canopy trees to define forest influence for VR purposes is useful for determining harvesting layouts that meet VR criteria. The definition in part arose as a method to distinguish VR from clearcutting, based on Keenan and Kimmons’ (1993) definition of clearcutting. This is based on the degree of removal of forest influence
from surrounding uncut forest, such that “the minimum size of opening that constitutes a clearcut varies with the height of the surrounding forest, and is roughly equal to an area greater than about four tree heights in diameter”. This translates to the majority (i.e. >50%) of a harvested area being beyond one-tree height. However, in practice, different taxonomic groups and individual species are likely to vary greatly in their dispersal abilities and thus the distances they can traverse to recolonise harvested areas from unlogged forest. Canopy height is likely to be relevant to overstorey seed dispersal and microclimatic conditions, but may not be directly scaled to recolonisation by the majority of forest biodiversity. Using the case of Tasmanian wet eucalypt forest where tree heights can vary from approximately 40 m to 70 m, the forest influence rule will allow much wider harvested areas (<160 m vs. < 280 m in these examples) in taller forests. Understanding the scale that different types of biodiversity will be influenced by uncut edges is therefore important.

Much of the focus on forest influence (sometimes described as an ‘edge effect’) has been with regards to its effect on the growth of commercial tree species, either by suppressing growth and/or survival, or by providing a seed source for regeneration (e.g. Kreyling et al., 2008; LePage et al., 2000; Martínez Pastur et al., 2010 in press; Palik et al., 2003). This may relate to competition for light, water and nutrients, and potentially allelopathic interactions (Rose et al., 1983). There has been much less research attention given to other forest plants, animals and fungi, with most forest edge effects studies focusing on gradients into unharvested forests. Most of the research in harvested areas of silvicultural trials tends to focus on average conditions in stands rather than exploring gradients from edges.

There are different possible mechanisms for forest influence. For example, the presence of certain ECM fungi in harvested areas is likely to be directly associated with the roots of retention trees, thus limiting the distance into harvested areas where they might be able to inoculate seedlings (Luoma et al., 2006). Forest influence is likely to be strongly related to dispersal distances for many species of plants, animals and fungi (e.g. Tabor et al., 2007). Microclimatic amelioration from retained trees and edges will also be important for certain species, e.g. cryptogams (Dynesius et al., 2008). Thus in some cases these factors will relate to the canopy height of trees, but in many cases they may not.

The nature of the retention will impact its functional ability to provide forest influence. Individual trees in dispersed retention may provide seed sources for tree re-establishment in harvested areas. They may also facilitate dispersal of any animals (vertebrate or invertebrate), fungi or epiphytic plants they are hosting. By ‘lifeboating’ a greater variety of species, aggregates are thus expected to serve greater overall function in facilitating re-colonisation of harvested areas, although certain species could be advantaged by the more even distribution of trees associated with dispersed retention, and the associated greater amelioration of microclimatic conditions in harvested areas (Aubry et al., 2009). Mixed retention, where both aggregates and dispersed trees are retained, combines the advantages of both systems.

With Tasmanian dispersed retention, epiphytic bryophytes and lichens on retained old-growth *Eucalyptus obliqua* trees often did not survive the altered conditions following clearcutting with a regeneration burn, thereby compromising their ability to provide propagules or fragments for re-establishment of the harvested stand (Forestry Tasmania, 2009; Kantvilas and Jarman, 2006). However dispersed trees were thought to provide habitat for some corticolous bryophyte species at DEMO, which combined with microclimatic differences, less logging slash and lower disturbance to the forest floor, were probably responsible for greater persistence of bryophytes in dispersed retention than the harvested areas of aggregated retention treatments (Dovciak et al., 2006). Retained tree densities are expected to impact the degree of forest influence with dispersed retention. A study of dispersal of canopy lichens
found a relationship between cyanolichen litter biomass and the number of retention trees (Peck and McCune, 1997). Biomass of alectorioid lichens was also higher in stands with retention trees. Compared to dispersed retention, aggregates contain a greater variety of habitats including undisturbed understorey, leaf litter and soil, and have microclimatic conditions more similar to unlogged forest.

With aggregated retention, aggregate size, shape and position will affect their functionality. Small isolated aggregates will by nature by edge and area affected habitat for some forest biodiversity (e.g. Aubry et al., 2009; Baker et al., 2009b; Lefort and Grove, 2009; Strutt, 2007), as well as being more susceptible to windthrow (Jonsson et al., 2007; Scott and Mitchell, 2005) and regeneration burn impacts (McElwee and Baker, 2009). These factors may thus compromise their ability to retain species and in turn limit their function as a source of re-introduction. Compared to small or narrow aggregates, intact harvest unit boundaries may provide greater functionality as a source of dispersing individuals and propagules. Better understanding of the relative functionality of dispersed trees, aggregates of various sizes and intact forest edges, both for retaining biodiversity within stands, and for facilitating recolonisation of harvested areas, would assist forest managers to design variable retention harvest layouts. For example, for a given level of retention, smaller aggregates result in a higher proportion of a site being within one-tree-height of ‘forest influence’ (Figure 12). However, the theoretical level of forest influence needs to be considered within the context of its functionality in practice, and in some cases larger aggregates and somewhat lower levels of forest influence may be desirable. There has been a trend towards using larger aggregates and less forest influence in both Tasmania and the PNW for these reasons. However, while there is science to justify this from the point of view of improved quality of the retention, the subsequent impacts on species abilities to recolonise harvested areas are largely unknown.

Figure 12. A variable retention site with 23% retention illustrates the impact of aggregate size on the amount of forest influence. Sites with smaller aggregates have higher levels of calculated forest influence. However smaller aggregates are more edge-affected and susceptible to windthrow and regeneration burn impact. Figure produced by Robyn Scott.

Distance from edges or individual trees has been relatively well investigated for ectomycorrhizal (ECM) fungi. One study by Jones et al. (Jones et al., 2008) of ECM fungi in western hemlock forests on Vancouver Is. compared different aggregate sizes to intact forest, and distances of 10 m and 20 m into harvested areas adjacent to the three aggregate sizes, four to six months after harvest. The ECM fungal richness and diversity did not differ between the aggregates and unlogged control, regardless of aggregate size. The influence of patches disappeared by 10 m into the harvested area regardless of edge type, indicating
narrow forest influence for ECM fungi. However, ECM species richness at the uncut edges of the smallest (5 m diameter) aggregates was slightly lower than for larger aggregate sizes. The authors therefore recommended that patch sizes should be at least 10 m in diameter, but also noted that since the edge:area ratio of smaller patches is higher, more small patches of at least 10 m diameter would be more effective than a few large patches in supplying ECM inoculum to seedlings in adjacent harvested areas. Luoma et al. (2006) found that the richness per unit area of ECM fungi declined with distance from dispersed Douglas-fir tree boles in relation to the decline in root density. This appeared to be scaled to the canopy drip-line, with 32% fewer fungal types in outside-dripline soil cores than with inside-dripline cores. This distance corresponded to approximately 4-5 m from tree boles. Kranabetter (1999) found paper birch seedlings next to refuge trees in clearcuts had equivalent ECM fungal richness to seedling next to mature trees in unlogged forest. Cline et al. (2005) also found higher richness and diversity of ECM fungi, and composition more similar to mature trees, on planted seedlings within 6 m of residual Douglas-fir trees in dispersed retention sites than beyond 16 m from trees. Seedlings outside the rooting zone of mature trees had lower richness in both cases, although richness reduced by 38% in clearcuts compared to only 18% in forest. Durall et al. (1999) found ECM fungal richness on seedlings decreased slightly at increasing distances from cutblock edges, with maximum richness within 7 m from forest edge. Outerbridge and Trofymow (2004) looked at ECM fungi associated with planted Douglas-fir in aggregated retention sites of both old-growth and second-growth stand ages. The percentage root colonization and number of fungal morphotypes declined strongly with distance from aggregates, suggesting lower fungal inoculum further away from retained mature trees. The age of retention also appeared to impact inoculum potential, with higher root colonization and numbers of morphotypes with old-growth than second-growth. Approximately one third of the morphotypes were unique to old-growth. The authors hypothesize that ECM fungal dispersal into cut areas may be more effective from old-growth trees because of the presence of associated dispersal agents such as mushroom-eating squirrels or molluscs.

Harper et al. (2005) proposed that the strength and distance of influence effects of unharvested forest dominated by earlier-successional species would be less than that for forest dominated by late-successional species. In Tasmania, wildfires in younger forests with a wet sclerophyll understorey are likely to both be more frequent (Jackson, 1968), but also more likely to be stand-replacing, compared to fires in older mixed forests that are more likely to be non-stand-replacing (Turner et al. 2009). Species associated with younger-successional forest may therefore have evolved to be less reliant on unburnt fire skips as sources for recolonisation. Wet sclerophyll plant species do appear to recolonise harvested areas much more readily (often from a soil seed bank) than rainforest plants (Garandel et al., 2009; Hindrum, 2009). It would be interesting to determine whether forest successional age has less impact on plant recolonisation in the more recently glaciated PNW forests.

Much of the focus with variable retention has been on maintaining structures and species from the old forests within stands. However it is important to recognise that VR harvesting patterns will also impact early-seral species. Many early-seral species have probably evolved to occupy early-seral habitat conditions supplemented with natural legacies from the previous stand (Swanson et al., 2010). So while VR harvesting may not be expected to greatly disadvantage early-seral species, this subject needs to be investigated further. For example fewer early-seral birds were recorded near edges of clearcuts in eastern USA, suggesting that some species will be advantaged by large openings (King and DeGraaf, 2000; Schlossberg and King, 2008). By contrast, two Australian studies did not find relationships with distance from edge into harvested areas for birds (Penny Atkinson and Richard Loyn, personal communication). As well as maintaining late-seral species, VR is intended to facilitate natural ecological assemblages in harvested areas. Harvesting and site preparation practices can
impact the habitat quality of harvested areas. In Tasmania, skid trails and cleared firebreaks have depauperate vascular plant communities, and plants are also strongly affected by the intensity of post-harvest regeneration burns (Hindrum, 2009). In the PNW, herbicide application is sometimes used to retard competing vegetation, thereby affecting not only communities of plants, but presumably also other associated biodiversity. Such site-preparation practices therefore have the potential to hinder the recolonisation of harvested areas, thereby compromising the functionality of forest influence.

One aspect of forest influence that is relatively well recognised is that deer and elk tend to preferentially browse more heavily nearer to the edges of openings, e.g. within approximately 200 m from edge (Marcot and Meretsky, 1983). Proximity of nearby forest may also impact species crossing between areas of mature forest, such as the northern flying squirrel which cannot cross wide stand-openings (Marcot and Meretsky, 1983).

One Tasmanian study of older clearcut areas found that rainforest trees continue to establish for approximately 15 years following harvesting, but that regeneration declines rapidly with distance from unlogged edges (Tabor et al., 2007) such that regeneration was limited beyond approximately 50 m. One bird-dispersed species had seedlings further into harvested areas than the three wind-dispersed species. In another study, these same species were rarely recorded one-year following harvesting, with regeneration of harvested areas primarily consisting of species that germinated from the soil seed bank (Garandel et al., 2009). By contrast, coppicing is much more important than soil seed banks in vascular plant regeneration in PNW forests. Most plants either readily coppice, or have good wind dispersal capabilities, meaning that vascular plant recolonisation is generally not terribly dispersal limited (Tom Spies, personal communication). However, in wildfire-burnt Douglas-fir forests of the PNW, seedling densities of the shade-tolerant species’ western hemlock and western red cedar were increased by the presence of remnant old-growth trees as seed sources (Keeton and Franklin, 2005; Wimberly and Spies, 2001). In a similar result to Australian research, vascular plants in harvested areas of DEMO aggregated retention treatments were found not to be significantly influenced by nearby aggregates in the years soon after harvesting (Nelson and Halpern, 2005), although gradients in microclimate were detected (Heithecker and Halpern, 2007). Comparing the retention patterns at DEMO, late-seral herbs were more commonly lost from the harvested areas of aggregated than dispersed treatments, although they were generally still found in the aggregates themselves (Aubry et al., 2009). Edge-gradient studies of plants in patchcuts at the MASS silvicultural trial on Vancouver Is. found a 5-10 m zone near edges with less regenerating trees and more shrubs (Bill Beese, personal communication), possibly because of shading of harvested areas. At Sicamous Creek, one plant increased in abundance in patch openings near south edges only, possibly because of increased moisture (Huggard and Vyse, 2002). Peck and McCune (1997) refer to unpublished data that showed an exponential decline in lichen litter fragments over a 50 m transect from a mature forest edge into a clearcut. They predict that lichen dispersal will be ineffective beyond 35 m, and further note that species with large litter fragments are likely to disperse shorter distances than species that rely on soredia or other, smaller propagules.

Forest influence on ground-active invertebrates was explored using transects into clearcuts at the HJ Andrews Experimental Forest. Changes in community composition were still apparent between 50 and 100m from edge, while 100 and 200 m sites were similar to one another and different from locations closer to the edge (Tim Work, personal communication). A study of carabid beetles along transects crossing edges from old-growth forest into clearcuts (Pearsall, 2003) found some mature-forest specialists appeared to have an edge effect of over 50 m into the clearcuts, with reasonable catch rates of two species remaining high until at least 75 m out of the forest along 125 m transects. In a study of staphylinid beetle responses immediately
following small gap cutting in Quebec, Klimaszewski et al. (2008) found twenty-four species that they considered forest specialists, because they were predominantly found in uncut controls, and were increasingly rare as the size of gaps increased. Since pitfall traps were located centrally to treatments, this equates to fewer mature-forest beetles with increasing distance from uncut forest. In Tasmania, ground-active beetle assemblages were not significantly different in harvested areas of aggregated retention sites than clearcuts (Baker et al., 2009b), although there was a trend for a slight shift towards uncut controls in an ordination. However it is possible that any differences may relate to differences in habitat conditions associated with patchier burns in the aggregated retention compared to the clearcut sites, and to shifts in abundance of young-forest affiliated beetles, rather than increases in abundance of mature-forest species because of greater proximity to retention.

Given the limited information about forest influence in relation to variable retention, comparisons of patchcuts to unlogged forest and clearcuts can provide some insights, since small openings are likely to have much greater forest influence overall for most species. Small mammals and birds in small patchcuts at Date Creek in NW British Columbia were more similar to uncut controls than clearcuts suggesting that forest influence effects in small gaps are sufficient to allow mature forest species to inhabit the cut areas (Steventon et al., 1998). Preliminary results of studies at the Sicamous Creek study in high elevation forests in British Columbia found generally very narrow zones of forest influence for biodiversity. Small 0.1 h patches often provided habitat for species from mature forest while 1 ha openings were similar to the 10 ha clearcuts. They conclude that the general rule-of-thumb for forest influence for VR using one or two tree heights from edge is not appropriate for most biodiversity, and advocate smaller distances between retained patches than are typically implemented.

The limited amount of research into forest influence has shown that proximity to retained forest does impact biodiversity. Therefore harvested areas of variable retention sites should gain different biological communities than clearcuts where much less of the site is within mature forest proximity. The available literature indicates that the distance of forest influence varies broadly among taxonomic groups, as well as between individual species within taxonomic groups. Other factors likely to relate to the strength and distance of forest influence include the successional age of the forest, the retention pattern (aggregated vs. dispersed) and sizes and shapes of aggregates, time since harvesting, slope and aspect, landscape position (e.g. riparian vs. upslope). Further research is needed to better understand these variables so that forest managers have better information to help with site planning.

3.4 Importance of early-seral forests for biodiversity

Early-seral (early-successional) forests are themselves very important for biodiversity, and there is a growing body of opinion amongst forest ecologists and conservation biologists that current PNW forestry practices are not catering for the habitat requirements of much early-successional biodiversity. The great emphasis on creating old-growth species and habitats in the PNW is beneficial for species dependent on mature and old-growth stand conditions. However, this emphasis may have been at the expense of early-seral species, many which are also undergoing population declines. This possibly arises from the assumption that the large areas of young regeneration forests on industrial land tenures adequately provides habitat for early-seral species. However, a recent paper (Swanson et al., 2010), and talks at a one-day ‘Early Seral Forest Workshop’ held at OSU in Corvallis in April 2010 http://ecoshare.info/projects/central-cascade-adaptive-management-partnership/workshops/early-seral-forest/, are questioning this assumption and emphasizing
that early-seral openings created by clearcutting are significantly different from natural early-seral habitats. Conservation of young-successional forests will likely take on increasing importance in the future once the subject has received more research attention. This topic is also of relevance to forest management in Australia.

After old-growth, structurally and compositionally diverse early-seral habitat is the ecosystem type that has suffered the next most severe decline in the PNW. Currently this habitat only makes up 2% of Western Oregon. Politics appears to play a major role in the focus on old-growth forests and species in the PNW, especially on federal land tenures, and may hinder management practices aimed at better catering for early-successional species. For example, the proposal to trial an entire watershed harvest (with riparian protection and retention of legacies), whilst having merit, is probably politically impossible. In the PNW, as for Australia, there appears to be ongoing mistrust of forest scientists, which hampers using certain silvicultural practices, even on a trial basis.

In stark contrast to federal land tenures, industrial Douglas-fir plantations are managed on short-rotations for timber production. Hence they are often considered to provide habitat conditions for early-seral forest species. However, there are important differences from natural wildfire-origin regeneration of this forest type. Following a wildfire, succession of plants, and germination and growth of Douglas-fir is much more gradual over an extended time period compared to industrial plantations where herbicide application and dense planting result in fast-growing trees that rapidly shade out any early-seral vegetation (Swanson et al., 2010). Industrial forests also retain few structural legacies, and herbicide used to kill understorey vegetation and hardwood trees limit vegetation diversity, with flow-on impacts to other biota.

A meta-analysis of the effects of logging on shrubland birds (Schlossberg and King, 2008) found that all seventeen species tested had higher abundances in the centers of clearcuts than edges. Another study (King and DeGraaf, 2000) compared birds between mature forest, shelterwood and clearcuts in New Hampshire. Overall species richness and diversity was highest in shelterwoods, however some specialized early-successional species were more common in clearcuts. These studies therefore suggest that clearcutting may be beneficial for some forest birds. King and DeGraaf (2000) noted that while species richness was higher at a stand-level with shelterwood, if this was used instead of clearcutting at all sites, species richness may be reduced at a landscape-level.

These findings have implications for application of variable retention silviculture. VR is not necessarily inconsistent with creating early-seral conditions, since natural disturbances leave biological legacies at the stand-level. In fact, the degree of structural variability is one of the differences between habitats produced by clearcutting compared to natural disturbance. If retention levels with VR silviculture are similar to the range of natural variability of the natural disturbance dynamics of that ecosystem, then conditions are likely to be suitable for many early-successional species. However, this assumption has not been tested. One of the characteristics of natural disturbances is the high degree of variation in spatial scale and severity (Baker et al., 2004). Disturbance size and intensity influences successional pathways (Turner et al., 1998). Thus it is possible that certain early-seral species may benefit from habitat conditions at the more extreme end of the spectrum. Given poor knowledge of habitat requirements of many early-seral species, employing a range of harvest unit sizes and retention levels across the landscape is a strategy which will assist in providing habitat for species with diverse habitat requirements.
This is an area that requires much more research, to understand whether variable retention will adequately provide for early-seral species at the same time as improving the habitat suitability of the stand for mature forest species. At the Warra Silvicultural Systems Trial in Tasmania, there was a non-significant trend for different ground-active beetle assemblages in the harvested areas of aggregated retention compared to clearcut treatments (Baker et al., 2009b). This appeared to be related to changes in assemblage composition of early-seral beetles, rather than the addition of late-successional species in aggregated retention treatments. This trend was possibly associated with differences in habitat conditions on the forest floor, since the regeneration burn at the aggregated retention treatments was much cooler and patchier than the uniform hot burns in the clearcut sites. However, more research would need to confirm these hypotheses. A study comparing ground-active beetles thirty-three-years after either clearcutting or wildfire found no differences in assemblage composition (Baker et al., 2004), however similar comparisons have not been made immediately after disturbance. Studies of vascular plants in burnt aggregates compared to adjacent burnt harvested areas one-year following disturbance found differences in species composition attributable to removal of seed sources and harvesting machinery disturbance preventing coppice-recovery of some species (Garandel et al., 2009). Research comparing recent natural disturbance (e.g. wildfire), variable retention and clearcutting is needed in both the PNW and Australia.

In the PNW, there is occasional use of forestry practices to specifically create early-seral habitat conditions to encourage deer and elk populations. For example, on the Grand Ronde tribal reservation in Oregon, elk meadows are deliberately created. Likewise, the private energy company Pacificorp are required to do ‘mitigation forestry’ to create wildlife habitat in compensation for areas of forest that were flooded to create hydroelectricity dams. Their work in Washington places an emphasis on creating forage conditions for deer and elk populations (Kirk Naylor, personal communication). They sow nutritious introduced forage grass and legume species after harvest. Once the planted trees and native understory species have become well established, they also utilize thinning to allow sufficient light to enter the stand to encourage species such as some of the native berries that these herbivores feed on. This mitigation forestry is performed on the basis that there is much less suitable forage for deer and elk than there was historically. This has occurred because of the emphasis on creating late-successional condition on nearby federal forests, in combination with management practices on industrial forests not producing optimal conditions. Apparently there is so little food in some winters that many animals starve, in spite of lower population levels than in the past. Deer and elk also have different dietary requirements, with deer requiring a higher quality and more digestible diet, with shrub and forb species being important. By contrast, quantity is more important than quality for elk. Early-seral habitats created for elk may provide habitat for fewer other early-seral species than high quality habitat developed for deer. Active management to retain elements important for other species (e.g. snags, coarse woody debris) is expected to maximize overall benefits for biodiversity, although more research is required in this area.

3.5 Lessons for Australia

- There are some ecological and social acceptability advantages of retaining dispersed as well as aggregated trees with VR. Although this was found not to be safe in Tasmanian wet old-growth forest, it may be worth considering including low numbers of dispersed trees if VR is used operationally in regrowth wet forests or other forest types. However, the logistics of conducting regeneration burns with retained trees needs consideration.
- Aggregates tend to be safer (e.g. snags can be retained safely), have advantages for the cost and ease of harvesting and have less impact on growth of regeneration. Large aggregates have advantages over small ones, especially further from edges. There is a
strong positive relationship between retention levels and biodiversity benefit for retaining species from the pre-harvest stand.

- Forestry practices should be guided by continued research into natural disturbance, e.g. to investigate whether retention has greater biodiversity benefits in later-successional forests.
- More research needs to be conducted comparing silvicultural regeneration to forests regenerating following natural disturbance to assess whether managed forests provide adequate habitat for early-seral biodiversity.
- Forest influence is still a poorly understood concept in need of further research. However, retention of mature forest habitats and structural legacies is likely to be very important in facilitating recolonisation of harvested variable retention sites by biodiversity associated with older forests.
- Well-designed and funded adaptive management programs can greatly assist changing forestry practices, and were central to the development of VR silviculture in both the PNW and Tasmania. However, adaptive management is not always particularly successful. It may be advisable to focus detailed active adaptive management programs on topics of most importance, but continue to use monitoring, reporting and feedback to assist adaptive management more generally.
4 Resolving conflicts between the timber industry and environmental groups

Forestry practices in Australia receive high levels of public scrutiny. Like Canada and USA, this can lead to conflicts with environmental groups including protests, blockades, court cases and market campaigns. USA experiences ongoing conflict over forest management, especially in relation to federal forests. By contrast, Canada provides a number of examples of successful negotiations between the forest industry and environmental groups (E-NGO’s) that have improved forest management practices at the same time as allowing for continued timber harvesting. Given comparable ongoing debate in Australia, the Canadian approaches may provide some useful lessons.

4.1 The NW Forest Plan

Forest management leads to continued conflict between some forest management agencies and E-NGO’s in western USA. However, environmental groups appear to target federal forests more often than other land tenures, leading to distinct dichotomy in allowable management practices. In general terms, the result is very little forest management on federal tenures which are now largely managed for conservation objectives, intermediate levels on state forests which are managed concurrently for timber, conservation and recreation, and relatively very intense management on industrial forests which are managed for timber and economic objectives (Von Hagen, 2009).

Federal legislation such as the Endangered Species Act appears to be a major driver of practices on federal forests; and listing of the northern spotted owl resulted in adoption of the NW Forest Plan in 1994 on federal forests managed by several agencies (United States Department of Agriculture and United States Department of Interior, 1994). President Bill Clinton convened a forest conference and interdisciplinary working group to develop a policy for management of more than twenty-four million acres of public land in California, Washington and Oregon that fell within the range of the northern spotted owl. The Forest Ecosystem Management Assessment Team (FEMAT) was an interagency, interdisciplinary team of expert scientists, economists, sociologists and others. They produced a report providing detailed assessment of ten options for management. Following a period of public consultation, Option Nine was adopted, which was considered to provide the best mix of conservation and timber production whilst being scientifically credible and legally defensible (McAlpine et al., 2007). Under the plan, land was allocated into one of several zones: late-successional reserves (30%) riparian reserves (11%), matrix areas (16%). Adaptive management areas (6%), wilderness areas and National Parks and designated Wild and Scenic Rivers (30%) and administratively withdrawn lands and those with unstable or low productivity soils (6%) (McAlpine et al., 2007).

Under the plan, timber harvesting was to have been allowed on matrix lands and in adaptive management areas. However, in practice, timber harvesting plans proved not to be immune from legal challenge, and the NW Forest Plan did not solve the dilemma about how to manage forests, or stop acrimony over forest harvesting (Von Hagen, 2009). Because of the legislative framework, harvest plans on federal forests are especially sensitive to legal challenge. In practice, this has made it impractical to propose regeneration harvests, since legal action will probably prevent harvesting after years of work has gone into developing the timber harvesting plan. Controversy over management on national forests was fuelled by the 1995 ‘salvage rider’ legislation that was enacted following huge wildfires in Western US national forests in 1994. This legislation directed the Forest Service to increase salvage logging of dead or diseased trees in the national forests. It also exempted salvage sales from
administrative appeals, limited the time available for judicial review, and eased environmental planning procedures during a sixteen-month ‘emergency’ period. Congress also ordered the release of timber that had been suspended or cancelled due to endangered species conflicts. This legislation immediately lead to controversy and put the Forest Service in a position of being challenged in court by both E-NGO’s over negative conservation implications, and by the forest products industry, who claimed that the law was not being following effectively. The ‘salvage rider’ is considered to have resulted in ongoing mistrust between the Forest Service, the timber industry and E-NGO’s. Public backlash and legal challenges sent a clear signal that significant additional harvest of old and mature forests could not occur without unacceptable levels of social protest. In US national forests, the ‘burden of proof’ has shifted, so that one needs to prove that harvesting will not be a threat to biodiversity to be allowed to harvest, compared to previously where opponents had to prove that it would pose a threat in order to prevent logging. Consequently, areas that should have been accessible for harvesting under the NW Forest Plan were in practice rendered unavailable (Jerry Franklin, personal communication). Currently there is little or no harvesting on federal forests, although variable density thinning (Wilson and Puettmann, 2007) is being used in some cases to accelerate the development of large diameter trees and late-successional structural conditions.

The NW Forest Plan has therefore resulted in unforeseen consequences including lower timber sales and fewer jobs than expected, which has had important societal implications. There is also concern over increased risk of large fires as a result of increased fuel loads as a result of fire exclusion and lack of management (McAlpine et al., 2007). Interestingly, the strong emphasis on encouraging old-growth characteristics in PNW forests is leading to concerns for certain early-seral forest communities amongst forest ecologists (see Chapter 3.4). Another perverse outcome is that many private forest owners are wary of managing forests to provide late-successional habitat in case this attracts endangered species or otherwise compromises their ability to manage their lands according to their personal objectives (Von Hagen, 2009). It seems that lack of trust for federal management agencies, forest managers and forest scientists has resulted in a situation where the timber harvesting and adaptive management objectives of the NW Forest Plan have not been realized. Because of the strong dichotomy of land management practices on public and private forests, and most of the burden for threatened species recovery falling on federal lands, there are continued concerns for biodiversity conservation of forest-dependent species in western USA. Hence, while the NW Forest Plan has successfully met many of its objectives (Von Hagen, 2009), it has not been successful in ending conflicts over forest management. Whilst there was a public consultation phase, the process was driven almost entirely by government rather than actively collaborating with environmental groups. Hence it provides an interesting contrast to several Canadian examples which employed a range of methods to engage with the environmental community.

4.2 The Glaze Forest Restoration Project

The Glaze Forest Restoration Project is a collaboration between E-NGO’s (in particular Oregon Wild), the Forest Service and the timber industry. These groups are working together on a 1,200 acre area of eastside ponderosa pine, aspen and riparian areas on federal forest land. Oregon Wild is an environmental group who traditionally sought to stop logging via court injunctions, but are now working collaboratively with the Forest Service to do some variable density thinning and planned burning treatments. The aims of the Glaze Forest Project are to restore the area so it can function more naturally in a fire-prone environment, and to “break barriers of mistrust and create a template on how people with diverse viewpoints can cooperate to achieve ecosystem, community and economic values”. Interestingly, the project was instigated by Oregon Wild, and the Forest Service were
apparently initially reticent to get involved. The project is an example of how groups that traditionally fought each other can work together collaboratively. Oregon Wild previously put approximately 90% of their effort into fighting the Forest Service in court to prevent harvesting, but this situation has now shifted to approximately 80% collaboration and only 20% fighting (Tim Lillebo, Oregon Wild, personal communication).

Restoration of the Glaze Meadow Forest was a pilot study which involved a huge amount of discussion, negotiation and community engagement, including getting advice from scientists such as Jerry Franklin and Norm Johnston. Groups of both forest industry and environmentalists worked together to mark the trees to be thinned and retained, which along with some playful bickering, worked well and helped foster some respect amongst traditional opponents. Although a lot of effort was put into this first small site, the model has since successfully been transferred to much bigger areas without nearly as much effort. In this case the harvesting revenue was put into restoration activities at the site, which probably helped get the environmental community on board. However, if these initial projects help build trust and demonstrate that some management intervention (e.g. thinning and/or burning) may be more ecologically appropriate than locking all the forest up, then E-NGO’s might be more willing to allow management activities in the future where the timber revenues are directed elsewhere.

4.3 Examples of resolving conflicts in Canada

Canada appears to have been particularly successful at brokering agreements with environmental groups. Examples are the Canadian Boreal Forest Agreement and the BC Coastal Forest Project where MacMillan Bloedel phased in VR in place of clearcutting. It is hard to say exactly why these projects have been successful while harvesting of US Federal and Tasmanian State forests are still subject to controversy. However, processes of directly engaging with environmental groups, if done carefully, may be more successful than attempts at resolving conflict where the main opposing groups are less directly involved. In the case of the Canadian Boreal Forest Agreement, extended mediated negotiations were conducted secretly away from media pressure and without government involvement. In the case of the BC Coastal Forest Project, having a science-based approach guided by workshops with independent scientists nominated by both industry and environmental groups seemed a successful approach to developing new ecological-based strategy for forest management without getting railroaded by politics. Neither of these examples would have been possible without commitment from both the forest industry and environmental groups to work together and make some compromises.

4.3.1 BC Coastal Forest Project

In 1998, MacMillan Bloedel, one of British Columbia’s largest forestry companies, announced that it would phase out clearcutting in all of its BC timber operations, and use landscape stewardship zoning to determine the allowable intensity of management. Variable retention was phased in as the main silvicultural system on their land tenure (Beese et al., 2003). Under the leadership of the newly appointed president Tom Stephens, MacMillan Bloedel took this action in response to market campaigns by E-NGO’s that opposed their use of clearcutting, with the result that the company was losing customers. MacMillan Bloedel invested considerable funds and effort into their forest project, which along with strong support from higher management, and an outward looking approach of engaging external scientists and the community, ensured its success. Although changes have occurred with subsequent management, the overall approach of ecosystem forest management has been robust to subsequent buy-outs by Weyerhaeuser and Western Forest Products.
The rapid change to 100% VR with a clearly transparent scientific committee and rigorous adaptive management process was robust to public scrutiny. MacMillan Bloedel engaged a ten to fourteen member scientific panel which included nominated representatives from E-NGO’s; up to half the scientists were nominated by environmental organisations and half from industry, although this varied by year. E-NGO representatives were able to attend annual ‘critique workshops’ as observers, although their actual participation in the meetings was limited, so they relied on their nominated scientists to participate. This restricted the talks to topics of science, where it was relatively easy to reach agreement, because the scientists could rein in their peers if proposals could not be justified ecologically. Most importantly, it was a scientific process rather than a political one. Strict frames of reference that excluded politics from discussion meant that the committee worked together collaboratively. Aspects of the process such as the use of mediators, very formal meeting structures, and the availability of transcripts ensured very high levels of transparency and rigor. For example, the company biologists Bill Beese and Glen Dunsworth gave talks at the beginning of each workshop, and were present to provide clarification, but were not allowed to interrupt the process with their own opinions. However, there were opportunities during the talks, and time at the end of the day in the summing up sessions, for questions and comments from observers including company and industry representatives and E-NGO observers. After the annual workshops, MacMillan Bloedel/Weyerhaeuser formally reported their proposed response to the issues discussed. Actual progress was then reported to the science panel at the following years meeting.

Training was a very important aspect to the project. This included explaining the rationale behind using VR instead of clearcutting so everyone understood the social and biodiversity benefits, detailed training about what structural and biological legacies to leave behind, and training about harvesting practices including safety. There was a big emphasis on safety, since variable retention was considered to be potentially much more dangerous to logging crews than clearcutting. However the strong emphasis and training about safety meant that the company’s safety record actually improved during the phase-in of VR.

Another important aspect to the BC Coastal Forest Project was their adaptive management framework which included rigorous monitoring and research programs. This included engaging external consultants to conduct implementation monitoring and collaborating with external scientists to develop programs for biodiversity research and monitoring (Bunnell et al., 2003; Bunnell and Dunsworth, 2004; Kremsater et al., 2003). Two large long-term silvicultural experiments were established; the Montane Alternative Silvicultural Systems (MASS, Beese and Arnott, 1999) and Variable Retention Adaptive Management (VRAM, Beese et al., 2005) trials.

4.3.2 Canadian Boreal Forest Agreement
The Canadian Boreal Forest Agreement http://www.canadianborealforestagreement.com/ was announced in May 2010. It is an agreement between twenty-one forest products companies (all members of the Forest Products Association of Canada) and nine E-NGO’s. It relates to more than seventy-two million hectares of public forests across Canada from British Columbia to Newfoundland, and initially arose out of concerns for habitat for threatened woodland caribou. The 2010 Agreement is not a final solution. Rather it sets a three-year agenda for future change with goals, milestones, annual reviews and mechanisms to allow for future extensions. Hence, there is some risk that negotiations may fail, although this is unlikely as the agreement brokers good working relationships between the different stakeholders.
The agreement initially resulted in the suspension of harvesting on nearly twenty-nine million hectares of boreal forest. Use of ecosystem-based management on areas available for timber production will provide further environmental benefits. In exchange, E-NGO's suspended market campaigns against the companies participating in the agreement. The funding that environmental groups previously spent on market campaigns will actually be redirected to finding solutions as part of the agreement process. If the forestry companies meet their end of the bargain, the E-NGO's will actually advocate buying their timber as being sustainably grown.

The negotiating team only included five E-NGO and five companies, rather than all the signatories under the agreement, and was facilitated by professional mediators. Negotiations were done in secret, and the media, company staff and government were not alerted to the fact that discussions were ongoing, although there was some engagement with First Nations representatives. This facilitated an extended negotiation process over two years, without interference and scrutiny from the media or the government. However, now that the agreement has been signed, there is a strong emphasis on reaching out to governments and communities to seek their involvement and support for the work that is being undertaken.

4.3.3 Other Canadian agreements

Another successful negotiation between forest industry and environmental movement was the Great Bear Rainforest Land Use Decision in coastal BC and the Haida Gwaii islands [http://www.forestethics.org/downloads/WWFpaper.pdf]. The 2006 agreement resulted from collaborative efforts between the provincial government, environmental organizations, logging companies, hunters and First Nations people. The agreement followed intense conflicts and protests about logging by environmental groups and First Nations people, and resulted in an extensive area of reserves as well as allowing ecosystem based management for timber harvesting in other areas.

Similar conflicts arose over logging of provincial lands in Clayoquot Sound on the west coast of Vancouver Island, culminating in 1993 when over 900 people were arrested trying to prevent logging. In response, the Clayoquot Sound Land Use Decision was developed [http://ilmbwww.gov.bc.ca/slrp/lrmp/nanaimo/clayoquot_sound/index.html]. An important part of the process was establishing the Scientific Panel for Sustainable Forest Practices in Clayoquot. The nineteen-member panel's mandate was to develop world-class standards for sustainable forest management by combining traditional and scientific knowledge. The panel produced five reports, containing over 170 recommendations for sustainable forest practices in Clayoquot Sound. In 1995, the B.C. government announced that it would fully implement all of the Scientific Panel's recommendations. The agreement reduced the area available for harvesting to 45%, and ensured sustainable ecosystem management, including banning clearcutting in favour of variable retention silviculture as an approach to maintaining ecosystem integrity (Clayoquot Sound Scientific Panel, 1995).

4.4 Use of variable retention silviculture

Using variable retention instead of clearcutting is one potential way of balancing social, ecological and timber objectives, and is thus a potential means of getting greater public support for the forest industry. Variable retention is used on many of the lands available for timber harvesting under the above Canadian agreements. In Australia, Forestry Tasmania has recently started implementing aggregated retention in most wet old-growth forests, although clearcutting is still practiced in regrowth wet forests, and partial cutting methods are employed in other forest types. Social acceptability research points to improved social
acceptability of VR compared to clearcutting (Ford et al., 2009; Ribe, 2006) as does operational experience with using VR, as was indicated in the VR surveys (Chapter 2).

It is interesting to consider the evolution of variable retention in Canada, USA and Tasmania. VR silviculture system appears to have been implemented broadly in Vancouver Island and Alberta, resulting in reduced conflicts with environmental groups. These Canadian examples contrast greatly with the PNW of the USA, where VR is less commonly used. There is a different political climate in the US, and acceptability of forest management activities appears to vary widely according to land tenure. Clearcutting is relatively acceptable on industrial lands, while little or no cutting is acceptable on federal lands. The Northwest Forest Plan included provisions for ≥15% retention by area in those areas designated as Matrix forest. As previously noted, in practice, the high success rate of court injunctions preventing harvesting means that thinning to accelerate old-growth characteristics is the only harvesting activity that occurs in PNW federal lands. VR is used on state forests in western USA.

Also in contrast with the situation in Vancouver Island, VR is currently used in a small proportion of the overall harvested area in Tasmania. Clearcutting has still been the predominant silvicultural system in wet eucalypt forests, since aggregated retention is mostly used in the small proportion of old-growth forests that were available for harvesting. Since harvesting of old-growth forests and clearcutting are both unpopular with sections of the Tasmanian community, continuation of these practices is likely to have contributed to the persistent campaigning by environmental groups, resulting in negotiations that may lead to phasing out harvesting on most public native forests. By contrast, it appears that much broader application of VR on Vancouver Island, combined with the approaches taken to negotiate agreements that included significant areas of additional reserves, appeared sufficient to temper opposition from environmental groups. Forestry Tasmania engaged an external scientific panel to assist the phase-in of VR (Forestry Tasmania, 2009). Whilst being well-placed to give expert independent advice, members were all appointed by Forestry Tasmania, and environmental organisations have never had any opportunity to participate in the process. This may be an influence on the greater acceptability for VR in British Columbia than Tasmania.

Currently some companies on Vancouver Island appear to be moving away from using VR, and use of clearcutting is increasing. Industry should carefully consider the risk that widespread return to clearcutting could result in a return to the conflicts that lead to development of VR initially. The fact that most companies moved to broad use of VR is relevant, since at a landscape scale it is the collective practices of all organizations that leads to general public perceptions about harvesting practices.

4.5 Lessons for Australia

In the past in Australia, the forest conflict has usually been dealt with politically, resulting in more permanent reserves, and more intensive management in remaining state forest. Instead of resolving the debate, the environmental movement would move on to fighting over the next area they wanted to ‘save’. This has not always resulted in optimal environmental outcomes, and it has been argued that “regional biodiversity conservation goals may be better achieved by implementing sustainable forest management practices across all ownerships and involving all stakeholders and the broader community” (McAlpine et al., 2007).

At the time of writing, the Tasmanian timber industry and E-NGO’s have signed a statement of principles regarding working towards an agreement to resolve the conflict over forestry. These principles include ceasing logging in contentious areas of ‘high conservation value’
forest, and a move towards a largely plantation-based forest industry. It is too early to say whether this process will successfully resolve the forest conflict in Tasmania. The negotiations, while conducted behind closed doors, still received pressure from government and the media to find a quick solution. Also, Forestry Tasmania, the management agency responsible for management of native forests on state land, was not a signatory to the agreement. Hence one of the key stakeholders was largely excluded from the process. The negotiations appeared to be largely based on political grounds and pragmatic approaches to attempting to resolve the conflict. Silviculture and science-based understanding of ecology and the conservation requirements for different forest ecosystem types appeared not to have played a role in the discussions.

Time will tell whether, given these potential shortcomings, the current negotiations can be successful in resolving a 25-year-old conflict. The 1997 Regional Forest Agreement had intended to resolve the forest debate in Tasmania by providing security for the industry whilst permanently reserving forest to meet targets for a Comprehensive, Adequate and Representative (CAR) reserve system along with other measures to facilitate conservation of forest-dependent biodiversity (Australian Government and Tasmanian Government, 1997). It is noteworthy that this agreement did not end the forestry debate in Tasmania. It is also interesting, given the focus of the Tasmanian E-NGO’s on protecting wet eucalypt forests (a well reserved ecosystem type), that targets have not yet been achieved for reservation of some of the dryer forest vegetation communities because there was insufficient representation on public land. Although the Government has provided incentives for private landowners to protect these forests, this has not been enforceable. This provides an example of how there can be disparity between the public debate over the environment and the issues of greatest conservation importance.

It will be interesting to see whether moving to a largely plantation-based industry will in fact end the forestry debate. There has been much media attention in the past airing unfounded accusations that plantation forestry poisons waterways, either because of chemical-use or the leaf-chemistry of the planted species. There has been debate over whether it is appropriate to convert farmland into forestry plantations because of impacts on rural communities. The perceived water requirements of plantations and flow-on (or lack thereof!) impacts on water available to farms and communities downstream has also received attention. It is hard to imagine that these issues will go away, especially as phasing-out of native forests will likely result in expansion of the area and intensity of plantation forestry.

Canada in particular provides some successful examples, described above, of negotiating agreements to resolve conflicts between environmental and forest industry groups. Given some of the E-NGO's that were involved in Canada, there is no reason why similar negotiations could not be successful in Australia. Parties involved in the Canadian agreements demonstrated the will to work together, and were prepared to make concessions towards the other side. In Canada, there were some smaller and more extreme E-NGO's that were not party to the various agreements and processes, and continued to place pressure on the timber industry. However, this was largely ineffective, since the fact that the larger E-NGO’s had publicly stated their support for agreed forest management activities meant that the dissenters were seen as extremists and not taken too seriously by the public.

However, one important difference is the very high recovery rates for high value sawlogs from Canadian forests compared to the low recoveries of lower value eucalypt sawlogs in Australia, which leads to the perception of a pulp-driven industry. This is presumably related to the widespread opinion in Australia that pulp in particular, and also many of the sawn products from native forests (especially old-growth forests), should be produced from
plantations. It may therefore be much more difficult to broker support for continued broad-scale harvesting of native forests in Australia.
5 Conclusions

Western USA and Canada provide a number of excellent examples of ecologically sustainable forest management. Variable retention is used across the region, and has been proven to be highly adaptable to various forest types, ages and natural disturbance regimes. Research and adaptive management have been central to the evolution of VR and forestry practices more broadly. There is an increasing emphasis on ecologically sustainable forest management, as evidenced by widespread certification of timber products. However, certification alone is not sufficient to prevent conflicts between the timber industry and environmental groups. Variable retention can play an important role in achieving improved biodiversity outcomes along with greater social acceptability for timber harvesting.

The biodiversity benefits of variable retention are being clearly shown in research trials in Canada (e.g. MASS, VRAM, EMEND), USA (e.g. DEMO), Tasmania (Warra SST) and Tierra del Fuego. Results are species-specific, but in general the aggregated retention form of VR appears to be beneficial for more plants, animals and fungi than the dispersed retention form. This should be considered carefully by forestry professionals, since there may be trade-offs between advantages of aggregated retention for biodiversity versus some advantages of dispersed retention for visual outcomes. Compared to retaining single scattered overstorey trees, aggregates also contain undisturbed soil, leaf litter and understorey vegetation, and snags can usually be safely retained in aggregate centres. Aggregates also have buffered microclimatic conditions much more similar to undisturbed mature forest. Aggregates thereby provide habitat for many more species of animals and plants, than are recorded in dispersed retention treatments. Mixed retention, where both aggregates and dispersed trees are retained, combines the advantages of these two systems.

Adaptive management of VR is ongoing and will help to inform organizations about topics where there is currently some uncertainty. Future research into areas such as the relative long-term advantages of aggregates vs. dispersed trees, the ability of retention to provide ‘forest influence’ for recolonisation of harvested areas, and how to better cater for early-seral species as well as late-seral ones will all be important. Having formalized active adaptive management programs to tackle specific issues such as shifting from clearcutting to VR can be highly beneficial as long as this is backed up by the support of upper management and sufficient funding to make it work. Utilizing outside expertise was important to the success of VR implementation in many cases, as was training to ensure that staff understood the ecological objectives and how to go about achieving them. Greater collaboration amongst different organizations using VR internationally, and between forest managers and researchers, should be encouraged in order to fully capture research results and operational experience.

Broad-scale implementation of VR across Vancouver Is., combined with successful engagement with environmental groups has helped to shift away from the previous situation of protests and market campaigns aimed to stop harvesting. It is likely that the combined actions of several companies across most of the production forests on Vancouver Is. contributed to this success. It is heartening to see examples where conflicts have been diffused, and in some cases turned into collaborations. This report provides examples of approaches which may be tried in Australia to help diffuse ongoing dispute between environmental groups and the timber industry.
Acknowledgements

I would like to thank the many people who assisted my research program and fellowship at the World Forest Institute, and ensured that it was a wonderful experience. People were incredibly generous with their time and knowledge, and unfortunately it is not possible to thank everyone by name.

I am very grateful to WFI staff for facilitating my fellowship, in particular Sara Wu, Chandalin Bennett and Rick Zenn. Funding to make it possible was provided by Forest and Wood Products Australia, the Gottstein Trust, the Harry Merlo Foundation, Forestry Tasmania and the University of Tasmania. OSU provided courtesy faculty membership and access to library resources. Michigan Technical University funded airfares for me to visit Houghton.

I would like to thank the people and organizations that participated in my lengthy VR interviews: Jim Witiw (DMI, Alberta), Elston Dzus (Al-Pac, Alberta), Bill Beese (Western Forest Products, BC), Rick Monchak (Timberwest, BC), Brad Taylor (Iisaak Forest Resources Ltd., BC), Warren Warttig (Interfor, BC), Angus Brodie and Florian Deisenhofer (Washington Department of Natural Resources), Richard Pine (O’Neill Pine Company, Washington), Peter Hayes (Hyla Woods, Oregon), Ian Hayes and Jeff Brandt (Oregon Department of Forestry), Matt Ferenbacher (Pacific Forest Trust, Van Eck Oregon Forest), Robb Rempel and Sarah Billig (Mendocino Redwood Company, California). I am also grateful to Rob Ribe, Tim Wardlaw and Rebecca Ford for assisting with formulating survey hypotheses and questions. Special thanks go to Ralph Wessman, Rebecca MueSSLle and Mark Hurlburt for assisting with the onerous task of transcribing the interviews.

Site visits were very important to building my understanding of PNW forest ecology, research programs and harvesting practices. As well as field trips organised through the WFI Fellowship program, I am grateful to the following people for taking me in the field to visit sites of particular interest to my project: Kirk Naylor (Pacificorp), Richard Bigley, Angus Brodie and Florian Deisenhofer (Washington DNR), Bill Beese (Western Forest Products VR, MASS, VRAM), Louise de Montigny (STEMS), Brian D’anjou and Melissa Todd (Roberts Creek Silvicultural Trial), Rick Monchak (helicopter flight of Timberwest’s coastal BC operations), Doug Maguire (Siulus Thinning for Understorey Diversity Study and Umpqua DEMO installations), Tom Spies (HJ Andrews), Charlie Halpern, Tom Spies, Paul Anderson, Jim Lutz and Keith Aubry (Olympia DEMO site), Robb Rempel (Mendocino Redwood Company), Peter Hayes (Hyla Woods), Tim Lilbeo (Glaze Restoration Project), Wayne Auble (Tillamook State Forest), Bill Richards (Cedar Creek Watershed), Brad Taylor (Iisaak Forest Resources), Andy MacKinnon (Vancouver Is), John Spence, Jim Witiw, Jason Edwards and the EMEND team (DMI and EMEND, Alberta). Bill Beese, Jerry Franklin, Bryce Bancroft, Melissa Todd, Jeff Meggs, Rod Chimner and Sigrid Resh even extended their generosity to hosting me at their homes.

I would like to thank the many people I met with this year to discuss aspects of my project. They included, but are not limited to, Bryce Bancroft, John Stadt, Richard Pelletier, Scott Ferguson, Kirk Naylor, Bruce Marcot, Nathan Poage, Bob Deal, Tom Spies, Jerry Franklin, John Spence, Matthew Pyper, Tim Work, Andy MacKinnon, Bryce Bancroft, Tony Trofymow, Neville Winchester, Lee Humble, Isobel Pearsall, Sari Saunders, Melissa Todd, John Deal. Ashley Steel was very helpful in providing statistical advice about meta-analysis of forest influence affects on biodiversity.
Finally, I would like to express my gratitude to my Tasmanian employers (Forestry Tasmania and the University of Tasmania) and my family for supporting me being away for a whole year. I am especially grateful to my partner Gedgar who arranged a Fulbright Fellowship so that he could join me in the US.
Literature References


Strutt, O. (2007) *Edge effects on bryophytes in the retained aggregates of a harvested wet eucalypt forest coupe in southern Tasmania*. University of Tasmania, Hobart.


United States Department of Agriculture and United States Department of Interior (1994) *Standards and Guidelines for Management of Habitat for Late-successional and Old-growth Forest Related Species within the Range of the Northern Spotted Owl*. United States Department of Agriculture Forest Service and United States Department of Interior Bureau of Land Management, Portland, OR.


Appendix 1. Interview Questions

**Forest grower background**

1. Grower Name:

2. Land Tenure: Federal / State / Tribal / Private – Industrial / Private – small grower

3. Country and State:

4. Silvicultural systems used – note % area managed with each system, and reason for use (re. forest type, age, management objectives etc):

5. Certified? Y/N   If Yes, which scheme:

**Drivers for using VR**

6. What lead your organization to use VR silviculture?

7. What were the objectives for using VR?

8. Has certification resulted in changes to management? If so, how?
   And did it play a role in decisions relating to use of VR silviculture compared to other harvesting systems? Encourage/Inhibit/No major role

9. Are there incentives or constraints (e.g. requirements under legislation) that relate to choices regarding use of VR?

10. What silvicultural system is VR used in place of?
   Is the previous management technique still used on a proportion of your land tenure? If so, where and why? Why is VR not used more broadly in place of this silvicultural system?

11. What factor/s influence where to do VR, if not done on all sites?

12. Forest type/s managed with VR:
   Why is VR used in this/these forest type/s?

13. Forest age/s managed with VR:
   Why is VR used in this/these age class/es?

14. What, if any, areas of risk and uncertainty have been important when deciding which silvicultural system/s to implement?

**Variable Retention - implementation**

15. Area managed with VR methods:

16. Approximate annual VR cut (land area including aggregates/dispersed trees):
17. Systems used (note % of each if more than one)
   Aggregated/group retention
   Dispersed retention
   Mixed - Description and %s:
   Other VR approach – Describe:

18. What factors lead to choices about whether to leave retention as aggregated vs. dispersed trees?

19. Rotation period:

20. Average harvest unit size:

   **Retention and influence guidelines**

21. Are there specific retention targets? Y / N Specify:
    If not, what percentage of harvest unit area or BA is typically retained?

22. Are there guidelines for aggregate sizes? NA / Y / N. Specify:
    If not, what is the typical range of aggregate sizes.

23. Time period for retention? Entire rotation/ Indefinitely / ……. years / Not specified

24. Are there aggregate anchor / retention tree recommendations? Y / N Specify:
    What proportion of aggregates or retained trees would be anchored to maintain certain species, structures or habitats vs. being located for purely spatial or visual reasons?

25. Are there snag retention and/or creation guidelines? Y / N Specify:

26. Is ‘forest influence’ over harvested areas a factor considered in coupe planning? Y / N If so, how?
    Are there forest influence rules? Y / N. Specify:
    Or are there limits to the size and/or width of harvested areas?

27. Are retention and influence of equal relevance in designing site layouts? If not, which is more important?

28. To what extent do VR practices vary between sites? Similar / some variability / very variable.
    How, and why do they vary?

29. What factors have been most important in guiding VR implementation?

   **Adaptive management and monitoring**

30. How did you first learn about VR, and what have been your main sources of information?

31. How well informed do you think you are, between 1(uninformed) and 10 (very well informed)?

32. When was VR first used?
33. Is there a formalized adaptive management program? Y / N Details:
   If not formalized, has implementation of VR been an example of adaptive management? Y / N / Partially Describe:

34. Does your organization employ or contract conservation biologist/s? If so, what is their involvement with VR?

35. Are/were collaborations in place with external experts to facilitate VR practices? Y/N If so, were they: Very helpful / helpful / neutral / not particularly helpful / not at all helpful. Details:

36. Is there a program of research? Y / N Details:
   Is there a monitoring program? Y / N Details:
   What proportion of research and monitoring relates to ecological compared to other aspects of VR?

37. How/why have VR practices changed since first used?
   Have the results of research and monitoring played a role in this?

38. Has implementation of VR been successful? Y / N / Partially
   What factors have been influential to success/failure?

39. What have been the major challenges associated with VR compared to alternative silvicultural systems?

40. Have the objectives for VR changed since initial implementation? If so, how?

41. Has adoption of VR successfully achieved it's intended objectives? Yes / Partially / No / Unclear. Comments:

42. Are the ecological objectives for VR clearly stated and understood by all relevant personnel? What are they?

43. Do you think the system has been effective in maintaining structural complexity and biodiversity at the stand-level? Yes/Partially/No/Unclear Comments:

44. Has the adoption of VR changed social attitudes to forestry operations? Improved acceptability / No change / Uncertain. Describe:

45. Do social considerations influence VR harvest designs or other aspects of VR implementation? Yes / Partially / No. If so, how?

46. Is your organization likely to continue implementing VR in the medium to long-term? Y / N / Maybe. Comments:

47. What aspects of current VR practices could potentially benefit from being changed in the future and why?

48. What kinds of new information or incentives would facilitate implementation of VR? How might these be obtained?