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Monitoring the implementation of variable retention silviculture in wet eucalypt forest: A key element of successful adaptive management

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ABSTRACT

Variable retention (VR) is increasingly being used as an alternative to clearcutting in temperate and boreal forests. VR is an approach to harvesting and regeneration that aims to improve biodiversity and social outcomes over the subsequent rotation, while continuing to meet silvicultural and economic imperatives. Aggregated retention, a form of VR in which patches of unharvested forest are retained at harvest, has been used operationally in Tasmania's public oldgrowth wet eucalypt forests since 2007. Development of aggregated retention required articulation of goals and guidelines for implementation in the Tasmanian context. An extensive research and monitoring program, as well as close liaison between research, management and operational staff, facilitated the adaptive management process. These arrangements aimed to overcome operational challenges and ensure that silvicultural practices were consistent with the available science and expert judgement relating to biodiversity outcomes. The three over-arching ecological objectives for VR silviculture in Tasmania were: Objective 1, facilitating rapid re-establishment of mature forest biodiversity in the harvested area by providing forest influence over the majority of the harvested area; Objective 2, ensuring the retention (2a) and integrity (2b) of biological legacies; and Objective 3, creating favourable conditions for plant regeneration and animal habitat in the harvested area, with connectivity between retained forest edges and the regenerating stand. An individual VR harvest operation ('coupe') needed to meet all three objectives in order to receive an overall rating as having delivered the ecological goals of VR. Twelve criteria were then established for assessing attainment of specific aspects of these objectives in each VR coupe, and metrics were developed to score harvest outcomes against each of these criteria. We present the results from 33 coupes that were harvested and regenerated between 2004 and 2010. Coupes harvested early in the development of VR usually rated well against Objectives 1 and 2a, less well against Objective 2b and poorly against Objective 3. Broadcast regeneration burns are integral to successful eucalypt regeneration. However, they can be more challenging to contain within harvested areas in aggregated retention coupes compared to clearcuts, and initially there were unacceptable levels of fire damage to retained trees, while wide firebreaks damaged soils. Changes in coupe design, in firebreaking practices, and in regeneration burning procedures resulted in coupes rating well against all objectives by 2010. The articulation of clearly defined, documented and measurable ecological objectives accompanied by a transparent assessment process was a key component of the adaptive management process that resulted in successful operational implementation of this new silvicultural system. Elements of this approach could be adapted for application in any forest type worldwide.

1. Introduction

This paper describes implementation monitoring and adaptive management of variable retention for improved ecological outcomes in tall oldgrowth wet eucalypt forests (hereafter 'wet

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eucalypt forests') in Tasmania, Australia. Variable retention silviculture (VR), also known as retention forestry (Gustafsson et al., 2012) or green tree retention (Rosenvald and Lõhmus, 2008), is an approach to harvesting and regeneration in which strong emphasis is given to biodiversity outcomes and social acceptability without unduly compromising silvicultural performance or economic outcomes (Franklin et al., 1997; Neyland et al., 2012). VR approaches are guided by natural disturbances such as wildfire (Franklin et al., 1997; Franklin and MacMahon, 2000; Gustafsson et al., 2012). VR aims to provide long-term retention within harvest units of key structures (e.g. oldgrowth trees and decayed logs), species and habitats ('lifeboating of biological legacies'), and continuity of ecosystem structure, function, and species composition in the post-harvest forest (Franklin et al., 1997; Lindenmayer et al., 2012). The influence of the retained forest should then facilitate re-establishment of populations of animals, plants and fungi in harvested areas ('forest influence' Baker et al., 2013b).

Variable retention was initially developed in western USA and Canada more than twenty years ago (Franklin et al., 1997; Mitchell and Beese, 2002) and has been used in Tasmania for approximately ten years (Baker and Read, 2011). VR and similar retention forestry approaches are now widely practiced in temperate and boreal forests globally, often as an alternative to clearcutting (clearfelling), but also in forests traditionally managed using uneven-aged approaches (Gustafsson et al., 2012; Puettmann et al., 2015). Supported by numerous papers showing positive biodiversity responses relative to traditional silvicultural practices such as clearcutting (Rosenvald and Lõhmus, 2008; Gustafsson et al., 2012; Lindenmayer et al., 2012; Fedrowitz et al., 2014; Mori and Kitagawa, 2014; S.C. Baker et al., 2016), VR and related approaches have been advocated for use in approximately 85% of the world's forests (Lindenmayer et al., 2012).

In Tasmania, VR is primarily used in oldgrowth lowland wet eucalypt forests on public lands as an alternative to clearcutting in these forests, which was the subject of heated controversy and public protest (Baker, 2013). Partial cutting systems are used in dry and high-altitude forest types and clearcutting is still used in regrowth lowland wet forests in Tasmania. The Warra Silvicultural Systems Trial in southern Tasmania (Hickey et al., 2006) was set up to test various alternatives to clearcutting in wet eucalypt forests, and this Tasmanian research found positive responses by various taxa to VR compared to clearcutting, namely plants (Neyland and Jarman, 2011; S.C. Baker et al., 2016), bryophytes and lichens (Strutt, 2007; Kantvilas et al., 2015), mammals (Stephens et al., 2012), birds (Lefort and Grove, 2009), fungi (Gates et al., 2009), and ground-active beetles (S.C. Baker et al., 2009, 2016), validating use of the VR system in wet eucalypt forests. Based on research into biodiversity responses (summarised in Baker and Read, 2011) and other factors including safety, economics and social acceptability (Neyland et al., 2012), it was decided to use the aggregated retention form of VR (where undisturbed habitat is retained in patches) for operational implementation rather than dispersed retention (where only individual overstorey trees are retained). In contrast to North American and European forests, silviculture in Australian eucalypt forests requires large post-harvest canopy openings and high-intensity burning of logging debris to facilitate germination and growth of shade-intolerant eucalypts (Pryor, 1960; Neyland et al., 2009), with eucalypt seed usually being sown aerially. Regeneration burning, combined with the hazards associated with felling oldgrowth eucalypt trees, provided some unique challenges to implementing VR in Australia (Neyland et al., 2012), which factored into the choice of aggregated rather than dispersed retention for state-wide application in Tasmania.

Translating silvicultural trials into operational practice around Tasmania was challenging, both in terms of developing operationally feasible silvicultural practices, and of achieving desirable ecological outcomes. In order to ensure the latter were achieved, it was essential to have clearly defined objectives and a means of determining whether these are likely to be realized.

A major focus of Tasmanian VR relates to facilitating ecological outcomes for late seral (mature forest) species, some of which are disadvantaged by clearcutting silviculture compared to natural disturbance (Hickey, 1994; Turner and Kirkpatrick, 2009), but consideration of early seral biodiversity is also important (Swanson et al., 2011). Most early seral biodiversity in wet eucalypt forests in Tasmania is likely to be robust to harvesting followed by regeneration burning, but lifeboating can facilitate recovery of early seral as well as late seral species, and some early seral species were more likely to recover from seed in burnt aggregates than harvested areas (Baker et al., 2013a). However, some early seral plants, spiders and birds are less common closer to retained forest edges in North America (Schlossberg and King, 2008; Baker et al., 2015). Thus, while current Tasmanian VR objectives and practices focus on mature forest biodiversity, future research may identify early seral or pyrophylic species warranting specific management attention (e.g. Harrison, 2007; Gustafsson et al., 2010).

Retention of biological legacies, and forest influence, are key concepts that distinguish variable retention from clearcutting (Bradshaw, 1992; Keenan and Kimmins, 1993; Mitchell and Beese, 2002; Baker and Read, 2011; Gustafsson et al., 2012). Most application of variable retention around the world uses retention targets (retention of a certain proportion of the coupe area, or a certain basal area) as a primary means of distinguishing variable retention harvest units from clearcuts (Gustafsson et al., 2012). However, consistently high retention levels (usually in excess of 30% of coupe areas) in Tasmanian VR were a factor in the decision that a simple retention target was both unnecessary and could distract from attaining the ecological objectives associated with optimising the configuration of the retained forest. Rather, implementation of VR in Tasmania uses a threshold level of forest influence as a primary means of distinguishing aggregated retention from clearcutting (Bradshaw, 1992; Keenan and Kimmins, 1993; Scott et al., 2011). Specifically, for a coupe to count as aggregated retention, more than half of the harvested area needs to be within one tree length (a pragmatic estimate of the distance of forest influence) of standing forest that is retained for the next rotation; that is, the width of harvested areas should generally not exceed four tree-heights. Forest influence both provided a straightforward measure of operational performance, but was also a crucial concept for articulating, communicating and developing measures to gauge success in achieving the ecological objectives of VR (Keenan and Kimmins, 1993; S. Baker et al., 2009).

Translating research results into operational systems can be challenging and requires substantial inputs of time from, and good collaboration between, researchers, managers and operational staff and harvesting crews. There are numerous examples where a disconnect between academic researchers and forest managers has meant that opportunities for improvement in management practices are not realised. Research results are more likely to be successful in changing management practices when there is a logical and clear connection between research findings, management objectives, silvicultural guidelines, operational practices and assessment criteria, all within an adaptive management framework (Baker, 2011; Larson et al., 2013). Successful adaptive management is most likely to occur when formal protocols are followed and sufficient resources allocated (Lindenmayer and Likens, 2009; Rist et al., 2016).

The overall approach taken for connecting the research, development and operational application of variable retention in Tasmania's wet eucalypt forests has previously been described by Baker and Read (2011), and adhered to the system of linked steps that