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Landscape change and the science of biodiversity conservation in tropical forests: A view from the temperate world

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ABSTRACT

Using a largely temperate forest perspective, this article briefly reviews four often inter-related types of landscape change which can have significant impacts on tropical and temperate forest biodiversity: logging, fire, forest clearing, and plantation expansion. There are many important similarities but also key differences in the kinds of work conducted on these four kinds of landscape change in tropical and temperate forests. For example, direct studies of the effects of forest conversion on biodiversity are relatively rare in both tropical and temperate ecosystems. Temperate forest research differs from tropical research in terms of relative amount of single species work, long-term studies, and research at scales spanning multiple landscapes. There are key areas for cross-fertilization of research in tropical and temperate forest biomes. These include: (1) the ability of species to persist in post-disturbed forest landscapes, including those perturbed by past clearing, logging or wildfire, (2) the impacts of plantation establishment on biodiversity, (3) the effectiveness of altered silvicultural systems on forest structure, vegetation composition, and biota, and (4) inter-relationships between forest logging and fire-proneness. Cross-learning about the impacts of drivers of landscape change between tropical and temperate forests is fundamental for speeding the progress of conservation efforts in both broad kinds of environments. However, some opportunities for cross-learning have not been taken because temperate and tropical forest research has often sometimes been isolated from one another. Some approaches to tackle this problem are briefly outlined.

1. Introduction

The papers in this special section of *Biological Conservation* highlight the quality and breadth of tropical forest research. They also illustrate some of the key issues facing the conservation of biodiversity in these environments as well as the challenges associated with the management of these forests and the biodiversity they contain. I have never worked in tropical forests (although several of my post-graduate students have) and this article is not an attempt to clumsily summarize the state of a field of research in which I have no direct experience or expertise. Rather, I touch on a subset of issues linked with landscape change and tropical forest biodiversity conservation but from a temperate forest biodiversity conservation perspective. I also outline some of the differences in research approaches and conservation opportunities in tropical and temperate forests. A common thread in this commentary is outlined in the final part of this paper; namely there are key areas of cross-learning from tropical forest research and temperate forest research.

2. Landscape change themes unifying tropical and temperate forests

Several kinds of landscape change can have a significant influence on how well tropical and temperate forests can support native biota and key ones include: (1) forest logging for the production of timber and/or pulpwood with forest regeneration after the disturbance, (2) wildfire with forest regeneration after the disturbance, (3) forest clearing and its replacement such as with other forms of vegetation cover (e.g. agricultural land or plantations of trees) or for urbanisation. They are the primary topics of discussion in the following section.

2.1. Logging impacts

Logging is a significant form of landscape change in forests worldwide and many tens of thousands of square kilometres are cut annually. The impacts of logging on biodiversity vary substantially depending on the ecosystem and ecological processes and biota involved as well as the type, intensity, frequency, and spatial pattern of logging. Logging effects, both in tropical and temperate forests, can be complex and multi-scaled ranging from effects at the level of individual trees through to modifications of entire

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landscapes and regions (Hunter, 1999; Lindenmayer and Franklin, 2002). A range of general approaches have been recommended to mitigate logging effects and these are also multi-scaled (Gardner et al., 2009b; Lindenmayer and Franklin, 2002). Hence, they span traditional conservation biology strategies like the protection of large ecological reserves through to off-reserve strategies at the tree, stand and landscape scales.

Altered silvicultural systems are one of the approaches to promote off-reserve forest biodiversity conservation that have received considerable attention. Such approaches can: (1) influence forest structure at the individual tree and the stand levels, (2) affect landscape-levels of critical structures (such as large cavity trees), and (3) shape patterns of landscape heterogeneity. There are exciting developments in new silvicultural systems to promote biodiversity conservation in temperate forests that are appearing under the banner of variable retention harvesting or green tree retention (Bunnell and Dunsworth, 2009; Vanderwel et al., 2007). A parallel body of work is developing in tropical forests based on the concepts of Reduced Intensity Logging (RIL) (Felton et al., 2008; Putz et al., 2008).

Although a large number of studies of altered silvicultural systems are underway in many different kinds of temperate and tropical forest ecosystems, general findings to date from them are equivocal (Putz et al., 2008; Vanderwel et al., 2007). It is clear however, that post-logging regrowth forests do indeed provide habitat for a wide range of fauna, both in tropical and temperate ecosystems (e.g. Bunnell and Dunsworth, 2009; Felton et al., 2008). Nevertheless, key challenges remain about how to best conserve those species which are highly sensitive to logging (even low-intensity methods) and: (1) the spatial scale of the effects such as how much of a landscape can be cut before there are impacts on populations of them elsewhere in uncut parts of a landscape and (2) the temporal scale of such impacts like how long it may take for those species to recolonise harvested forests (if they can become re-established in them at all). There are also important issues to address like the cumulative impacts of repeated logging entries into forest stands over time and the potential for habitat degradation over time (Felton et al., 2003). Addressing these challenges is a critical part of identifying truly conservation-dependent taxa for which traditional kinds of conservation biology, strategies such as the large ecological reserves and extensive logging exclusion zones will be mandatory if they are to persist.

2.1.1. Salvage logging

An increasingly prevalent form of logging in forests worldwide is salvage harvesting. Salvage logging is the removal of damaged or dead trees that have been injured by major natural disturbances such as wildfires, windstorms and volcanic eruptions. Post-disturbance salvage logging is widespread in temperate forests, particularly where stand-replacing disturbances, like wildfires or insect outbreaks occur (Lindenmayer et al., 2008a) but it is not unknown in tropical forests (e.g. van Nieuwstadt et al., 2001). Salvaged timber is an increasing component of wood production in temperate forests around the world and volumes may further increase as a result of a predicted rise in the frequency and severity of major large-scale catastrophic events due to the impacts of climate change (Lindenmayer et al., 2008a; Westerling et al., 2006). There is potential for increased salvage logging with increasing fire in tropical rainforests (see below).

The limited work completed on salvage logging in tropical forests shows that, like in temperate forests, ecological effects of this kind of timber harvesting are almost invariably negative (Lindenmayer et al., 2008a; van Nieuwstadt et al., 2001). There is therefore an urgent need to better understand natural disturbance regimes in tropical and temperate forests, better understand and quantify the processes and patterns of natural ecological recovery after such disturbance events, and better quantify the ecological impacts of salvage logging operations. There is also a need to better manage prescriptions for forests to ensure that large areas of forest that have been subject to major natural disturbances are excluded from salvage logging and that those areas which are cut are harvested with reduced logging intensity methods (Lindenmayer et al., 2008a).

2.2. Wildfire

Wildfires and their effects on forests and forest biodiversity are becoming an increasingly important issue around the globe. This is, in part, linked with the substantial impacts of recent major wildfires on human populations and human infrastructure around the globe (International Federation of Red Cross and Red Crescent Societies, 2009). It is also related to predictions by climate scientists that large-scale natural disturbances such as wildfires will become more frequent, widespread and intense as a consequence of climate change (e.g. Cary, 2002; Cochrane and Barber, 2009; Westerling et al., 2006).

Given such forecast changes in fire regimes, additional factors which may increase the fire-proneness of tropical and temperate forests need careful consideration. Logging is one of those factors. A number of studies in tropical rainforests over the past two decades have indicated there can be strong relationships between logging and altered fire-proneness (e.g. Cochrane and Barber, 2009; Uhl and Kauffman, 1990) with subsequent negative impacts on biodiversity (Barlow and Peres, 2004). There is also an increasing body of parallel work from moist temperate forests highlighting how logging operations can influence fire regimes (e.g. Odion et al., 2004; Thompson et al., 2007). Studies from tropical rainforests and moist temperate forests indicate that logging can influence wildfire frequency, extent and/or severity in forests in several ways (Lindenmayer et al., 2009). Three key ones include: (1) changing microclimates (Ray et al., 2005) which can dry the understorey and ground layers and in turn, alter fuel characteristics (Krawchuk and Cumming, 2009; Mahli et al., 2009), (2) increasing the prevalence of ignition points such as roads that are constructed to facilitate timber extraction (Krawchuk and Cumming, 2009), and (3) altering patterns of landscape cover and spatial juxtaposition of different kinds of forests stands which can, in turn, influence the spread of wildfires through landscapes (Franklin and Forman, 1987; Mahli et al., 2009).

Although the effects of logging on fire regimes in tropical rainforests appear to be unequivocal, such inter-relationships have an added complexity in temperate forests (Lindenmayer et al., 2009). This is because, unlike moist temperate forests, there are some kinds of drier temperate forests where logging interventions, like thinning, can be employed to alter vegetation structure as part of restoring natural fire regimes (Noss et al., 2006). These include forests such as those dominated by ponderosa pine (*Pinus ponderosa*) in the south western USA where prolonged periods of fire suppression and other forms of human-derived forest modification, like domestic livestock grazing, have led to increasing fuel loads, radically changed natural fire regimes resulting in elevating the risks of uncharacteristic high-severity wildfires (Covington, 2003; Noss et al., 2006).

An important insight from work on inter-relationships between wildfire and logging in tropical rainforests and moist temperate forests include the need to maintain large and intact areas of native forest cover where logging operations are excluded. These areas will retain moist microclimatic conditions likely to reduce the risks of damaging wildfires (Mahli et al., 2009; Uhl and Kauffman, 1990). There also may be a need to create appropriate fire buffers around intact areas of rainforest and moist temperate forest to limit spatial contagion in wildfires in which fires burn into intact areas from