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Conserving forest biodiversity across multiple land ownerships: Lessons from the Northwest Forest Plan and the Southeast Queensland regional forests agreement (Australia)

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ABSTRACT

As the area of the world's forests shrinks, the management of production forests is becoming increasingly paramount for biodiversity conservation. In the United States and Australia, public debate and controversy about the management of production forests during the later decades of the 20th century resulted in governments adopting sweeping top-down changes to forest policy, with regional forest plans a cornerstone of this process. This paper reviews the biodiversity conservation outcomes of two such processes, the Southeast Queensland Forests Agreement (Australia) and the Northwest Forest Plan (United States). Several key lessons are identified. First, these plans are significant steps forward in the struggle to conserve forest biodiversity while providing for production of timber. Second, expanding the conservation reserve system by itself does not necessarily ensure biodiversity conservation, especially if reserves are traded off for increased timber harvesting in forests outside of reserves or if certain important elements of biodiversity are not accounted for either by conservation forests or production forests. Third, reserves often need active management to restore diversity in previously-logged forests and reduce fuels that have accumulated as a result of fire exclusion. Fourth, the current plans fall short of the comprehensive whole-of-landscape, multiple-ownership approach needed to support long-term sustainable forestry and biodiversity conservation. Fifth, adaptive management was not adequately institutionalized and sometimes misapplied, although, in the case of the Pacific Northwest, a major regional monitoring strategy was developed and partially implemented. Finally, ecological science suffered in the collision with the socio-political decision-making process due to the limited scope that was left for testing and evaluating the new approaches to forest management. We conclude, based on the evaluation of the two regional plans, 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.

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1. Introduction

As the area of the world's native forests shrinks, the sustainable management of production forests is increasingly paramount for biodiversity conservation (Lindenmayer and Franklin, 2002). Throughout the latter part of the 20th century, public debate and controversy about management of production forests resulted in divisive protests and disputes in many countries. The "unproductive stand-offs" ultimately resulted in "productive changes" in forest practices. Prominent in these actions were disputes over the fate of old-growth forests in the Pacific Northwest dating from the 1970s and peaking in the early 1990s (Johnson et al., 1999). Similar debates raged concurrently on the other side of the Pacific about the fate of Australia's old-growth eucalypt forests (forests with a high proportion of hollow-bearing trees) and tropical rainforests (Dargavel et al., 1998; McDonald and Lane, 2000). To contain and address these concerns and divisions, federal governments in the United States and Australia adopted sweeping top-down changes to forest policy and planning processes.

In the United States, decades of short-rotation clearcutting (combined with fire suppression and road building) radically altered forest landscapes, dramatically reducing the abundance of mature and old-growth forests, and increasing the abundance of young conifer plantations (Franklin and Forman, 1987). Environmental concerns included the decline in old-growth forests and riparian and stream habitat diversity, loss of large blocks of uncut forests, threats to populations of wildlife and fish species, and changes in scenic quality (Hansen et al., 1991). In 1990, the Northern Spotted Owl (*Strix occidentalis caurina*) was listed as a threatened species under the *Endangered Species Act* (for background on the Act see Clark, 1994), logging was greatly reduced across the federal forests, and controversies erupted around forest management.

When campaigning for office, Bill Clinton promised to find a solution to the crisis, and once elected President, he held an inclusive "forest summit" with representatives of all affected parties. He then assigned Forest Service Wildlife biologist, Jack Ward Thomas, to lead a team of scientists (FEMAT, 1993) to craft a comprehensive ecosystem management plan for federal forest lands in portions of three states that would conserve forest wildlife, bring management into compliance with the law, and resolve the court injunctions that had held up logging of suitable owl habitat. The Forest Ecosystem Management Assessment Team was to produce a set of alternatives for the administration to select a plan that would maintain and/or restore:

- habitat conditions to provide for the viability of the Northern Spotted Owl and Marbled Murrelet (*Brachyamphus marmoratus*) (another at-risk species that nests in Coastal old-growth);
- habitat conditions to support viable populations of other species known to be associated with old-growth forest conditions;
- spawning and rearing habitat on federal lands to support viable populations of anadromous fish species and stocks considered at risk; and
- connected or interactive old-growth forest ecosystems on federal lands.

The Northwest Forest Plan was officially implemented in 1994, following the defeat of legal challenges that help-up its implementation for many months. Recently, a series of 10-year evaluation reports were published that examine the status and trends of key components of the Northwest Forest Plan and evaluate how effective it has been in the first 10 years of the 100 year plan (Lint, 2005; Moeur et al., 2005). Our summary of the Northwest Forest Plan is based largely on those reports.

In Australia, over 75 major inquiries into the environmental impacts of the timber industry since the end of World War II had failed to find a solution to conflicts over management of production forests (Mobbs, 2003). In the 1970s and 1980s, forest disputes escalated, particularly over the ecological impacts of export wood-chipping of native eucalypt forests and the logging of tropical rainforests (McDonald and Lane, 2000). In response, the Commonwealth Government adopted an increasing role in environmental management (Lane, 1999). The National Forest Policy Statement (Commonwealth of Australia, 1992) outlined a shared vision between the Commonwealth and State Governments for the ecologically sustainable management of Australia's forests, and sought to balance the social, economic and environmental values of forests, including biodiversity, both now and in the future.

Regional Forest Agreements were Australia's model of large-scale forest ecosystem management, and were jointly adopted by Commonwealth and State Governments as the mechanism for achieving ecologically sustainable forest management. Ten Regional Forest Agreements were progressively signed between 1997 and 2001, key outcomes being the allocation of approximately 30% of publicly owned commercial forests to an expanded reserve system, strengthening of codes of practice and other mechanisms to ensure the sustainable management of the remaining publicly owned forests, and increased certainty of resource access for the timber industry. While Regional Forest Agreements did manage the conflicts in most regions (Lane, 1999), at least initially, their capacity to deliver long-term conservation of biodiversity is still questioned and conflicts continue in several regions (Lunney, 2004). Most recently, the Tasmanian Regional Forest Agreement has come to prominence with clear-felling of old-growth eucalypt forests, allocated for production under the agreement, a hotly debated issue of the 2004 federal elections.

In Southeast Queensland, an agreement was brokered between the Queensland Government and the peak stakeholder groups – the Queensland Timber Board, the Australian Rainforest Conservation Society, the Queensland Conservation Council and The Wilderness Society – after the State Government withdrew from negotiations with the Commonwealth. The Southeast Queensland Forests Agreement was signed on 16 September 1999, its key objectives being: a world class conservation reserve system; ecologically sustainable management of forests; a competitive and efficient timber industry; and enhanced economic development and employment prospects for rural communities (Norman et al., 2004; McAlpine et al., 2005).

This paper examines the effectiveness of the Northwest Forest Plan and Regional Forest Agreements, with a particular focus on the Southeast Queensland Forests Agreement, to deliver long-term biodiversity outcomes across the regional forest estate encompassing all land ownerships. We then outline key lessons for regional biodiversity conservation including the need for: active management within reserves to meet conservation goals; conservation plans to consider both reserves and non-reserved lands intended for timber production and other land uses; and, expansion of the role of scientists and ecological science in the decision-making process. However, as both case studies are taken from developed countries, our conclusions may be specific to these areas, with other issues being more relevant in less developed countries. We conclude by identifying possible improvements for future similar processes.

2. The Northwest Forest Plan

2.1. *The plan*

The stage was set for the Northwest Forest Plan (United States Department of Agriculture and United States Department of Interior, 1994) by a series of preceding conservation strategies that began with a relatively narrow focus on the Northern Spotted Owl and eventually expanded to include multiple species and watersheds (Johnson and Herring, 1999). More than 80 scientists worked on the Northwest Forest Plan, developing 10 alternative management strategies with differing levels of risk to biological diversity and differing levels of timber production for the area defined by the United States range of the Northern Spotted Owl. The Clinton administration selected an alternative (option 9), which it felt provided the best mix of protection of native forest biodiversity and commodity production, and was scientifically credible and legally defensible. The Northwest Forest Plan covers 9,416,599 ha of federal land, which represents about 40% of the land in the area of the Northern Spotted Owl in Washington, Oregon and Northern California. The plan added the following major land allocations to federal lands:

2.1.1. *Late successional reserves: (3,008,421 ha; 30% of total area of federal forest land)*

These are large blocks of forest ranging from 5000 to over 50,000 ha in size, encompassing a significant fraction of the remaining ecologically valuable mature and old-growth forests as well as young natural and plantation forests, where permitted activities include thinning of existing plantations to restore ecological diversity, and use of mechanical treatments and prescribed fire in dry forests to reduce high fuel loads that have built up with fire suppression. Limited salvage logging is allowed following wildfire.

2.1.2. *Riparian reserves: (916,093 ha or 11% of federal forest lands)*

These are stream buffers on all flowing and intermittent streams (within all land allocations), and other water bodies that vary from 1 to 2 site potential tree heights in width (50–70 m) on each side of the stream, where permitted activities are similar to that of the late successional reserves (e.g., thinning to improve habitat diversity is allowed). The primary purpose of riparian reserves is conservation of aquatic resources and habitat. A secondary purpose is to provide for dispersal and connectivity for terrestrial species across the landscape. Active management is permitted for ecological goals.

2.1.3. *Matrix: (1,609,433 ha or about 16% of the federal forest land)*

These are areas where management for timber production is allowed, but clear cutting may not be used and 15% of the area must be retained in large live trees and small patches of trees to provide habitat refugia and structural diversity within the regenerating forest. Many of these matrix areas contain old-growth forests, which are still targeted for cutting. A further mitigation requirement within matrix areas involved pre-logging surveys for rare and uncommon species, but this requirement was considered an expensive burden by the agencies and they have attempted to eliminate it or modify it. A recent court ruling has declared the decision to eliminate the surveys as illegal and the agencies are currently proposing alternative strategies.

The remaining major land allocations are: Wilderness Areas and National Parks and designated Wild and Scenic rivers (30% of the land base); administratively withdrawn lands (recreation, scenic, and wildlife areas, and areas with unstable ground or low productivity soils) (6%); and Adaptive Management Areas (about 6%). Adaptive Management Areas are designated for efforts to conduct experiments and other studies to evaluate different approaches for achieving the overall goals of the Northwest Forest Plan.

2.2. *Conservation outcomes*

After 10 years of implementation of the 100-year plan many of the ecological trends and ecosystem management approaches are occurring as expected (Borman et al., 2006). For example, over 85% of the mature and old-growth forest on federal lands was captured in the reserve system (Moeur et al., 2005) and the logging of old-growth forests has been substantially reduced on federal lands (Moeur et al., 2005). Although the plan intended for some mature (stands >80 years of age) and old-growth forest in the matrix to be cut to achieve timber production goals, the level of production from older forests has been well below that envisaged in the plan. The planned cutting of older forest in the matrix was unpopular with some members of the public and lead to lawsuits and protests that forced the agency to avoid cutting many older forest stands even though this practice is still part of the plan. Losses of older forest to wildfire occurred at an annual rate of 0.18%, exceeding the rate of loss to timber harvest (0.03%) but falling below what was expected for the region as whole (Moeur et al., 2005). Within drier provinces, however, annual rates of loss to stand replacement wildfire have been relatively high (e.g. 0.14–0.95%) (Spies, 2006). Despite the losses to fire and logging, the area of mature and older forest actually increased at an annual rate of 1.9% during the first 10 years of the plan. Most of this increase came as stands in smaller diameter classes grew into the lower diameter range (>50 cm dbh) of the mature class (Moeur et al., 2005). However, a small net increase in area of old-growth diameter classes (>75 cm dbh) still occurred.

Other trends have not been in line with expectations. For example, owl population declines, which were expected to continue through the early period of the Northwest Forest Plan, have been much higher than expected in the northern part of the region (Raphael et al., 2006). This is hypothesized to result from the invasion of Northern Spotted Owl territories by the Barred Owl (*Strix varia varia*), a similar species whose range is expanding in western North America. Many, but not all, of the Adaptive Management Areas, which along with the regional monitoring program were critical to the adaptive management process, have not met all expectations (Stankey et al., 2003). Timber production from the federal lands has been somewhat less than expected largely because of the lack of logging of older forests within the matrix lands, where timber and ecological goals were blended. Finally, controversy around federal forest management has continued as evidenced by lawsuits and protests largely aimed at the Northwest Forest Plan's provision for logging of older forests within the matrix lands and salvage-logging in late successional reserves following wildfires.

The monitoring strategy that was implemented is probably the largest and most comprehensive forest plan monitoring ever conducted. Involving eight federal agencies and seven modules, ranging from social and economic monitoring to demographic monitoring of owl populations, the monitoring effort produced status and trends data that could be scaled up to the 10 million ha region. Although some modules, such as watershed health and implementation monitoring, were late in getting started and not well developed the overall monitoring effort produced a wealth of information that managers and policy makers are using to make decisions. For example, the monitoring results have spurred the management and regulatory agencies to increase efforts to reduce risk to older forest from high severity fire in dry provinces.

The concept of forest reserves also has been a source of controversy, with some people assuming they are places where no management can occur and forests are left to grow, senesce, or be subject to "natural" stand-replacing events such as wildfires. The standards and guidelines for the reserves allow silvicultural activities to achieve ecological goals or reduce the risk of stand replacement fire. In the moist forest types, much of this activity takes the form of thinning in dense young plantations that were originally intended for timber production. Thinning to variable densities, including creating gaps and leaving areas unthinned, is conducted to enhance habitat diversity and potentially accelerate development of large trees and other old-growth structures. In dry forest types, the Northwest Forest Plan recognizes that some older forest is at risk from high severity wildfires that may be more common now that decades of fire suppression have increased understorey density and fuel levels (United States Department of Agriculture and United States Department of Interior, 1994). It is ironic that fire suppression has actually increased the area of habitat for the owl, which prefers the denser, multi-layered forests. Silvicultural activities are allowed within older forest habitats in the reserves, and many such treatments have occurred, but it does not appear so far that the rate and landscape pattern of fuel treatments has been sufficient to reduce the risk of loss of owl habitat to fire significantly (Spies, 2006).

Another concern about the Northwest Forest Plan is that in some regions, such as the Oregon Coast Range, where more than 95% of the federal lands is designated to grow into old-growth forest, the landscape pattern and diversity will change to a high contrast pattern with old forests on federal lands and intensively managed plantations on adjacent private industrial forest lands (Spies et al., 2002). In the absence of significant wild fires and assuming continued salvage logging after each fire, this will likely result in declines of structurally-diverse, early successional forest types including hardwood forests that are not provided for on any ownership. The goal of the federal lands in these areas is nearly complete coverage of older forests, through suppression of fires, and the goal on the private lands is to establish uniform well-stocked plantations of native conifers as soon as possible after clear cutting.

3. Southeast Queensland Forests Agreement

3.1. *The plan*

The Southeast Queensland Forests Agreement was the outcome of a six-year process of scientific investigation and negotiation beginning in 1993. The following land allocations of this agreement are directed specifically at biodiversity conservation.

3.1.1. *Immediate additions to Forest Reserves (425,000 ha of Crown [Public] Land)*

The cessation of timber harvesting and the immediate addition to the conservation reserve system of about 425,000 ha of Crown Land that had been managed as State Forest or other similar reserves. These areas were moved into a new class of protected area ('forest reserve') created under the State's nature conservation legislation. The forest reserves will be progressively transferred into one of five classes of protected area, including national park, through a process of detailed negotiations with key stakeholders (in particular recreational users and indigenous groups).

3.1.2. *Once-only logging (375,000 ha of Crown Land)*

Once-only logging of the balance of the area of Crown native hardwood forest within the region, with harvesting of these forests completely phased out by 2024. In forests of high conservation value covering approximately 80,000 ha, the logging industry was encouraged to transition to plantation forests and to log the forests only as a 'last resort.' The remaining forests (approximately 295,000 ha) were to be selectively logged only once in the period up to 2024, and in accordance with a new forestry code of practice that allowed more intense harvesting of saw logs. This guaranteed a resource supply to the mills remaining in the industry.

In addition, the agreement committed the signatories to the immediate implementation of a strategy to develop substantial native hardwood plantations, to enable the timber industry to transition to a plantation-based resource within 25 years. This commitment, while primarily a social and economic goal, has the potential to provide additional habitat for native fauna. No commitment was made for the long-term monitoring of the biodiversity outcomes of the agreement. The monitoring of a system of long-term permanent plots was discontinued after the agreement. No provision was made for setting aside areas for adaptive management.

3.2. *Conservation outcomes*

The creation of new Forest Reserves had an immediate impact by ensuring retention of old eucalypt trees with hollows that would otherwise have been logged, within the reserved areas over the next 50–100 years. The overall size of the protected area system has increased from around 342,000 ha at the time the Southeast Queensland Forests Agreement was announced to over 700,000 ha since the addition of the new reserves. This helped to expand and consolidate the previously fragmented reserve system, which was not fully representative of regional ecosystem diversity (McAlpine et al., 2005). The new reserve system is less fragmented, and hence less vulnerable to external pressures from surrounding land use. However, it remained significantly biased in favor of rainforest and wet eucalypt forests, with a 100% and 92% representation respectively in the conservation reserve system (Norman et al., 2004). The Southeast Queensland Forests Agreement failed to improve significantly the representation of previously poorly represented dry eucalypt ecosystems and their fauna within the conservation reserve network (33% protected). However, these dry forests support a proportionally high component of the region's biodiversity, providing primary habitat for 94 vertebrate fauna species, compared to wet eucalypt forests (76) and rainforest (5) (Norman et al., 2004). The rainforest and wet-eucalypt bias is influenced by a public affinity with these forests, reflecting their greater attraction aesthetically and for recreation, and a widespread belief that they are of greater biodiversity value and hence in need of protection (McAlpine et al., 2005).

Under Commitment 2, in once-only logging areas, as a trade-off with the timber industry, the remaining 77% of dry forests are available for more intensive timber harvesting where all stems larger than 40 cm+ diameter at breast height (dbh) are permitted to be removed, other than six habitat trees (>60 cm dbh) ha^{-1} and trees in riparian buffers protected under a forest management Code of Practice (Environmental Protection Agency, 2002). It is generally considered that eucalypt trees in the region do not develop large hollows, until they exceed 60–100 cm in diameter, depending on tree species (Lamb et al., 1998). The more intensive logging under this commitment will remove the critical recruits to replace existing old eucalypt trees with hollows, hence degrading the habitat quality for a range of hollow-dependent fauna species such as possums and gliders (*Acrobates pygmaeus*, *Petaurus* spp., *Petaroides volans*, *Trichosurus* spp., *Pseudocheirus* spp. and *Cercartetus* spp.). It will also reduce the abundance of large-crowned dominant and sub-dominant trees that are important food sources of nomadic honeyeaters (family Meliphagidae) and megachiropteran bats (*Pteropus* spp.) that rely on massive flowering events in large eucalypt trees (Norman et al., 2004). In the long-term, recovery of dry eucalypt forests from this intense logging disturbance is likely to be constrained by the increased density of small stems that will regenerate after intensive harvesting. This problem is already evident in many dry forests where harvesting has been intense in the past (McAlpine and Eyre, 2002).

4. Lessons learnt

4.1. *Comparison*

A comparison of the context and outcomes of the Northwest Forest Plan and the Southeast Queensland Forests Agreement (Table 1) shows that they both aimed to address similar concerns over the impact of native forest timber harvesting on forest wildlife, while providing greater certainty to the timber industry. The implementation of the Northwest Forest Plan proceeded after court challenges, and controversy still remains regarding certain activities such as salvage logging in reserves, the ecological impacts of logging remaining unprotected old-growth forest, and the use of reserves instead of other approaches such as long-rotations. In Southeast Queensland, public controversies over forest management have declined substantially since the Southeast Queensland Forests Agreement, although important issues remain about management within conservation reserves and the management of production forests on public and private-owned lands. In the following sections, we identify key lessons from both plans for the long-term conservation of forest biodiversity. The lessons build on lessons identified for the Southeast Queensland Forests Agreement by McAlpine et al. (2005).

4.2. *Lesson 1: Conversion of public forest to conservation reserves will not in itself secure regional biodiversity in perpetuity*

Conversion of public forest to reserves managed primarily for ecological and non-consumption social goals has advanced biodiversity conservation in both regions, and represents a major improvement over previous policies (Borman et al., 2006). However, we see several shortcomings that will need to be addressed in securing regional forest biodiversity in the longer run. While the Northwest Forest Plan appears to be on track to meet many of its ecological goals (Borman et al., 2006), it has several potential shortcomings in implementation and design. In Australia, the Regional Forest Agreements process centered on minimizing conflict over forests and the outcome was essentially a re-allocation of public forest lands between conservation reserves and production forests. In Southeast Queensland, while an expansion in the reserve system was achieved by the Southeast Queensland Forests Agreement, there are similar shortcomings to the Northwest Forest Plan in design and implementation.

4.2.1. *Shortcoming 1: converting forests public land to reserves often perpetuates existing conservation biases*

Experience gained through planning processes such as the Northwest Forest Plan and Southeast Queensland Forests Agreement have highlighted the inadequacies of relying solely on a reserve-based approach in situations: where the

Table 1 – Comparison of key elements and outcomes of the Northwest Forest Plan and the Southeast Queensland forests agreement

Characteristic	Northwest Forest Plan	Southeast Queensland forests agreement
Policy/statutory context	Endangered Species Act, National Forest Management Act and others	National Forest Policy Statement
Basis of assessment area	US range of the Northern Spotted Owl	Biogeographic region
Drivers	• Conservation concern about clear cutting of old-growth and its impacts on wildlife, fish, water quality, scenic values, etc. • Douglas-fir forests and replacement by short rotation plantations of native tree species (initially in relation to particular species)	• Conservation concern about general biodiversity impacts of selective logging of old eucalypt forests and replacement with young forests • Native forest timber industry experiencing decline in certainty of timber supply
Use of science/scientists	• Developed options • Assessed options • Participated in monitoring and adaptive management	• Initial comprehensive bioregional assessment • Independent scientific panel (report not adopted) • Limited scientific input into final decision
Conservation strategies	• Reserves covering 80% of federal lands, many of which were previously logged • 'Matrix' lands where logging of older forest is still allowed with 15% retention	• Reserve system – addition of about 425,000 ha (mainly national parks) • Once only logging of about 375,000 ha under Code of Forest Practice (compulsorily applied to timber production on public lands), with eventual conversion to protected area status
Social/political outcomes	• Greatly reduced logging of old-growth forest. Cutting unreserved old-growth remains controversial • Plan survived court challenges, has been implemented • Lower than expected timber production • Uncertainty of federal timber supply • Grants and loans to small timber communities and counties	• Immediate cessation to logging of publicly owned wet eucalypt forests • Gradual phasing out of logging of dry-eucalypt forests and replacement with hardwood plantations • Buy-out of some impacted mills • Compensation to the timber industry • Twenty-five year commitment to certainty of log supply (but at much reduced levels)
Remaining ecological concerns	• Harvesting of unreserved old-growth • Increased fuel build-up and fire risk in dry forest types which cover a portion of the plan area • Contrasting landscapes on public and private lands, watershed issues • Possible declines of diverse early-successional/hardwood forests (assuming continued effectiveness of fire suppression)	• Intensive logging in remaining dry eucalypt forests until 2024. • Increased fire fuel build-up in reserve areas • Continued grazing of dry forests • Increased density of small stems in dry forests subject to continued harvesting • Increased harvest pressure on privately-owned forests

public estate is already fragmented and many of the forests highly modified; when the biodiversity representation of the public land base is already biased (e.g., through a history of selective conversion of the most productive forests to agriculture under private ownership); and where the political process inevitably results in trade-offs in favor of iconic elements (e.g., rainforests) over less iconic elements (e.g., dry forests). Further, as we improve our understanding of the complex spatial and temporal dynamics of forested landscapes, the limitations of reliance on static reserves to assure biodiversity conservation in perpetuity, have become increasingly apparent. The emergence of issues such as climate change (Martin, 1996; Hughes, 2000, 2003; Hilbert et al., 2001; Thomas et al., 2004), the extent to which contemporary patterns of disturbances such as fire reflect historical patterns (McCarthy et al., 1999; Lindenmayer et al., 2000), and the predicted consequential spatial shifts in species habitats and distributions are prominent examples of those limitations.

Under the Northwest Forest Plan, the area in large blocks dedicated to the production of older forest stages may not be large enough to maintain older forest stages in some drier provinces where natural disturbance regimes are characterized by a mixture of low to high severity fire. In several of these provinces, the percentage of large areas for older forest development is only about 50%. If wildfire severity and size is increasing as a result of climate change and fuel accumulation from fire suppression, as some studies suggest (Dale et al., 2000; Flannigan et al., 2000), alternatives to the current reserve-matrix approach may need to be considered. For example, it may be more effective to set a serial stage distribution goal for the entire province rather than attempting to reach and hold old-forest structure in only a relatively limited portion of the landscape. Under such a scenario, management would conduct fuel treatments to remove smaller diameter trees and reduce the risk of fire spreading to high-priority multi-storied areas intended for owl habitat. In coastal wet provinces where fire is infrequent and little regeneration harvesting is scheduled, it is plausible that the plan will lead to large blocks of older forest and little early successional forest. Large natural stand replacing disturbances will eventually occur in most of these areas but it may take many decades. It such situations, it might be desirable to use limited logging to create some openings and diversity of early successional stages for other wildlife species.

The selection of the reserve system for the Southeast Queensland Forests Agreement was not based on the comprehensive, adequate and representative principles of systematic conservation planning (Margules and Pressey, 2000), and has thus failed to protect those ecosystems and species with the highest vulnerability and irreplaceability (sensu Pressey et al., 2004). The outcome of the agreement is a reserve system that has exacerbated the existing biases by providing further protection to the least threatened landscapes and species, namely the wet eucalypt forests and rainforests within the public forest estate. Many ecosystems and biota remain under-represented or overlooked (Norman et al., 2004), as is the case for other forest regions of Australia (Flint et al., 2004; Lunney, 2004; Meek, 2004). Dry eucalypt forests remain poorly represented in the reserve system and the Southeast Queensland Forests Agreement has resulted in more intensive timber harvesting of these dry forests on public and private lands and thus increased the level of threat to the biodiversity on these lands. This was accepted as an apparent trade-off for the remaining wet eucalypt forests becoming fully protected (McAlpine et al., 2005). Pressures from powerful conservation and timber industry interests have resulted in a lost opportunity to represent the biodiversity of Southeast Queensland within the conservation reserve system more comprehensively and adequately.

4.2.2. *Shortcoming 2: limited management of degraded forests within the new reserves*

An important related issue is the notion, which many associate with the term "reserve" in both plans, that ecological goals are best achieved by allowing nature to largely take care of itself. We recognize that forests that have been subjected to minimal disturbance by logging (or other anthropogenic activity) do not require active management, except in fire prone forest types. However, a legacy of logging disturbance has left many forest stands in both regions in a degraded state and requiring active management to create desired ecological conditions. Evaluating management effectiveness and responding appropriately to the results of this evaluation are at the core of good protected area management. Active restoration through the use of selective thinning, fire management, or reestablishing extirpated species, has the potential to speed the recovery of old forests and foster the production of ecosystem goods and services such as clean water as well as benefit wildlife populations.

The Northwest Forest Plan recognized that active management was needed in reserves to diversify plantations, reduce fuel levels and remove roads. However, the proclamation of "reserves" created, in some, a mindset of inaction in management/regulatory agencies and environmental groups and a sense that active forest management constituted a greater risk to the goals of the Northwest Forest Plan than unmanaged wildfire. The plan did not assume that a hands-off approach was best for the reserves. The standards and guides clearly state that active management is needed. There is a perception, however, around the term reserve that does give some people the impression that active management is undesirable or risky. This can be seen in the perspectives of some in the environmental community and in some parts of the wildlife regulatory community who do not have experience with forest dynamics and who may mistrust the forest managers to use active management for ecological goals. This mistrust is partly a legacy of past management practices, where there were cases where cutting excesses have occurred under the name of "improving" the forest. In Australia, a similar mistrust has grown out of public protests against woodchipping of the southeast Australian forests – "the public like forests but hate woodchipping". This is exemplified by long-running disputes over the controversial "Harris-Daishowa" woodchip scheme at Eden, New South Wales, which involved the export of large volumes of pulpwood for the Japanese papermaking industry to the detriment of the ecological integrity of the region's forests (Penna, 2004). Although the standards and guides within the Northwest Forest Plan allowed for active management for ecological goals, in practice much less active management, especially fire risk reduction, has occurred (Spies, 2006). The reasons for this are various but appear to be related to funding limitations, caution on the part of forest managers and regulators, and opposition from some environmental groups, who do not trust the land management agencies to conduct extensive active management, even for ecological goals.

The Northwest Forest Plan reserve strategy has created some confusion and conflicting goals. The confusion stems from the question of whether the reserves are intended to produce some particular ecosystem condition, e.g., old growth, or to serve as a place for natural processes to operate, regardless of the outcome. The Northwest Forest Plan actually has both types of reserve. The flexibility that managers need to meet the first goal is often a source of mistrust from environmentalists who prefer strict nature preserves. Part of the conflicts arise from the fact that the goal of producing owl habitat (dense old-growth forests) in dry, fire-prone parts of the plan area is difficult to reconcile with the goal of restoring open old-growth forests that were maintained by frequent, low severity fire. Conflicts also have arisen because the plan allowed 'conservative' quantities of post-fire salvage logging to occur in late-successional reserves and some post-wildfire salvage operations in the plan area are considered too aggressive by environmental groups and some scientists.

The Southeast Queensland Forests Agreement allocated inadequate resources for the management of the new conservation areas. The primary conservation goal of the new reserves is to produce old-growth forests. Although management plans are being developed, they will require an on-going input of resources, in particular, to: restore degraded forests with a high density of small stems (the result of more intensive once-only logging); implement appropriate fire, grazing, feral animal and weed management strategies; and to evaluate the effectiveness of these management approaches within an adaptive management framework. Impacts of grazing, weeds, feral predators, and fire remain the major issues in management of new conservation areas (McAlpine et al., 2005; Norman et al., 2004). Under the agreement, while increased funding has been provided in the short-term to develop management strategies for all forest reserves and undertake identified priority actions, their on-ground implementation is likely to be patchy and their beneficial impacts will diminish with time (unless further additional funds are forthcoming).

4.2.3. *Shortcoming 3: balancing conservation and timber production has proved elusive*

The plans highlight an important dilemma as to how the conservation goals of sustainable forest management should best be achieved. There appear to be two competing solutions to meeting the increasing pressures on forest biodiversity: wildlife friendly forestry where conservation and production objectives are spatially integrated and spread across a broad estate; and forest land sparing which minimizes demand for production land by increasing yield in concentrated harvest areas (sensu Green et al., 2005). The high yield model is equivalent to intensive logging of remaining production forests while reserving the rest. Given the social challenges and scientific uncertainties about how to balance conservation and timber production, it seems clear that a blend of approaches should be used and evaluated through monitoring and experimentation. Areas the size of large landscapes and regions are needed to enable evaluation of different landscape-level allocation and management strategies.

The high yield model best fits the outcomes of the Southeast Queensland Forests Agreement where conservation and production areas were spatially separated. The agreement has fallen well short of the vision of ecologically sustainable forest management, as agreed by the Commonwealth and State governments of Australia (Commonwealth of Australia, 1992). The vision stated that Australia's forests both public and private, and their resources are used in an efficient, environmentally sensitive and sustainable manner. New Southeast Queensland Forests Agreement logging rules for the remaining production forests on public land allowed increased harvest rates, while recommendations by an independent scientific panel for codes of practice for sustainable management of private forests were ignored (Ecologically Sustainable Forest Management-Expert-Panel, 1999). Private forests were the "forgotten forests" (sensu Prest, 2004), forgotten in favor of much more prominent struggles over the future of publicly-owned forests. Five years after the Southeast Queensland Forests Agreement was adopted, regulation, through a Code of Practice has only just been applied to a portion of private forests (Department of Natural Resources, Mines and Water, 2006), although they remain subject to increasing logging pressures as timber production declines in public forests (Fig. 1).

The future timber flow from federal lands under the Northwest Forest Plan is uncertain (Fig. 1). In the early decades timber production had been expected to come from logging of mature and old forest stands in the matrix. Older forest in the matrix has not been a large source of timber and most of the harvest has actually come from reserves where plantation thinning has occurred. Once these plantations reach 80 years of age (most are now 20–50 years old), they will no longer be thinned and will be expected to grow into older forests. Presumably, at some time in the future, the flow of timber will then shift to the matrix where current young stands may be available for regeneration harvesting.

4.2.4. *Shortcoming 4: failure to consider biodiversity conservation needs across all land ownerships*

We acknowledge that after 50 years of unsustainable logging that took great risks with many species of wildlife, water quality and quality of life, the plans have achieved some important gains towards regional biodiversity conservation. A few options may have been forgone, but lots of options have been preserved. Adopting a regional, multi-ownership landscape approach is an important step towards improved forest management and biodiversity conservation, but it was "not on the cards" in the 1990s due to the massive levels of distrust that prior management had engendered. Increasingly, global socio-economic forces will have to be factored into regional strategies. Expansion of science and planning over the next 20–30 years can help provide options available to future generations if multiple spatial and temporal perspectives are used.

Unintended adverse outcomes may however, result from the uneven application of planning outcomes across land ownerships. For example, the Pacific Northwest's Bureau of Land Management forests in the Oregon Coast Range are potentially quite sensitive to effects of forest management practices on private industrial and non-industrial lands because they result in highly fragmented patterns and high edge density (Spies et al., 2002; Stanfield et al., 2002). Under the Northwest Forest Plan, landscape conditions across ownership boundaries are expected to diverge over time, as federal lands are dominated by older forest structure and

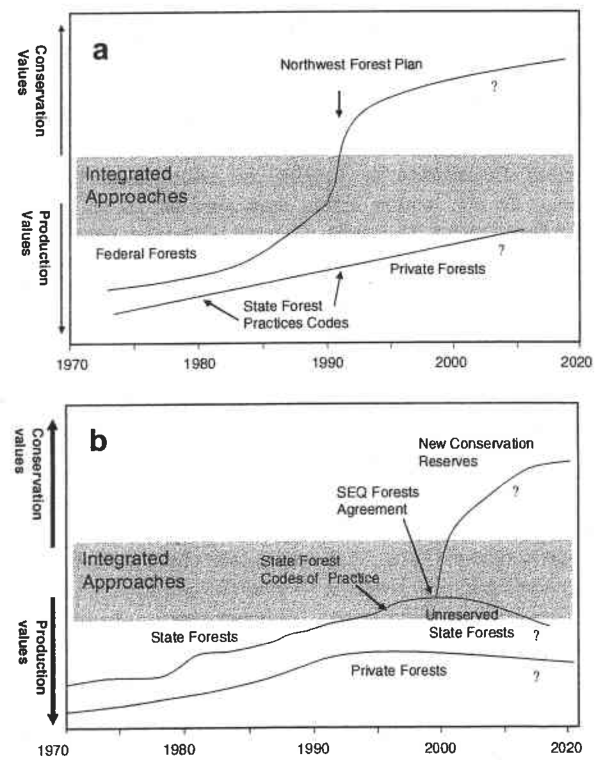

Fig. 1 – Schematic showing trends in the level of integration of forest conservation and production for: (a) the Pacific Northwest Region of the United States; and (b) South East Queensland (SEQ) (Australia).

industrial and private lands experience increased forest management intensity and/or conversion to more intensive land uses.

A similar situation exists in Southeast Queensland, where attempts to integrate landscape ecology into forest management and planning, have made little progress, despite efforts to develop such an approach (McAlpine and Eyre, 2002). This has resulted in a continued decline in old eucalypt trees within the remaining production forests (both public and private), with important consequences for forest fauna (Norman et al., 2004). A similar outcome occurred under the Regional Forest Agreements process in north-eastern New South Wales, where lowland fertile forest types were underrepresented in the Regional Forest Agreements outcomes despite being the most vulnerable to logging, clearing and degradation (Pressey et al., 2002). In Southeast Queensland, clearing of private mature native forests on rural lands was phased out under the Vegetation Management Act and other Legislation Act of 2004 (Queensland Government, 2004). However, clearing of young regrowth forests continues on rural lands as does that of mature and young forests on urban lands. The region's lowland coastal forests have a history of failed nature conservation plans. However, these forests support a rich diversity of fauna populations, including the koala (*Phascolarctos cinereus*), many of which are threatened as forests are cleared for a rapidly expanding urban population (McAlpine et al., 2006). Since the end of the Regional Forest Agreement process in Australia, most states have endeavoured to conserve biodiversity outside formal reserves through native vegetation management legislation, although progress has been slow (McAlpine et al., 2002; Lindenmayer et al., 2005; Vesk and Mac Nally, 2006).

The decision of the plans to not consider forest ecosystems across all ownerships is not consistent with scientific understanding of the ecological role of the unreserved matrix forests and the importance of adopting a continuum of conservation strategies, rather than reliance on conservation reserves (Lindenmayer and Franklin, 2002). The overarching goal of regional biodiversity conservation must be to prevent further habitat loss or degradation by maintaining habitat quality and quantity across a full range of spatial and temporal scales. This requires assessments and policies that take into account all land ownerships – not just the fraction falling under State or federal ownership. The aggregate ecological conditions of a region are controlled by the relative amounts and spatial distribution of individual land holders and the ecological interactions among those holdings (Spies et al., 2002; Stanfield et al., 2002).

A landscape perspective offers useful guidance and tools for conserving and restoring these biota across multiple land ownerships by fostering multi-scale, spatially-explicit, cross boundary, adaptive and integrative approaches to forest management (Boutin and Herbert, 2002; Liu and Taylor, 2002). However, it is apparent that policy and planning processes have not kept pace with the science, and there is a lack of policy and planning instruments that are able to accommodate the spatial and temporal dynamics required for comprehensive biodiversity conservation at the regional scale (Spies et al., in press). In fact, some policies actually discourage multi-ownership planning. For example, anti-trust laws in the US appear to constrain large forest industrial owners from coordinating their management in a watershed or landscape (Thompson et al., 2004).

4.3. *Lesson 2: Politicians and interest groups are not comfortable dealing with uncertainties in achieving conservation outcomes*

Forests are extremely complex and dynamic systems about which it is difficult to predict the consequences of actions with anything more than a moderate level of certainty and they are managed within an equally complex framework that is impacted upon by global climate change, globalization and the impacts of new and sometimes unpredictable socio-economic policies. In these circumstances, adaptive management (Holling, 1978; Walters, 1986; Lee, 1999), which involves implementing policies and plans as experiments, provides a deliberate process for learning about the managed system, and allows improved management in the face of uncertainty, rather than being stifled by uncertainty. This approach requires the taking of risks, and the acceptance of a level of uncertainty that some participants inherently find difficult.

A cornerstone of the Northwest Forest Plan was adaptive management and in particular the establishment of Adaptive Management Areas (United States Department of Agriculture and United States Department of Interior, 1994). Whilst some studies have been conducted in these areas, progress in application of adaptive management has been very limited, due to the short time frame of studies, failure of the participating agencies to provide adequate funding or leadership to complete some projects, inability to engage all the participants equally, and constraining effects of certain legislation (e.g., the Endangered Species and Federal Advisory Committee Acts). An ongoing barrier has been the risk-averse environment (both within and outside agencies) of today's public land management arena, making it difficult to obtain the required agreement among all interested parties on activities that may be innovative or experimental (Diaz and Haynes, 2002; Stankey et al., 2003). Despite problems with adopting adaptive management in the Northwest Forest Plan, a comprehensive regional monitoring strategy was implemented and there have been ongoing efforts to explore innovative alternatives to established forest management practices (Cissel et al., 1999; Spies et al., 2002).

Whilst the Southeast Queensland Forests Agreement provided for monitoring and periodic review, no resources have been committed to this work, and no structured process developed to set and evaluate objectives – a key feature of meaningful adaptive management. There is a strong sense that the parties to the agreement are unwilling to have its assumptions seriously examined or reviewed, lest they prove difficult to sustain, generating pressure for further revision and consequent uncertainty (McAlpine et al., 2005). It would be interesting to postulate how the outcomes may have differed had a more flexible approach been taken. For example, forests throughout the region, including those within the newly declared reserve system, are already in a degraded condition for biodiversity conservation (e.g., availability of tree hollows), and this will be exacerbated in areas subject to the

40 cm+ harvesting regime introduced by the Southeast Queensland Forests Agreement (Norman et al., 2004). There is evidence to suggest that the process of restoring degraded areas to old-growth forests more suitable for biodiversity conservation, if left to chance, will be very drawn out. There is a strong case, therefore, for a level of experimentation within an adaptive management framework to investigate forest management alternatives that could hasten the recovery process. Adaptive management approaches have been adopted in other Regional Forest Agreements areas such as the Wombat Forest of Central Victoria (Loyn, 2004).

4.4. *Lesson 3: Scientists need to be actively engaged in the forest-planning process if long-term conservation goals are to be achieved*

The marriage of science and policy is, at best, an uneasy relationship (Meffe and Viederman, 1995; Johnson and Herring, 1999; Lee, 1999; Guldin, 2003; Briggs, 2006). Most natural resource management policies are prepared quickly to fix a problem, often in reaction to public pressure; while in contrast, science may be slow, project driven and not reactive to public pressure (Briggs, 2006). However, is important that scientists are actively engaged in the policy process by: alerting managers, policy makers and the public to the environmental problems; responding to public pressures; proposing solutions to the problems; participating in assessments and evaluating outcomes; following-up on the plans through participation in adaptive management; and monitoring efforts (Swanson and Greene, 1999). Whatever role was taken in the Northwest Forest Plan and the Southeast Queensland Forests Agreement, the intersection of science and policy in these efforts was a place where the relatively simple rules of the scientific process collided with social phenomena including environmental law, economics, sociology, psychology and political power. Science, as learned by most scientists, often did not fare well in this collision. Scientists were heavily involved in creating the Northwest Forest Plan, and in the Comprehensive Regional Assessment of Southeast Queensland forests which preceded the Southeast Queensland Forests Agreement, although the latter were subsequently overlooked in the final planning decision. In neither case study did adaptive management (e.g., treating the plans as working hypotheses to be tested) become a strong foundation for their implementation, and yet both were dealing with highly uncertain and dynamic environments that lent themselves to this. A monitoring program has been implemented in the Northwest Forest Plan (Mulder et al., 1999), but not in the Southeast Queensland Forests Agreement. In the Northwest Forest Plan, the opportunities to experiment and learn from alternative approaches (e.g., blending active management and biodiversity goals rather than relying on reserves) have been limited.

Scientists need to be actively engaged in the planning process. The longer scientists (and other players) can stay involved in the plans after their implementation, the more likely it is that the plans will take on a more adaptive form and evolve toward practices that can approach long-term sustainability goals. This requires a collaborative approach with stakeholders and takes time away from traditional research and may require a form of "civic science" (Lee, 1993) in which researchers work with non-researchers and land managers to develop hypotheses and new forms of communicating scientific results and uncertainty. Not all scientists are suited to this type of work.

The lack of trust by conservation (and other sectoral interests) groups of forest management and forest science subsequently limits the flexibility in plans that managers require to deal with the dynamics and diversity of ecosystems. Given a history of forest management in which policy makers gave priority to timber production goals over environmental considerations (often despite rhetoric to the contrary), flexibility in plans may be perceived by many as a loop hole. In addition, the very crisis that attracts the attention of policy makers also creates the perception in many people that ecosystems or species are already pushed too far to allow alternative management strategies to be trialed. New approaches to ecosystem management and sustainable forestry require more information and more resources to implement than previous extraction orientated approaches, which ignored many parts of the ecosystem (Johnson et al., 1999). The history following these new policies indicates that governments are reluctant to pay for all of the costs of implementing ecosystem management.

In both the Pacific Northwest and Southeast Queensland, resources available for forest management, especially within reserves, have declined since the implementation of the plans. The dilemma faced by policy makers is then whether to allow some extractive management that could be an ecological risk, but would allow them to pay for the active management needed to restore or maintain ecosystems, or to use the less expensive, minimal management approach that carries risks of its own. Integrated forest ecosystem research is needed to help evaluate these tradeoffs, but it requires experimentation to evaluate management alternatives. Research on this scale and in such controversial situations requires that researchers work carefully with stakeholders otherwise legitimate research goals can be seen as simply a ploy to get timber cut under the guise of research objectives. In informing conservation decisions, science provides many things including ammunition for the different sides of the debate, cover for politicians, who have to make difficult decisions, or assessment of the risks associated with different options. In the end, decisions are made based on interpretation of many factors, of which science is only one.

5. Conclusion

Both the Northwest Forest Plan and Southeast Queensland Forests Agreement, represent major advances in conservation of forest biodiversity. They have changed the course of forest management and will lead to improved protection of biodiversity over the previous timber-oriented management. The journey toward sustainable forestry is long and complex, however, and the current approaches will require some improvements and course corrections if they are to deliver truly ecologically sustainable outcomes. For example, both plans rely on an expanded reserve system on public lands as the means to resolve conflicts between timber production and conservation groups. The long-term effectiveness of these reserves to conserve the full complement of regional biota in both regions is questionable given the limitations at the outset on their representativeness, risks from wildfire in fire-prone regions and the absence or slow pace of restoration activities within previously logged areas in the reserves. Furthermore, the conservation strategies in Queensland focus entirely on reserves, ignoring forests managed for timber production, and both conservation plans focus entirely on public lands, ignoring risks to biodiversity that occur on private industrial and non-industrial lands. There is very little momentum in both regions at present to comprehensively address biodiversity concerns on private lands including increasingly intensive forest management and conversion of forest land to housing developments, and exotic plantations, or plantations with native species that are indigenous to the area. While changes in management practices on these lands could alter biodiversity conditions (Spies et al., in press), relatively few studies have examined how alternative forest management approaches affect biodiversity and almost no efforts are underway to monitor biodiversity on private lands. Adaptive management, advocated as a way of dealing with uncertainty, has proven difficult to achieve, mainly because of a lack of funding and trust by many stakeholders in the process. We conclude that while these plans were significant steps in the journey toward conserving forest biodiversity, biodiversity conservation goals cannot be fully achieved without more comprehensive conservation planning, active management of degraded forests within reserves, and the adoption of sustainable forest management practices across all land ownerships within an adaptive management framework. This will require developing new policy and planning instruments that take advantage of recent improved scientific understanding of the spatial and temporal dynamics of forest ecosystems and more explicit consideration of uncertainty/risk. In particular, it will require innovative approaches to integrate the management of private and public off-reserve forests with that of reserves to better insure long-term sustainability from ecological, economic and social perspectives.

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