Cedar (*Polyscias murrayi*), Native Frangipanni (*Hymenosporum flavum*), Red Bean (*Dysoxylum mollissimum*), White Cedar (*Melia azederach*), Red Cedar (*Toona ciliata*), and Cudgerie (*Flindersia schottiana*). Most of these are bird dispersed and may have germinated from relatively fresh seed. The last two are wind dispersed and their regeneration was dense near mature adults.

Vegetative recovery of trees, ferns and sedges was conspicuous, especially in forest, while seedling recruitment in forest was dominated by grasses and forbs, particularly Dwarf Panic (*Panicum pygmaeum*). In areas of former Lantana scrub, a common succession, taking 5 years, was *Solanum prinophyllum* → *Hypolepis muelleri* → *Cyperus tetraphyllus* → *Hypolepis glandulifera* → *Rubus rosifolius* → juvenile trees (Brittlewood, White Cedar, Cudgerie, Pencil Cedar) and vines (*Cissus* spp. and *Rubus* spp.). Red Ash, though a common germinant, recruited poorly because of browsing by Swamp Wallabies (*Wallabia bicolor*).

The three threatened species on site were in the Tall Open Forest. *Senna acclinis* seed germinated on relatively bare ground beside a road. Four survive, two have fruited. Several individuals of the threatened climber *Marsdenia longiloba* were browsed down by herbivores after removing the protective effect of Lantana. Some recovered. Several protected by native plants showed good growth; one specimen fruited. Only one seedling has been observed. The single *Parsonsia dorrigoensis* continues to grow.

Discussion. While the observations after treatment have been of longer duration and more intensive, direct observation of regeneration in the treated areas enabled new recruits to be distinguished from plants present prior to treatment. Therefore the observations that certain species have newly recruited to the site as the result of the treatment are judged to be reliable. The removal of the competitive effect of Lantana should not of itself be assumed to explain the increase in species. The disturbance associated with its removal and the establishment of a new succession, new vegetation structure and new and different kinds of disturbance also provide opportunities for recruitment of additional species (McDonald *et al*. 2002).

Threatened species. Adair (1995) reports no documented cases of national species extinctions due solely to weed invasion. However Leigh and Briggs (1992) cite weeds as a major cause of extinction in four plant species and a threat to 57 other species. It does appear from the recruitment of new species that, at least at a restricted spatial and temporal scale, extinctions could potentially be occasioned by Lantana and the change of disturbance regime that is associated with invasion and dominance by Lantana.

Low (2002) voices common views when he commends Lantana for sheltering and feeding wildlife (e.g. Eastern Whipbirds, *Psophodes olivaceus*) and cites it as having a role in rainforest succession and soil conservation. At our site, however, other shrubby habitats replaced Lantana and the Lantana removal was gradual. The only observed change in wildlife over the 7-year period has been an apparent, perhaps unrelated, reduction in numbers of Common Brush-tail Possum (*Trichosurus vulpecula*) and Mountain Brush-tail Possum (*T. caninus*). Eastern Whipbirds still appear common, especially in *Cissus*. Our experience is that Lantana blocks rainforest succession and in the absence of Lantana, rainforest succession has proceeded with more species and more structural diversity. Soil loss was minimal during weeding and regenerating native vegetation itself conserves soil.

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PLANNING, MONITORING & ASSESSMENT

10.16

Implementing ecological restoration in national parks. Jason Cummings and Nick Reid (Ecosystem Management, University of New England, Armidale, NSW 2351. Email: nrei3@metz.une.edu.au) [Peer reviewed]

Key words: *national park, plan of management, restoration planning.*

Introduction. Recent expansion of the NSW protected area estate has captured degraded and substantially modified land. National Parks on the NSW mid-north and north coast are estimated to now contain at least 200 timber plantations (R. J. Hunter, pers. comm., 2003). The conservation estate also includes sand-mined areas, previously cleared and grazed sites, land that has been exposed to inappropriate fire regimes and areas infested with weeds and feral animals. The NSW National Parks and Wildlife Service (NPWS) is responsible for managing these reserves. The NPWS charter requires that degraded areas be managed to enhance biodiversity values (Steering Committee to the Minister for the Environment 1998).

Since 1999 the University of New England and the NPWS have collaborated in the ecological restoration of degraded areas in Bongil Bongil National Park on the NSW mid-north coast. We have adopted Hobbs and Harris' (2001) restoration framework (Fig. 1).

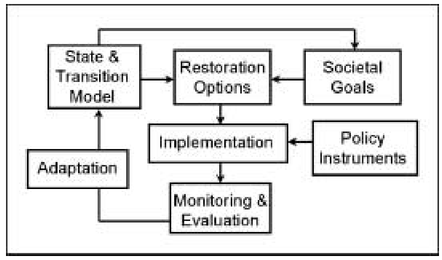

Figure 1. Restoration framework outlining inter-relationship between aspects of the restoration process (redrawn from Hobbs & Harris 2001).

Several NPWS planning and policy instruments are integral to the successful implementation of this framework. Expertise in the design, monitoring and analysis of restoration projects has been equally important in ensuring successful outcomes. Inclusion of case studies is beyond the scope of this short note. Here we present our current views on the value of applying ecological models to restoration planning and evaluation, given the anticipated escalation of ecological restoration projects in national parks.

State and transition models. Ecological restoration projects begin with a degraded site requiring restoration. A state and transition model indicating hypothetical restoration barriers needs to be developed for the site. Such a model identifies the current degraded state, alternate desired states and the barriers restricting transition between them (Westoby *et al*. 1989). Pre-treatment measurements should assess the functional, structural and compositional attributes of the site, predicting the likely potential for, or limits to, recovery based on the autecology of the desired species. Although it is not possible to predict the composition and condition of seed banks, prediction of likely barriers currently restricting natural regeneration is important to maximize the chance of early success. Restoration options that do not address the barriers and current degradation pressures are unlikely to be successful (Hobbs & Norton 1996).

Understanding land use history of the site is helpful for identifying alternative vegetation states and the potential barriers restricting transition to a preferred state. A land use history can be compiled using aerial photographic interpretation and oral and written histories of the site. Quantitative comparisons of degraded sites with comparable natural and less disturbed sites should be made. Comparisons of the degraded, semi-degraded and natural states provide insights into the ecological conditions and processes maintaining the site in a degraded state and preventing transitions to more desirable states. Once restoration barriers are identified, the literature and local expertise can guide planning of restoration options to overcome these thresholds.

Societal goals. Restoration within a national park will usually entail restoring vegetation and ecological processes approximating a putative pre-European state and disturbance regime. Permissible activities within NSW National Parks are generally those allowed within the World Conservation Union (IUCN) definition of a national park, precluding rehabilitation goals other than those related to establishing natural communities or low-impact wildland recreation facilities (IUCN 1994).

Societal goals for degraded sites within national parks should be documented in the plan of management (POM). POM preparation includes public consultation and review. Statements within plans are usually generic and of the form 'the site will be rehabilitated to a natural condition', providing little specific guidance for park managers. Restoration goals need to be quantified and achievable (Hobbs & Norton 1996). We suggest quantitative restoration goals be determined by experimenting with various restoration options. Through experimentation, realistic goals can be set as the minimum achievable standard for further restoration attempts, with some confidence that they can be achieved. Monitoring of initial restoration experiments must continue to update response models and longer term restoration goals. Once restoration goals are quantified, they should be included in POM review for societal approval. Detailed restoration and rehabilitation plans can also be developed in parallel to provide specific implementation guidelines for park managers.

Restoration options. Without experimentation, a site's potential for natural regeneration cannot be determined. Furthermore, it is important that proposed restoration treatments test hypothesized restoration barriers from the state and transition model. If treatments do not address putative barriers, not only are they likely to fail, but it will also be difficult to refine the model. Equally, if treatments have under-estimated regeneration potential and actually suppress it, failure can also occur. A range of treatments should be proposed, including treatments that test the potential for natural regeneration, so that the cost to biodiversity benefit ratio of the different options can be determined.

From a pragmatic perspective, restoration options must aim to establish self-sustaining communities as rapidly as possible without compromising the integrity of local communities. Enhancing natural successional pathways can minimize long-term management inputs. The NSW Parks estate is still expanding with > 7% of the state reserved. Efficiency is paramount in ensuring successful restoration so that resources can be used to rapidly restore the maximum number of degraded sites.

Treatments should also be practical. Restoration options must be applicable to the scale of the problem and capable of implementation across the whole area affected. While it may be feasible to temporarily fence small research plots or areas of threatened species to minimize browsing of planted seedlings, fencing large tracts is usually not. Similarly, skills and equipment maintained by the agency should guide potential restoration options. For example, herbicides, fire, or other tools for weed control can be used, given agency staff usually have the appropriate skills.

Policy instruments. The reserve POM is the policy instrument that outlines which sites should be restored and with what priority. Plan developers can utilize a triage approach to restoration site prioritization, whereby the relative probability of recovery and current level of degradation are considered (Hobbs & Kristjanson 2003), along with the site's importance in the conservation matrix. The POM should also briefly outline the monitoring and reporting requirements for restoration projects. Increasingly, restoration and rehabilitation plans are being prepared since site-specific implementation guidelines are too detailed for inclusion in the POM. In such cases, the POM should outline that a separate rehabilitation plan is to be developed. The aims for degraded site restoration should be clearly stated in the POM since it is developed and periodically reviewed through community consultation. Explicit objectives and implementation guidelines can be outlined in the restoration plan, that is subject to more frequent review via the adaptive management reporting of the specific project.

Environmental impact assessment is required in NSW reserves for any on-park 'activity' (Part 5 of the NSW EP&A Act 1979). Usually this entails production of a review of environmental factors (REF) that is assessed within the Environment Protection and Regulation Division, separate to the Parks Service Division, of the

Department of Environment and Conservation (NSW). The REF is designed to determine whether a significant impact is likely to occur from the proposed activity, in this case restoration treatments. The REF can be a key policy instrument in implementing best-practice restoration by requiring monitoring and reporting that otherwise may have been avoided. Impact assessment ensures consideration of the potential to further degrade the site through restoration treatments. We have also found REF preparation useful for improving community awareness regarding restoration activities and receiving feedback from local experts about restoration options.

Monitoring and evaluation. Restoration options should ideally be implemented according to a statistically valid experimental design with random allocation of treatments to replicated experimental units. This requires additional planning in consultation with restoration ecologists and statisticians but not necessarily additional on-ground works. An experimental approach enables rigorous and reportable comparison of various restoration treatments in terms of compositional, structural and functional outcomes. Where testing state and transition hypotheses, experimental design needs to be tailored to overcoming transition thresholds (barriers) suggested by the response model.

Integral to successful restoration (Hobbs & Harris 2001) and the development of restoration ecology (Lake 2001) is the capture and dissemination of both scientific and non-technical information from restoration projects. Monitoring is key to comparing restoration options and determining whether restoration goals are being met. NPWS park management staff can qualitatively monitor restoration success. However, scientists should also conduct quantitative monitoring of ecosystem function, composition and structure, relevant to the state and transition model. This monitoring is required to test hypotheses arising from the state and transition model in order to refine and improve it. Once quantified restoration goals have been established, restoration ecologists and park management staff can develop a simplified monitoring protocol that can be implemented by local staff to assess restoration success.

Evaluation needs to consider more than the achievement of quantified restoration goals. Consideration should be given to the costs and ongoing management requirements of treatments. Reporting of both successes and failures is essential to ensure others do not make similar mistakes and can replicate the successes. Publication of results can be multifaceted in the form of research theses, journal articles, NPWS restoration workshops and the scientific literature. Given the number of restoration projects currently being undertaken by NPWS, there is a wealth of information that should be captured and disseminated. A simple inter- or intranet reporting template might be contemplated to communicate outcomes and experiences. Periodic collation and review of emergent patterns could be centralized before dissemination.

From monitoring and evaluation comes improved scientific understanding of the system and the state and transition model. Furthermore, restoration goals can become more realistic in terms of area restored per unit time and cost and through realization that the site may be unable to support the community type that had originally been intended. Information gained from monitoring should be used in POM reviews so that revised restoration goals and costs can be evaluated by the agency and community as a whole.

Conclusions. Given current and expected restoration efforts within national parks, it is important to maximize returns. By implementing best-practice restoration techniques, positive outcomes will be achieved more quickly. Short-term restoration failures, when conducted within an appropriate research framework like the one advocated here, can provide invaluable information for future success. Although extra costs are borne through rigorous monitoring and evaluation, we argue that the long-term biodiversity benefits and financial savings are worth the modest short-term expense.

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10.17

Triage: Appropriate for prioritizing community funded river restoration projects, but not for advancing the science of river restoration. Robyn J. Watts and Andrea L. Wilson (Johnstone Centre, School of Science and Technology Charles Sturt University, PO Box 588 Wagga Wagga, NSW 2678, Australia. Email: rwatts@csu.edu.au) [Peer reviewed]

Key words: *funding allocation, research priorities, river restoration, triage*.

Setting priorities for the allocation of limited resources to restoration projects has become an important issue in Australia due to the increasing incidence and spatial extent of environmental degradation. Concern about the way landscape restoration projects have been prioritized has resulted in a move towards the adoption of triage assessment approaches similar to those employed in medical fields (e.g. Hobbs & Kristjanson 2003). Medical triage classifies patients on the basis of illness or injury severity and the need for medical or nursing care (Monash Institute of Health Services 2001). Triage assessment of natural landscapes directs resources to systems where there is a high level of threat