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Boosting forest succession in North and South Island, New Zealand

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New Zealand is the largest remote oceanic island (Diamond 1990) and comprises less than 0.2% of the land area of the world (Daugherty et al. 1990). Islands are important for many reasons, but are particularly important for their wealth of unique flora and fauna. Human colonization plays a big role in the loss of species and in the destruction of land (Hobbs and Norton 1996). Facilitating forest succession therefore, is an important restoration tool because it helps recreate functional, self-sustaining ecosystems (Smale et al. 1999). This paper will focus on two long-term restoration projects, one in Aratiatia, North Island, New Zealand and the other in Port Hills Ecological District, South Island, New Zealand. The ultimate goal of both projects is to boost forest succession and ultimately bring back indigenous species by: 1) planting indigenous species; and 2) capitalizing on a single native species to facilitate growth of indigenous species.

Study Site

Aratiatia is located in the North Island's Central Volcanic Plateau Ecological District (latitude 38°37' and longitude 176°08') (Figure 1) (Smale et al. 1999). Aratiatia is warm-temperate and humid, with mean annual rainfall totaling 1200-1600 mm (Smale et al. 1999). Soils in this area had been classified as rhyolitic Taupo Tephra gravelly sand, a Pumice Soil, which is of low natural fertility (New Zealand Soil Bureau 1954).

Waikato River, which flows through Aratiatia, is New Zealand's longest and second largest river (Smale et al. 1999). In 1964 following the completion of a hydroelectric dam, areas along the Waikato River including Aratiatia, were grossly disturbed. This development was headed by the former New Zealand Electricity Department following World War II (Smale et al. 1999). Soils on these grossly disturbed sites are derived from a variety of artificially mixed rhyolitic Tephras (Smale et al. 1999). Like Pumice Soil, these Anthropic Soils are also of low natural fertility (Smale et al. 1999). Destruction of natural landscapes and losses of major aesthetic and tourist values were just a few of the repercussions Aratiatia faced.

Historically along the Waikato River, vegetation was comprised of broadleaved forests with scattered emergent conifers (Smale et al. 1999). Dominant broadleaved trees and shrubs included: *Knightia excelsa* (rewarewa), *Weinmannia racemosa* (kamahi), *Elaeocarpus dentatus* (hinau), *Nestegis cunninghamii* (black maire), *Melicytus ramiflorus* (mahoe), *Pseudopanax arboreus* (five finger), *Fuchsia excorticata* (tree fuchsia), *Schefflera digitata* (pate), and *Coprosma grandifolia* (karangu) (McKelvey 1963; Wardle 1991). Conifers mostly consisted of *Podocarpus totara* (totara) and *Prumnopitys taxifolia* (matai) (Smale et al. 1999). Secondary succession on intact substrates is dominated by, *Pteridium esculentum* (bracken) and adventive (non-native) *Rubus fruticosus* (blackberry) and *Ulex europaeus* (gorse). It is speculated that forests dominated by *Pittosporum tenuifolium* (kohuhu), *Kunzea ericoides* (kanuka), and *P. arboreus* may have persisted before the onset of these adventive shrubs (Smale et al. 1999).

Port Hills Ecological District located on the South Island, forms the southeastern boundary of the city of Christchurch (latitude 43°37'and longitude 172°36') (Figure 1) (Reay and Norton 1999). Port Hills is cool-temperate with mean summer and winter temperatures of 13.5° C and 5.2° C (Norton, pers. comm.).

Mean annual rainfall totals 760-1020 mm (Wardle 1991). The soils of Port Hills are derived from igneous rock and loess, are well drained, and are of moderate fertility and acidity (Norton, pers. comm.).

The original forest cover was cleared around 1860 for timber, in addition a major fire in 1868 destroyed much of the remaining tall forest (Norton pers. comm.). The best remaining example of undisturbed mature indigenous forest consists of the dominant canopy layer *Prumnopitys taxifolia* (matai) and *Dacrycarpus dacrydioides* (kahikatea), and the co-dominant canopy layer *Pseudowintera colorata* (horopito), *Fuchsia excorticata* (tree fuchsia), *Griselinia littoralis* (broadleaf), *Melicytus ramiflorus* (mahoe), and *Pittosporum eugenioides* (lemonwood) (Reay and Norton 1999). Shrub and herbaceous layers are also present in this mature indigenous forest (Reay and Norton 1999). This undisturbed forest remnant is what the forest might have been like had this area not been cleared in 1860 (Reay and Norton 1999).

Revegetation of North and South Islands

Prompted by the enormous loss of aesthetic and tourist value on the North Island, the former Department of Lands and Survey began revegetation of indigenous species in 1962 (Smale et al. 1999). In preparation for the 1962 revegetation of indigenous species, artificial contouring to mimic previous landforms was initiated over 108 ha along 5 km of the Waikato River (Smale et al. 1999). Additional site preparation was not documented for this study site. Forty-six native species, including 8 non-indigenous species to the site, were planted in two stages with the goal of emulating natural successional pathways (Smale et al. 1999). Stage one consisted of native nurse vegetation; fast-growing, short-lived shrubs. The more widely planted nurse vegetation included: *Hebe stricta* var. *stricta* (koromiko), *Coprosma robusta* (karamu), *Coprosma lucida* (karamu), *Leptospermum scoparium* (manuka), and *Brachyglottis repanda* (rangiora) (Smale et al. 1999). Stage two, occurring approximately five years later, consisted of native fast-growing, short-lived small trees such as *Pittosporum tenuifolium*, *Kunzea ericoides*, *Sophora tetraptera* (kowhai), and *Cordyline australis* (cabbage tree) that were interplanted with native longer-lived medium-sized trees and tall trees (*Griselinia littoralis* and *Podocarpus totara*, respectively) (Smale et al. 1999). Replanting, where necessary, was done within a year or two after initial planting (Smale et al. 1999). Unplanted or unsuccessfully planted sites were used for comparison. Management or monitoring was not done on these sites between 1980-1999.

Three different aged restoration sites that had previously been grassland were planted in 1953 with *Olearia paniculata* (akiraho), a native species to the study sites on the South Island (Reay and Norton 1999). No site preparation was documented for this study site. Restoration site 1 is the youngest site (12 year) and still contains a fair amount of grass and restoration sites 2 and 3 (30 and 35 years, respectively) are dominated by *Olearia paniculata* and contain indigenous shrubs, herbs, and ferns (Reay and Norton 1999). Three additional sites were used for comparison and include: 1) A grassland site, remnant of conditions prior to planting, containing a mixture of introduced and indigenous species; 2) A ~100 year old naturally regenerating forest dominated by *Melicytus ramiflorus*, *Kunzea ericoides* (kanuka), *Pittosporum eugenioides*, and *Plagianthus regius* (lowland ribbonwood); and 3) An undisturbed forest remnant including mature indigenous forest (Reay and Norton 1999). The grassland site was used for comparison to see what would happen if succession wasn't facilitated by plantings of *O. paniculata*. The (~100 year old) naturally regenerating forest and mature forest were used for a model of what species (both regenerating and canopy) could potentially be expected on the 3 restoration sites. Continual planting occurs on these restoration sites, however other specific management or monitoring has not been documented.

Research on North and South Island Restorations

In 1999, scientists from the Landcare Research New Zealand and Department of Conservation initiated research efforts at the Waikato River restoration site. The success of the North Island restoration project was evaluated based on comparisons between successional pathways on previously planted sites and unplanted or unsuccessfully planted sites and how closely these planted (indigenous) sites mimic natural successional pathways (Smale et al. 1999). Fifty sampling plots were randomly distributed in areas that were devoid of vegetation following completion of the hydroelectric dam (Smale et al. 1999). Thirty-six of the 50 plots were established in planted areas and 14 plots were established in unplanted or unsuccessfully planted areas and ranged in size between 36 and 64 m^2 (Smale et al. 1999). Diameters of all woody plants were measured within each plot and numbers of established seedlings of woody species, presence of ephemeral seedlings, and ground cover were measured in a nested subplot (Smale et al. 1999). The largest stem of each major canopy tree was felled in each plot for measurements on age, diameter, and height (Smale et al. 1999). In addition, other vascular plants in and around these plots were noted (Smale et al. 1999).

In 1999, scientists from the Conservation Research Group, University of Canterbury initiated research efforts at the Port Hills Ecological District restoration site. The success of the South Island restoration project was evaluated based on comparisons between restored successional pathways and natural successional pathways, as well as the recolonization of indigenous forest species by a single planting of a native species, *Olearia paniculata* (Reay and Norton 1999). Thirty-eight circular plots (5 m diameter) were established at 5 m intervals along two 50 m perpendicular bisecting transects within each restoration site (Reay and Norton 1999). In each of the circular plots, abundance of all plant species in five strata (ground, shrub, subcanopy, canopy, and emergent) was measured by estimating foliage cover.

Results of Research Efforts Conducted in 1999

Of the fast-growing, short-lived shrubs planted on the North Island along the Waikato River, *Hebe stricta* var. *stricta* and *Brachyglottis repanda* were the only nurse vegetation to survive (Smale et al. 1999). The other nurse vegetation reached the end of their natural lifespans or were out-competed and eliminated by dominant canopy species (Smale et al. 1999). By classifying basal area of woody species, Smale et al. (1999) distinguished 3 canopy communities; adventive shrubland, *Pittosporum-Kunzea* short forests, and *Pittosporum-Sophora* short forests. Thirty-seven years after planting, stem diameters were low on unplanted sites for shrubland species (2 cm) and higher on planted sites for short-lived small trees such as *Pittosporum- Kunzea* forests (6 cm) and *Pittosporum-Sophora* forests (9 cm) (Smale et al. 1999). Mean seedling density (>15 cm high) was greater in *Pittosporum-Sophora* forests (9192 stems/ha), followed by shrublands (8083 stems/ha), and *Pittosporum-Kunzea* forests (4322 stems/ha) (Smale et al. 1999). It is important to note that on planted sites, 83 vascular plants were recorded with two-thirds of them being native (Smale et al. 1999). On unplanted sites, 41 species were recorded with three quarters of them being adventive species (Smale et al. 1999). Fifty-three percent of native species on planted sites were trees and shrubs and 59% of adventive species on unplanted sites were grasses and herbs. Percentages of plots with ephemeral seedlings were widespread, particularly on planted sites (Smale et al. 1999). Percentages of plots with established seedlings however were less widespread, with no seedlings occurring in the unplanted sites (Smale et al. 1999).

On the South Island, diversity of canopy species was found to increase from the youngest restoration (restoration 1) to the mature forest, in comparison with no woody species found in the grassland site (Reay and Norton 1999). Diversity of regenerating species, however, varied little between sites (Reay and Norton 1999). Of the regenerating tree species, 71% are primarily dispersed by birds (Reay and Norton 1999). Floristic differences between the youngest restoration and the two oldest restoration sites (restoration 2 and 3), the (~100 year old) natural regenerating forest, and the mature forest sites for canopy species were found (Reay and Norton 1999). The youngest restoration was less heterogeneous in its floristic composition (Reay and Norton 1999). Low floristic differences among sites (restorations vs. (~100 year old) natural regenerating forest and mature forest) were found for regenerating species (Reay and Norton 1999).

Outcomes of Restoration Efforts

Reay and Norton (1999) describe successful restoration based on a continuum, meaning that through success in the initial plantings, new individuals colonize the restored habitat and become a part of and contribute to the maintenance of the system. Smale et al. (1999) found that stands on the North Island are entering a third phase called an understory reinitiation phase. This phase occurs when herbaceous and woody plants begin to grow in the understory. It is thought that correct species selection in the initial planting is crucial to facilitate the early stages of plant succession (Aber 1987). The restoration sites on the North Island were planted with consideration of indigenous species. This is evident on planted sites where native forest are now mimicking young secondary forests. It seems then, that plantings of fast-growing, short-lived native shrubs and trees have been enormously successful in restoring woody vegetation (Smale et al. 1999). Plant communities on unplanted or unsuccessful planted sites were identified as being stable systems although lacked the transition to woody native plant communities (Smale et al. 1999). Therefore big differences between plant communities of planted vs. unplanted or unsuccessfully planted sites were evident.

The restoration sites on the South Island were not planted with consideration of indigenous species (Reay and Norton 1999). *Olearia paniculata* is native to the South Island, but it not indigenous to the restoration study sites (Reay and Norton 1999). Reay and Norton (1999) found that restorations 1, 2, and 3 as well as the (~100 year old) natural regenerating forest and mature forest had similar regenerating tree species, which implies that, the single planting of *O. paniculata* is, in fact, facilitating the recolonization of indigenous species. Results show, specifically for the older restoration sites (30 and 35 year old), that restorations provide conditions that are suitable for the recolonization and establishment of species. *O. paniculata* forms a single tree canopy that helps facilitate the recolonization of regenerating indigenous species and suppresses grass growth (Reay and Norton 1999). Reay and Norton (1999) conclude that these plantings are mimicking natural succession, and are doing so at an even faster rate then what would naturally occur. The natural processes occurring in the grassland sites help support Reay and Norton's findings. No woody species were found in the grassland sites. Planting on these sites is evidently crucial for boosting forest succession. In addition, plantings on these sites are facilitating the reestablishment of indigenous invertebrate species (Reay and Norton 1999).

Discussion

Direct comparisons of the two long-term restoration projects cannot be made because of differences in landscape, species composition, soil classifications, and climatic factors. However, the similarities and differences as well as the successes and failures of both projects can be examined. A similar objective that both restoration projects had was to see if restored successional pathways mimicked natural successional pathways and if these restored systems contained indigenous species. The way that this objective was accomplished, however, differed among projects. For example, the restoration project in Aratiatia, North Island focused on planting 46 indigenous species, while the restoration project in Port Hills focused on planting a single native species. The restoration project in Aratiatia has essentially tried to put back all the pieces, while the project in Port Hills has capitalized on a single species to bring back all the pieces. While some might argue that indeed correct species selection is crucial to facilitate the early stages of plant succession, this was not the case at the Port Hills restoration site. Whether planting

46 species or a single species, natural successional pathways are being mimicked and the return to indigenous species at both restoration sites is evident. While there is no doubt that *Olearia paniculata* helped facilitate indigenous regeneration by providing canopy cover and suppressing grass growth, other facilitating factors should not be neglected. Bird dispersal is also an important factor in helping facilitate the recolonization of species. Two-thirds of neighboring indigenous tree species bear fruit and seed that are dispersed by birds (Reay and Norton 1999). It has been well documented in New Zealand that planting fruiting species enhances the attractiveness of a site and in turn increases the likelihood of bird colonization and establishment (Reay and Norton 1999).

It is clear that by either planting abundant indigenous species or capitalizing on a single species both restoration projects proved to be successful at recreating functional, self sustaining ecosystems. Planting, even of a single species, accelerated the return to forests as compared to areas left unplanted. At both restoration sites, areas left unplanted lacked the transition to woody plant communities.

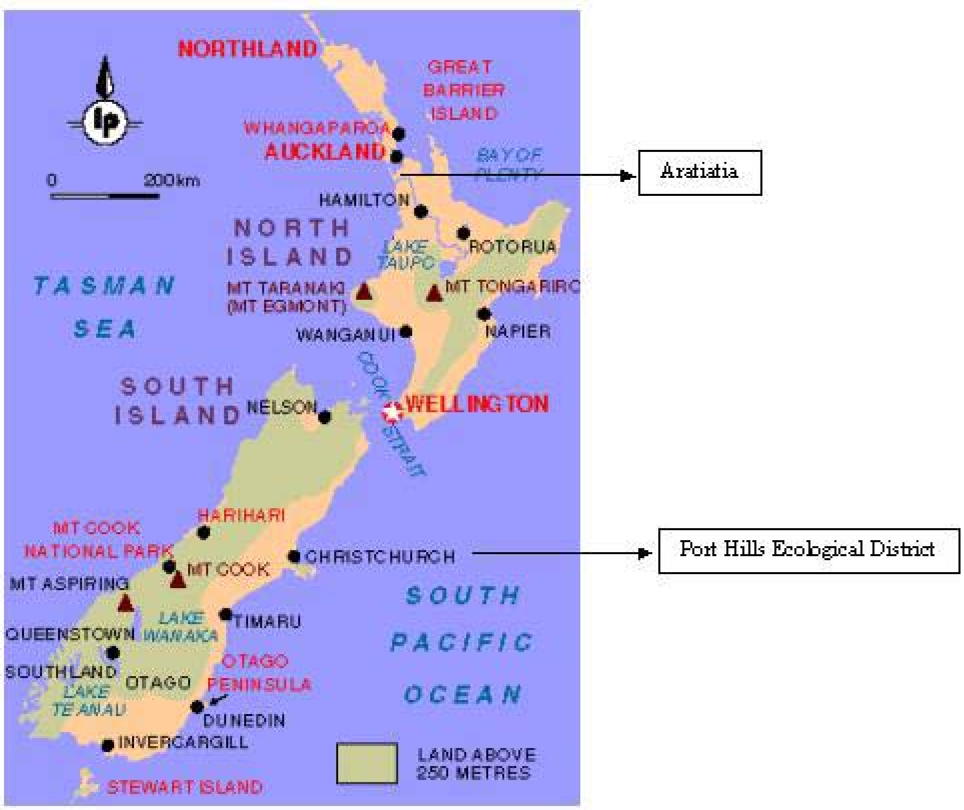

Figure 1. Map of North and South Island, New Zealand
(http://www.lonelyplanet.com/mapshells/australasia/new_zealand/new_zealand.htm)

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Literature Cited

Aber, J.D. 1987. Restored forests and the identification of crucial factors in species-site interactions. Pages 241-250 in W.R. Jordan III, M.E. Gilpin, and J.D. Aber, Editors. Restoration Ecology: A Synthetic Approach to Ecological Research, Cambridge University Press, Cambridge, U.K.

Daugherty, C.H., D.R. Towns, I.A.E. Atkinson, and G.W. Gibbs. 1990. The significance of the biological resources of New Zealand Islands for ecological restoration. Pages 9-21 in D.R. Towns, C.H. Daugherty, and I.A.E. Atkinson, Editors. Ecological Restoration of New Zealand Islands. Conservation Sciences Publication No. 2.

Diamond, J.M. 1990. New Zealand as an archipelago: An international perspective. Pages 3-8 in D.R. Towns, C.H. Daugherty, and I.A.E. Atkinson, Editors. Ecological Restoration of New Zealand Islands. Conservation Sciences Publication No. 2.

Hobbs, R.J., and D.A. Norton. 1996. Towards a conceptual framework for restoration ecology. Restoration Ecology 4: 93-110.

http://www.lonelyplanet.com/mapshells/australasia/new_zealand/new_zealand.htm. 2001. Map of New Zealand Islands. Date accessed: September 09.

McKelvey, P.J. 1963. The synecology of the West Taupo indigenous forest. New Zealand Forest Service Bulletin 14. New Zealand Forest Service, Wellington.

New Zealand Soil Bureau. 1954. General survey of the soils of North Island, New Zealand. New Zealand Department of Scientific and Industrial Research Soil Bureau Bulletin (new Series) 5. N.Z.D.S.I.R., Wellington.

Norton, D.A. 2001. Conservation Research Group, School of Forestry, University of Canterbury. Personal Communication.

Reay, S.D., and D.A. Norton. 1999. Assessing the success of restoration plantings in a temperate

New Zealand forest. Restoration Ecology 7: 298-308.

Smale, M.C., P.T. Whaley, and P.N. Smale. 1999. Ecological restoration of native forest at Aratiatia, North Island, New Zealand. Restoration Ecology 9: 28-37

Wardle, P. 1991. Vegetation of New Zealand. Cambridge University Press, Cambridge, England.