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Vegetation structure, composition and effect of pine plantation harvesting on riparian buffers in New Zealand

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ABSTRACT

The composition and structure of vegetation within riparian buffers prior to, and immediately post-harvesting in a managed radiata pine (*Pinus radiata* D.Don) forest is described and compared with riparian buffers in residual adjoining native forest on the Coromandel Peninsula, New Zealand. One hundred and twenty-one species (71% native) representing life forms from grasses to trees were recorded. The highest species richness, including both native and adventive (non-native) species, was found in riparian buffers in the post-harvest and native reference sites which had 18–25 species per site. Riparian buffers in mature pine plantations contained a mix of native species that was generally similar to, and not significantly reduced in species richness, from the reference native forest. Native species comprised 82–92% of the total cover in mature pre-harvest sites (irrespective of riparian width), and 99.8% in native reference sites. Compared with native forest the principal difference was a reduction of total cover in the upper tiers (5–12 m), and some increase in cover in the lower tiers. Adventive species in post-harvest sites comprised 16–67% of the total cover and were most frequently found in riparian areas highly disturbed by recent harvesting of the pines, particularly where riparian buffers were narrow or absent. Invasion by light-demanding adventives is expected to be temporary and most species are likely to be shaded out as the new rotation of pine trees develops. Radiata pine plantations in Whangapoua Forest can provide suitable conditions for the development of riparian buffer zones that will become dominated by native species, similar in richness and structure to neighbouring native forest.

1. Introduction

Vegetated riparian buffer zones are often advocated as a suitable environmental management tool for reducing impacts of land use activities, including forestry, on aquatic resources by buffering streams from changes in habitat and energy supply (volume and velocity of flow entering the system), and increases in contaminant loads (Gilliam et al., 1992; Collier et al., 1995; Lowrance, 1998; Lowett and Price, 1999).

Vegetation is widely accepted as a key factor in stream bank stability. Above ground vegetation is known to increase roughness slowing floodflows and trapping fine sediments when the stream channel expands into the riparian zone (Smith, 1976; Platts et al., 1985). Vegetation spreads and divides the incoming overland or channelised flow and reduces the velocity of the water with an associated reduction in water depth resulting from increased infiltration in the undisturbed area (Clinnick, 1985). A vegetative mat protects banks from scouring although excessive riverbank shading by trees or shrubs will inhibit ground cover growth (Collier et al., 1995), resulting in greater sediment inputs (Smith, 1992) and increased bank erosion (Murgatroyd and Ternan, 1983). Below ground, roots increase bank stability by protecting soils against entrainment from floodflows, and root mass and density provide soil strength and thereby protect against gravity collapse of undercut banks (Smith, 1976; Kleinfelder et al., 1992). However, riparian vegetation can destabilise banks if inappropriate vegetation types or planting densities are established (Collier et al., 1995).

The use of poplars (*Populus* sp) and willows (*Salix* sp) for protecting eroding stream banks has been widely practised in New Zealand (e.g., Van Kraayenoord and Hathaway, 1986). Some planted native species have not been found to match the vigour and protection that poplars and willows provide (Collier et al., 1995; Czernin and Phillips, 2005). However, evidence from surveys of rapidly eroding stream banks in pine forests near Hamilton, New Zealand (Smith et al., 1993) suggest that native tree ferns (*Cyathea*

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sp and *Dicksonia* sp) with their extensive fibrous root systems can provide excellent stream bank protection. Collier et al. (1995) note that kanuka (*Kunzea ericoides* (A.Rich.) Joy Thomps.) and manuka (*Leptospermum scoparium* (Labill.) J.R. & G.Forst.) appear to have the inherent characteristics required for stream bank protection, but further study is required. Czernin and Phillips (2005) compared the performance of the native *Cordyline australis* (G.Forst.) Endl. with willows for riverbank protection. Their results for root breakage and pullout indicated that, on its own, *Cordyline australis* was inferior to willows, however, riparian vegetation combining *Cordyline australis* and *Phormium* sp. performed similarly to willow, especially in low-order streams. Marden et al. (2004) compared the effectiveness of 12 native woody species for stream bank and slope stabilisation. All were recognised as early successional species and showed good below ground growth attributes suited to colonising steep and unstable riparian slopes.

In a comprehensive study of stream environments in Nelson, New Zealand, Graynoth (1979) found that a 30-m wide riparian buffer of native trees, ferns, and shrubs left alongside each side of the stream channel was effective in reducing the impact of plantation forest logging on the aquatic environment and fauna, in contrast to catchments with no riparian buffer. Wylie (1975) concluded that 30-m wide riparian buffers, with variation in width suited to local conditions, were sufficient to protect stream environments in New Zealand. Erman et al. (1977) (in Clinnick, 1985) found that riparian buffers had to be greater than 30 m to achieve similar channel stability and species diversity to that achieved in unlogged streams in a California (U.S.) study. Boothroyd and Langer (1999) compared international guidelines for riparian buffers in relation to forest harvesting and noted the lack of a fixed riparian width in the New Zealand guidelines. However, they found that narrower riparian zones (<10 m) may be adequate to protect streams although no evidence is available in the New Zealand context. If narrow riparian buffers could be shown to be effective, they would also reduce the loss of production. In a study performed in Whangapoua Forest, the productive area of forest affected by roading and riparian areas was calculated to be 14% with 20 m and 28% with 40 m wide riparian strips on either side of stream centre lines, assuming that 75% of total stream lengths were buffered (Visser and McConchie, 1993). If no harvesting or log hauling is allowed in the riparian zone, then the reduction in the harvestable area is compounded by the additional roading and landings which are required. In turn, these will often be in more difficult locations, have higher adverse environmental impacts, and cost more to construct and maintain.

The riparian vegetation analysis described in this paper was part of a larger multi-disciplinary study of the influence of riparian vegetation along afforested streams which included stream geomorphology and periphyton (Boothroyd et al., 2004), macroinvertebrate (Quinn et al., 2004) and fish studies (Rowe et al., 2002). The study took place in plantation forest in Whangapoua Forest, Coromandel Peninsula, New Zealand between 1998 and 2001. The riparian buffers in harvested catchments were found to enhance native fish communities, with greater numbers of banded kokopu (*Galaxias fasciatus*) in streams with riparian buffers than in those where riparian zones were absent (Rowe et al., 2002). Quinn et al. (2004) showed that clearcut reaches had lower aquatic invertebrate diversity, taxon richness, and relative abundance compared with sites with continuous buffers which did not differ from intact native or mature plantation forest. Logged sites with patch buffers had intermediate biometric values. In this paper, the structure and composition of riparian plant communities in varying combinations of presence and absence of pine canopy are examined and compared with intact native forest.

2. Methods

2.1. Study sites

This study was undertaken in four catchments within Whangapoua Forest on the Coromandel Peninsula (Fig. 1). The physical riparian environment is detailed in Boothroyd et al. (2004). In brief, the catchments are characterised by steep topography. Rivers and streams, with highly variable flow rates, drain northward from the Coromandel Ranges (maximum elevation 573 m) into the Whangapoua Harbour. Soils are predominantly yellow-brown earths with clay overlaying weathered greywacke and andesite rocks. Mean annual rainfall is 1700 mm, but rainfall up to 2300 mm per annum has occurred in recent years (C. Nelson pers. comm.). Extreme storm events occur in most years (such as 15–20 mm/h in July 2000).

Coromandel Peninsula was formerly covered in native forest, dominated by large kauri (*Agathis australis* (D.Don) Lindl.) that was logged from the early 1800s to the 1930s. Cleared areas were grazed and burned to promote grass growth until the 1940s (Quinn et al., 2004). Large areas of Whangapoua Forest (7560 ha) have been planted with exotic pines (predominantly radiata pine, *Pinus radiata*) since the early 1960s. Cutover native forest remnants were retained in the headwaters of some of the catchments, and as patches of riparian forest alongside some of the rivers and streams. Areas of native riparian vegetation vary in width from over 20 m (of relatively unmodified native forest) to margins less than 3–5 m alongside mature pine plantings.

All riparian buffers generally contain a diverse array of predominantly native species. Principal native species include hardwood species such as mahoe (*Melicytus ramiflorus* J.R.Forst. & G.Forst.), five-finger (*Pseudopanax arboreus* (Murray) Philipson), big leaved Coprosma species such as kanono and karamu (*C. grandifolia* (Hook.f.), *C. robusta* Raoul), kanuka, manuka, rangiora (*Brachyglottis repanda* J.R.Forst. & G.Forst.), *Pittosporum colensoi* (Hook.f.), nikau palm (*Rhopalostylis sapida* H.Wendl. & Drude), and tree ferns such as mamaku (*Cyathea medullaris* (G.Forst.) Sw.), *C. dealbata* (G.Forst) Sw.), and wheki (*Dicksonia squarrosa* (G.Forst.) Sw.). Infrequent semi-mature kauri, and other native conifers, also remain and are regenerating. The presence of radiata pine within the riparian buffers appears to be dictated by terrain. Where

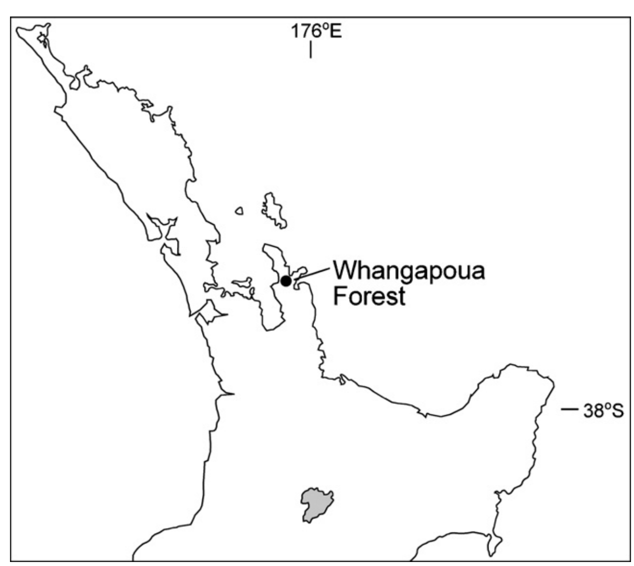

Fig. 1. Location of Whangapoua study site in the North Island of New Zealand.