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How soon does regenerating scrub control erosion?

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Summary

Surveys of damage caused by Cyclone Bola which struck the East Coast of the North Island, New Zealand in March 1988, indicated a strong relationship between vegetation cover and the degree of shallow landslipping on erosion-prone Tertiary hill country. An examination of the age, species composition and stand structure of manuka/kanuka dominated indigenous scrub was carried out. Young stands contained a mixture of manuka and kanuka, with kanuka becoming dominant in older stands. Compared with pasture, there was a 54% reduction in landslipping in fully-stocked eight-year-old scrub and a 91% decrease at 16 years. Under-stocked stands gave a somewhat lower level of protection. A substantial decrease in landslipping on steep erosion-prone hill country during major storms can therefore be expected within 10-15 years of establishment of indigenous scrub.

Keywords: indigenous scrub, *Leptospermum scoparium*, *Kunzea ericoides*, Cyclone Bola, landslides, East Coast.

Introduction

On March 5-9, 1988, Cyclone Bola struck the northern part of the North Island, New Zealand, bringing with it strong easterlies and heavy rain (New Zealand Meteorological Society 1988). Tertiary hill country of the East Coast (Fig. 1) was severely affected by shallow landslipping with large volumes of sediment transported downstream, resulting in extensive damage by flooding and deposition of silt on productive alluvial land (Phillips *et al.* 1990).

Surveys of damage carried out shortly after indicated a strong relationship between vegetation cover and the degree of shallow landslipping (Marden & Rowan 1988). Several studies have subsequently shown the effectiveness of exotic pine plantations in controlling erosion (Phillips *et al.* 1990; Marden *et al.* 1991) while Hicks (1989) demonstrated that indigenous forest and scrub also gave good protection compared with pasture. A comparison of the severity of damage under several different vegetation types following Cyclone Bola showed that indigenous forest and exotic pine forest (> eight years old) were 16 times more effective than pasture and young pine plantations (< six years old) and four times more effective than both regenerating

scrub and six-eight year old pines in preventing the initiation of new landslides on Tertiary hill country during extreme rainfall events (Marden & Rowan, in press). However, there has been no detailed examination of the relationship between landslide damage and age, species composition and stand structure of indigenous scrub. The NZ Forest Research Institute and Landcare Research are carrying out a detailed investigation to answer this question (Bergin *et al.* in prep). Some preliminary results are presented in this article.

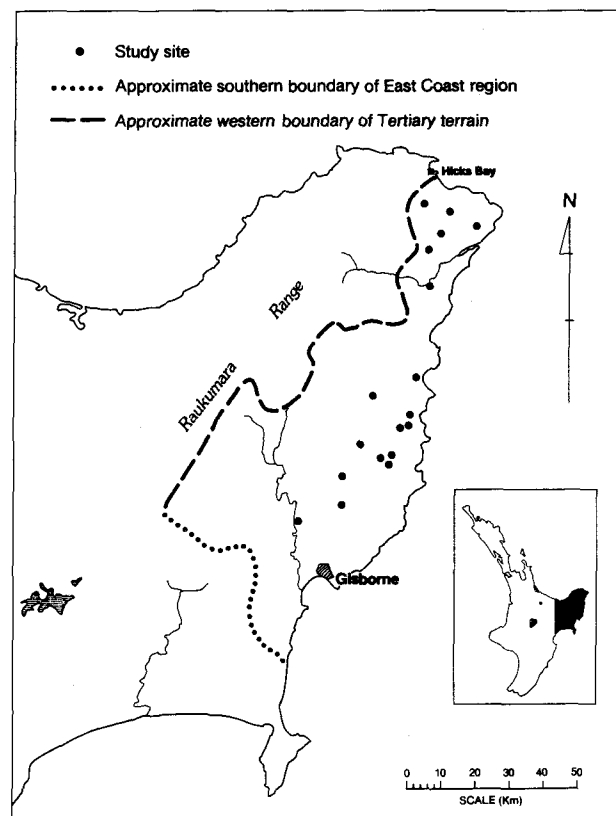


Figure 1: Location of the 18 study sites on Tertiary hillcountry of the East Coast, New Zealand.

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Characteristics of Regenerating Scrub

Eighteen sites between Hicks Bay in the north and Gisborne in the south, with each site containing even-aged stands of manuka (*Leptospermum scoparium*) and/or kanuka (*Kunzea ericoides*) and an adjacent area of pasture on similar terrain, were selected for study (Fig. 1). All sites were on Class VI and VII Tertiary hill country but do not cover the full range of units within these classes (National Water and Soil Conservation Organisation 1975). Sites were between 10 and 20 ha in extent, were mostly located on farmland and had been subjected to grazing.

At each site the heights and basal diameters of tree and shrub species were measured within 2-5 plots, subjectively classified as being fully-stocked or under-stocked based on degree of canopy closure. The age of cover vegetation was determined for each plot by counting rings of stem cross sections sampled across the range of stem sizes and adjusted back to the date of Cyclone Bola. Stand age was defined as the age at which occupancy began. This was estimated for each plot by adding a constant times the standard deviation to the mean age. A value of 1.65, representing the lower 5 percentile of the age distribution, was used. Stands ranged in age from four to over 70 years. For the purposes of analysis stands were allocated to appropriate age classes, i.e., 0-10 years, 10-20 years, etc.

Young stands (0-10 years) reflected a variety of establishment mechanisms, presumably resulting from grazing pressure or other disturbance factors (e.g. burning). The stands classified as fully-stocked had established over a short period and averaged over 30,000 stems per ha (Fig. 2). Young under-stocked stands were evidence of a more gradual establishment process and most are likely to achieve a full stocking by age 20-30 years. In contrast, the few older under-stocked stands contained small numbers of scattered trees, possibly a result of earlier attempts at scrub clearance. In older fully-stocked stands, intensive self-thinning was evident with mean density reducing to 1600 stems per ha by 70 years. Basal area increased rapidly within fully-stocked stands before stabilising at about 40 m²/ha at a stand age of about 20 years (Fig. 3).

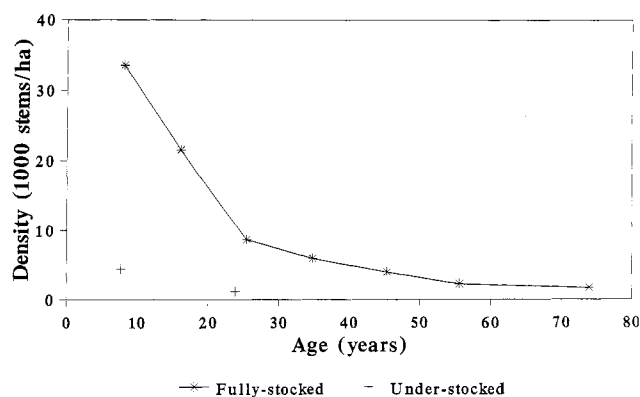


Figure 2: Stand density vs age for fully-stocked and under-stocked stands.

Canopy height of kanuka reached a maximum of about 14 m by age 40 years (Fig. 4). Young stands generally consisted of a mixture of kanuka and manuka but with its greater height growth, kanuka became dominant after about 30 years. In the 30-40 year age class, manuka comprised less than 10% of the basal area, and stands greater than 40 years contained virtually no manuka. On these drought-prone sites, most of which had some history of grazing, very few other shrub or tree species were present even in the oldest stands, apart from occasional mingimingi (*Leuco-*



Figure 3: Basal area vs age for fully-stocked and under-stocked stands.

pogon fasciculatus) and kamahi (*Weinmannia racemosa*). This pattern of succession is consistent with previous studies on the ecological roles of manuka and kanuka (Burrows 1973; Burrell 1965), and similar to that reported by Allen *et al.* (1992) in 2-70 year kanuka dominated stands near Dunedin. They found that manuka was replaced by kanuka at about 30 years, and that there was no evidence of replacement of kanuka by other species in the older stands.

Role in Reducing Erosion

Aerial photographs taken immediately after Cyclone Bola were examined to determine the degree of damage at each site (Fig. 5). The per cent area affected by landslide scars and debris tails was calculated separately for scrub and pasture using dot matrix grids.

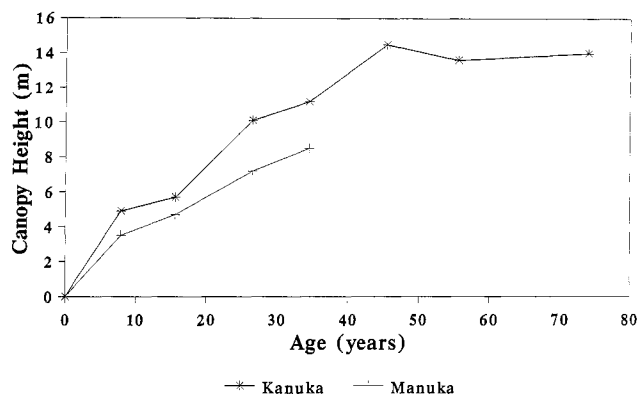


Figure 4: Canopy height vs age for kanuka and manuka.

On average 14% of pasture land area was affected by slipping. The corresponding figure for scrub was only 3.7%. Age and stocking both influenced the degree of erosion protection provided by the scrub (Fig. 6). By age eight years, land slipping in fully-stocked stands was reduced by 54% compared with pasture, and by 91% at age 16 years. In scrub more than 30 years old, slip damage was minimal. Erosion protection provided by under-stocked stands was significantly less than fully-stocked stands, particularly in the older age classes.

These results support earlier studies which have shown that closed forest cover ameliorates the full impact of rainfall through interception by the canopy and root reinforcement of the soil (Pearce *et al.* 1987; Phillips *et al.* 1990) but that little protection is afforded by young or scattered vegetation (Marden *et al.* 1991).

The principal mechanism by which manuka stands control erosion on hill slopes is by providing a reinforced surface layer of soil, usually less than 1 m deep (Watson & O'Loughlin 1985). This explains the lower level of protection afforded by older under-stocked stands (Fig. 6), which are typified by a few widely spaced trees, unlikely to produce an overlapping network of roots necessary for soil reinforcement. The level of protection provided by fully-stocked 15-year-old scrub is comparable to that provided by eight-year-old exotic pine plantations which reduced erosion resulting from Cyclone Bola by 90% (Phillips *et al.* 1990). Given the high level of protection afforded by older scrub stands, it should be recognised that clearing and replanting in pine will lead to a period of vulnerability to erosion before the plantation can provide a similar level of protection. The root systems of manuka and kanuka are likely to decay within three years (Watson & O'Loughlin 1985). If a pine plantation is established immediately after scrub clearance, this period of vulnerability will last for at least five years (between plantation age three and eight) or until canopy closure is attained.

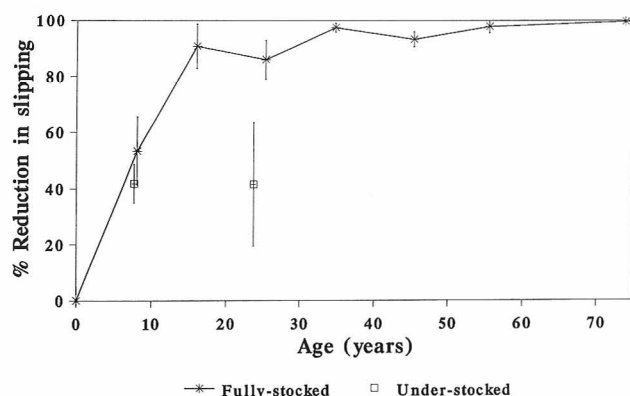


Figure 6: The percentage reduction in landslipping afforded by scrub stands compared with pasture. Vertical lines indicate standard errors.

Conclusion

A substantial decrease in shallow landslipping on steep erosion-prone hill country during major rain storms can be expected within 10-15 years of establishment of indigenous manuka/kanuka scrub. A high level of protection is provided by older fully-stocked scrub stands. Although the planting of pines in pasture will provide protection against erosion more quickly than regen-



Post Cyclone Bola. Comparative slip densities on pastured slopes and slopes with regenerating scrub cover.



Figure 5: The degree of landslipping on pasture contrasts markedly with minimal damage in adjacent indigenous scrub in this typical site used in the survey. Aerial photographs were used to give relative estimates of erosion on pasture and scrub of different ages.

erating scrub stands, clear-felling of older scrub will leave erosion-prone hill country vulnerable to damage if a major storm occurs before a replacement tree cover becomes established.

The pattern of succession on the East Coast is consistent with other studies in which kanuka appears to have a competitive advantage over manuka, becoming dominant after about 30 years. There is no evidence of any replacement of kanuka by other forest species before age 70 years.

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