Erosion under pasture, pine plantations, scrub and indigenous forest: a comparison from Cyclone Bola

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SUMMARY
Erosion under pasture, pine plantations, reverting scrub and indigenous forest was assessed along a transect through the East Coast hill country. The data clearly demonstrate that maintenance and restoration of forest cover, whether indigenous or exotic, substantially reduces erosion even during extreme storms such as Cyclone Bola.

Keywords: Erosion, pasture, pine plantation, scrub, indigenous forest, Cyclone Bola.

INTRODUCTION
Several days after Cyclone Bola struck the East Coast in March 1988, DSIR's Soil Conservation Centre took aerial photographs along most country roads and highways. Although taken to assess damage to roadways, they also provided excellent transects across the various terrains of the East Coast. One along the Waimata-Hokorora Road, which crossed areas of juxtaposed pasture, pines, scrub and indigenous forest, provided an opportunity to investigate the amount of damage to hill country under different vegetation covers.

SITE DESCRIPTION AND METHODS
The transect rises from the Waimata river, at NZMS260 Y17060875, follows ridges and streams in the extreme north-west of its catchment, and continues along the Pakarae river headwaters to its divide with the Waingaromia and Mangahkea at NZMS260 Y17064087. Its geology is more stable than much of the East Coast, but typifies "hard" hill country which occurs in pockets amongst softer rocks. Banded Tertiary siltstones and sandstones have been dissected by streams and shallow mass movements. Steep, long slopes with skeletal soils (LUC units VIIe9 and VIIe2, Driver and Page 1974) rise to narrow, undulating ridges, mantled by rhyolitic ash (LUC unit VIe4).

During Cyclone Bola, the transect was subject to rainfalls ranging from 500 mm in the valley to over 700 mm on the divide (Jones, 1988 unpub.). The exotic forest plantation comprised pines (Pinus radiata) between five and eight years old, just starting to form a closed canopy and continuous root mass. The indigenous forest was a cut-over mosaic of tall forest and seral scrub but undisturbed for many decades. It has a vigorous regrowth of kanuka (Kunzea ericoides) and rewarewa (Knightia excelsa) around remnant patches of beech (Nothofagus spp.) and podocarps (Podocarpus spp.). Pasture was improved, ryegrass-clover ( Lolium, Trifolium) dominant, with good ground cover and little weed infestation in the south. Some areas of former pasture towards the northern end of the transect, still lightly grazed, were reverting to scrub. Species composition of the scrub was diverse, but kanuka (Kunzea ericoides), manuka (Leptospermum scoparium) and tree ferns (Dioxinia and Cyathea spp) were significant components.

While there are some variations in geology, slope, soils and rainfall within the transect, these occur from valley-bottom to ridge-top. The same pattern of valley-to-ridge variation is repeated under pasture, pine plantations, scrub and indigenous forest. Thus the transect permits direct comparison of erosion under the different vegetation covers. This was to each, variation in erosion susceptibility, attributable to other site factors, is about the same. The 1:11,000 colour aerial photographs were used during field inspections to record mass movements on hillsides, as well as other forms of damage such as siltation in watercourses, breach of fences, and slipping or subsidence along roads and vehicle tracks. Areas surveyed totalled 2165 hectares; 92 hillsides (965 ha) in pasture, 38 (714 ha) in pine plantation, 26 (84 ha) in reverting scrub, and 36 (402 ha) in indigenous forest. Further details of the field survey are given by Hicks (1989), and survey methods are discussed by Hicks (1991).

RESULTS AND DISCUSSION
Table 1 and Figure 1 summarise results relevant to mass movement on hillslopes.

The proportion of uneroded hillslopes increases from less than a tenth under pasture, through less than a fifth under pine plantation, to a quarter under reverting scrub, and a third under indigenous forest. About a third of slopes under pasture and scrub are slightly eroded (i.e. have lost between 1% and 4% of their surface), compared with two-thirds under pine plantation, and half under indigenous forest. Moderately eroded slopes (5-9% of surface lost) are about the same under pasture and scrub, at a fifth, and somewhat less under pine plantation and indigenous forest. The proportion of severely eroded slopes (more than 10% of surface lost) declines from almost two-fifths under pasture, through one-fifth under scrub, to a twentieth under pine plantation and none under indigenous forest.

The most likely physical explanation for the different erosion frequency distributions is that tree roots are sufficiently dense and strong to form a binding "membrane" over the soil, which resists fresh mass movement of the underlying regolith (Pearce et al 1987). The indigenous forest, undisturbed for some 50 years, is certainly dense enough for this effect to have occurred; and the pine trees, aged between five and eight years, are just at the stage where it could be expected (Pearce et al 1987).

This raises the question whether younger pine trees, which
had not yet formed a closed canopy and continuous root mass, suffered worse damage; also whether damage was further reduced by older pines. The answer is given by a separate survey conducted by Forest Research Institute on differentiated stands of pine forest (Phillips et al., 1990). This indicates that the bulk of damage reduction is achieved once stands reach eight years. A separate question, whether damage varies with age and condition of indigenous forest, is currently being investigated by another Forest Research Institute survey (Marden pers. comm.).

In the meantime, Figure 1 and Table 1 help explain contradictory statements which emanated from different sources in the wake of Cyclone Bola, about forest cover's effect on erosion. There are hillsides where heavy damage occurred under forest cover, whether indigenous or exotic. However as a proportion of forested hillsides, they are small. Completely intact hillsides are more numerous under indigenous forest than under pines. The proportion of slightly eroded hillsides is somewhat greater under pines than under indigenous forest. Both types of forest cover are equally as effective in reducing moderate to severe erosion. Overall, erosion is very much less under pine plantations or indigenous forest than under grazed pasture or reverting scrub where livestock have not been excluded.

**CONCLUSION**

The Waimata-Hokorua survey data reinforce research findings published prior to Cyclone Bola, about incidence of erosion under pasture, pine plantations, reverting scrub and indigenous forest during lesser storms, e.g. Gage and Black 1979, Pearce 1982. Maintenance or restoration of forest cover, whether indigenous or exotic, clearly reduces mass movement relative to pasture or reverting scrub. This remains the case, even when hillsides are subjected to extreme rainfall of between 300 and 700 mm over three days.

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**REFERENCES**


![An example of contrasting erosion under indigenous forest, pine plantation and pasture, on the Waimata-Hokorua transect. Photo N.A. Trustum, DSIR.](image)

**TABLE 1: Erosion Frequency Distributions**

<table>
<thead>
<tr>
<th>% of hillslope</th>
<th>Pasture</th>
<th>Scrub</th>
<th>Pine Plantation</th>
<th>Indigenous forest</th>
</tr>
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<td>n = 92</td>
<td>n = 26</td>
<td>n = 38</td>
<td>n = 36</td>
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<td>.15</td>
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<td>.11</td>
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<tr>
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<td>1.00</td>
</tr>
</tbody>
</table>

n = number of hillsides in sample.


Hicks, D.L. 1989. Storm damage to bush, pasture and forest: some evidence from Cyclone Bola. Technical Record PN2, DSIR Land Resources.


Marden, M. in prep. Comparative landslide damage to pasture and exotic forest plantations by Cyclone Bola, East Coast North Island.


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