The Effects of Pollarding on the Fine Roots of Willows Planted for Soil Stabilisation on Pastoral Hill Slopes

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Introduction

On New Zealand farmland slopes, soil erosion, through heavy rainfall, can result in damages and costs that are both financial, in terms of farm repairs and insurance payouts, and physical. The sediment from the removal of soil enters streams, causing silting on the lowlands and waterways.

We all depend on soil for survival and farms need to maintain and preserve good organic humus-rich topsoil during these "erosive" periods by using control methods, such as tree cover, as their root systems can stabilise the soil and significantly reduce the effects of erosion on hill slopes (Douglas et al. 2009; National Poplar and Willow Users Group 2007). Willow trees are used because they are multi-functional. They are easy to grow from poles, propagate in most climates, can be used for shade and shelter for farm animals and yet allow sunlight for pasture growth under their open-branched canopies. They provide nutritious fodder for stock in drought conditions, which usually occur in late summer and autumn.

They also possess extensive root systems that stabilize the soil and so can help to prevent erosion on pastoral hill slopes.

How Do Willow Roots Help?

Tree roots stabilize soil using their root binding properties. In this study, we examined the ability of willow roots to regenerate and continue their root growth after pollarding.

Why Pollard?

"Pollarding is a very old technique for limiting the above-ground size of a tree and promoting leafy growth at the expense of woody growth" (I. McIvor 2007)

Pollarding reduces the canopy size of large trees, reducing the risk of damage and injury from branch breakage and reducing the likelihood of strong winds toppling trees, particularly when the soil is saturated. The cut branches provide fodder in times of drought and the reduced canopy increases light to ground level around the tree, potentially increasing pasture growth close to the trunk. However, removal of leaves also cuts off the carbohydrate supply to the tree roots and this may be expected to have a significant impact on root dynamics and consequentially on the tree's contribution to soil stabilisation.

This study investigated the impact of pollarding on root dynamics, by measuring root parameters for unpollarded and pollarded mature willow trees at different distances from the trunk.

Method

Study area

The study area is located at Ennor Farm, Central Hawke's Bay, a hill country sheep farm. The erosion-prone slope where the study was conducted was space planted with *Salix*

matsudana × *alba* 'Tangoio' hybrid tree willows. The incline of the slope varied from 15 to 25 degrees. The study trees were all planted within a year of each other.

Root sampling

Three trees from each treatment: pollarded (IP) in 2006, repeat pollarded (RP) in 2006 and 2009, and unpollarded (UP) were selected, such that a transect could be extended from the tree trunk and always remain further from an adjoining tree than it was from the study tree. For each tree, soil cores were excavated at depths of 0-150 mm and 150-300 mm at intervals of 2, 3, 5, 8 and 11 metres along a transect from the trunks. The soil cores were broken up and passed through a 10-mm mesh sieve to capture all the tree roots. The roots were transferred to sealed bags and stored in a chilly bin until they could be stored in a cool room at 5°C before further processing. The soil was replaced in the holes.

Laboratory analysis

In the laboratory, roots were washed and sorted into diameter classes: 0<1 mm, 1<2 mm, 2<5 mm, 5<10 mm and ≥10 mm. Any non-willow roots were identified by appearance and texture and removed at this stage. Root lengths were measured and recorded for each diameter class. The roots were then oven-dried at 70°C for 48 hours, and dry weights measured and recorded.

Results and Discussion

Tree dimensions

While the trees for which transects were sampled varied a little in diameter at breast height (DBH), mean DBH for each treatment group of trees was similar (Table 1). Trees from all treatments showed a similar incremental diameter growth rate regardless of status in the year 2009-2010 (Table 1).

Table 1. Mean diameter at breast height (DBH) of the willow trees from which transects were taken.

	DBH cm		Mean annual growth rate cm
Treatment	Feb. 2009	Feb. 2010	
Unpollarded (UP)	35.4±5.6	36.9±5.7	1.4±0.9
Pollarded once (IP)	36.3±4.7	38.1±6.6	1.8±1.9
Repeat pollarded (RP)	37.2±4.4	38.8±5.7	1.7±1.5

Root analysis

Root length density (RLD measured in mm^{-3}) including all roots was higher in cores taken at equivalent distances from UP and IP trees than from RP trees (Figure 1). There was a decline in RLD with distance from the trunk from 2 m to 5 m, after which there was little change in RLD. The greatest reduction in RLD for the RP trees was at 2 m and 3 m. At distances greater than 3 m, the RLD was very similar for all treatments and at all distances (Figure 1).

Fine roots

The patterns for fine RLD (Figure 4) were almost identical with those for all roots. This is not surprising, since fine roots contribute >80% of all root length. Of particular interest, however, was the observation that the greatest decline (30-50%) in fine RLD following the RP treatment occurred close in to the tree, whereas little decline was observed at 5 m and beyond. Since RLD was highest closest to the tree, any change in fine RLD is more than compensated for by the presence of large structural roots in stabilizing soil. The lowest RLD was found furthest from the trunk and the contribution of the tree roots to soil stabilisation is expected to decline with distance from the trunk. The data suggest that pollarding the trees did not markedly reduce either the RLD (Figure 1, 3) or RMD (Figure 2, 4) at 5+ m from the tree, and that one, and certainly four, years after pollarding, fine RLD and RMD were not noticeably different from those of unpollarded trees of similar size..

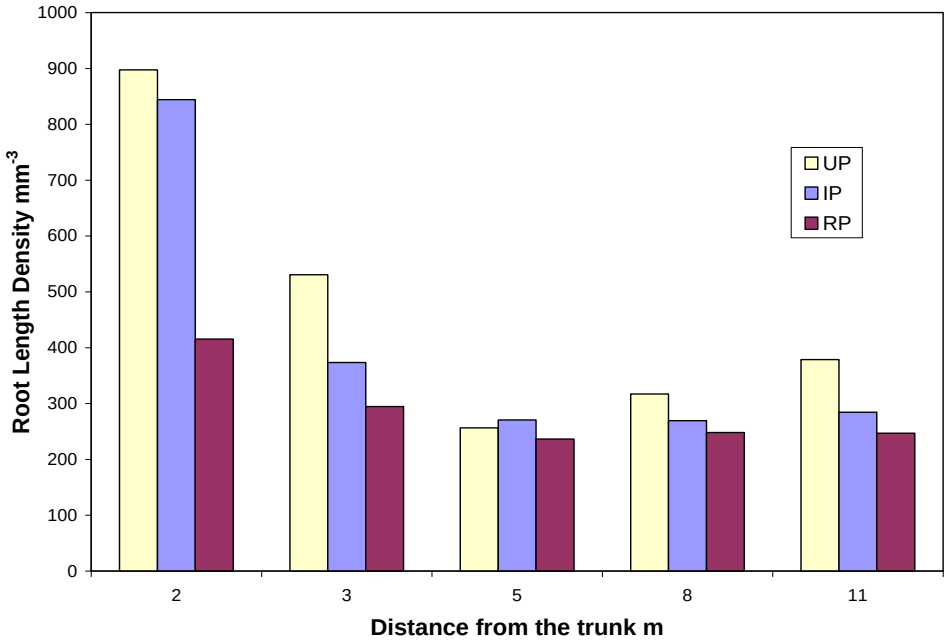

Figure 1. Change in root length density at different distances from the trunk for the unpollarded (UP), pollarded once (IP) and repollarded (RP) willow trees.

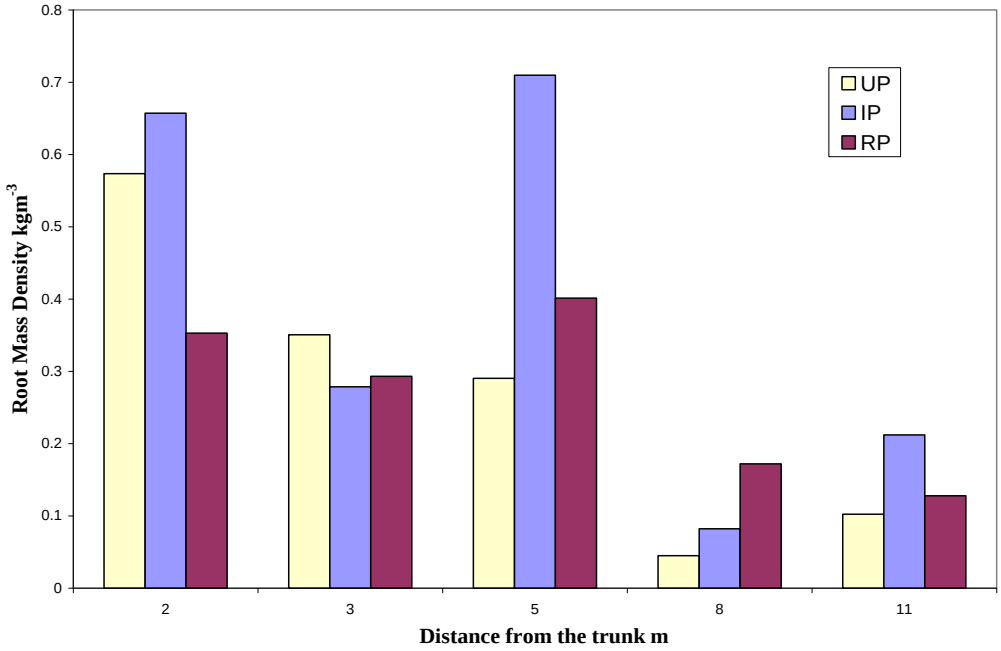

Figure 2. Change in root mass density at distances from the trunk for unpollarded (UP), pollarded once (IP) and repollarded (RP) willow trees.

Root mass density including all roots was much lower at 8 m and 11 m from the trunk than for closer distances (Figure 2). The decline in RMD with distance from the trunk was not as pronounced as for RLD. The RMD for the RP trees was not lower than that of the UP and IP trees, except at 2 m. RMD including all roots can be strongly biased by the presence of a large root(s) in the core. As an example, RMD for IP tree at 5-m distance was very high because of a single 19-cm root with diameter >10 mm.

The influence of single large roots prohibits generalisations about differences in RMD for the different treatments.

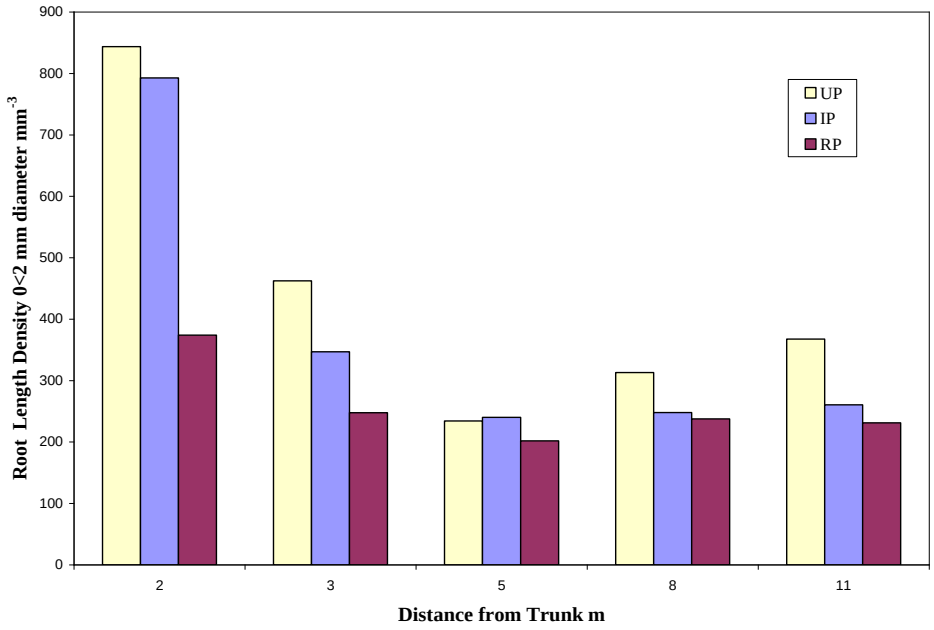

Figure 3. Willow root length density for roots 0<2 mm diameter (fine roots) at varying distances from the trunk.

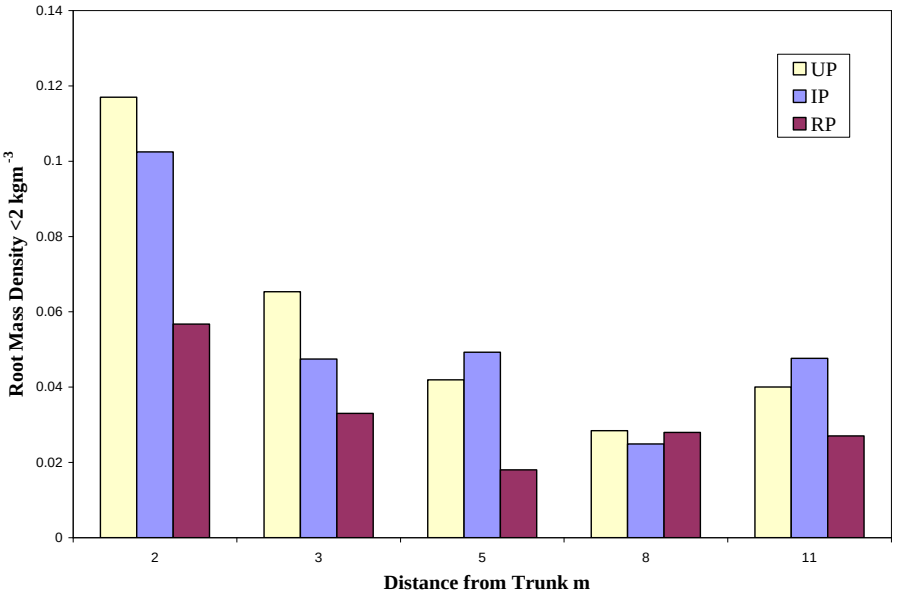

Figure 5. Willow root mass density 0<2 kgm^{-3} (fine roots) at varying distances from the trunk.

Conclusion

Pollarded willow trees showed a marked reduction in root length density and root mass density in the following year at distances up to 3 m from the trunk and at depths to 300 mm compared with unpollarded trees. At distances greater than 3 m, only small reductions were measured. Four years after pollarding, differences in RLD and RMD between pollarded and unpollarded trees were not notable.

Pollarding appears to have only a short-term reduction on root production and this study suggests that the role of willows in soil stabilization is not compromised by regular pollarding.

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References

Douglas G, McIvor I, Manderson A, Todd M, Braaksma S, Gray R 2009. Effectiveness of space-planted trees for controlling soil slippage on pastoral hill country. In Nutrient Management in a Rapidly Changing World (Eds. L D Currie and C L Lindsay) Occasional Report No. 22, (423 pages).

National Poplar and Willow Users Group. 2007. Growing Poplar and Willow Trees on Farms, Guidelines for establishing and managing poplar and willow trees on farms. Compiled and prepared by the National Poplar and Willow Users Group as part of the Sustainable Farming Fund's Poplar and Willow Project (Grant No. 04/089).