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Implications of tree management on poplar and willow pasture-tree systems

A thesis presented in partial fulfilment of the
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To Paty, Lily and Pau.

Abstract

Willow and poplar trees planted at wide spacing have proved their effectiveness as a biological method to control soil erosion in pastoral hill country. Due to lack of management, many trees aged 30⁺ years have grown very large (>60 cm diameter at breast height), resulting in excessive shading of understorey pasture. The large trees are also prone to breakage of branches and toppling during strong winds, potentially damaging farm infrastructure or injuring livestock.

Management of tree size can coincide with providing edible poplar and willow foliage as a source of supplementary fodder in summer droughts. Trees can be pollarded, involving total canopy removal, but the effects of pollarding on tree root dynamics are poorly understood.

This thesis evaluated the effect of the tree canopy removal on the root dynamics and root non-structural carbohydrate dynamics of pollarded mature willow and poplar trees and decapitated young willow and poplar trees grown from cuttings. Impacts of tree canopy removal when trees were at different phenological stages were also studied in pollarded mature willow trees and decapitated young willow and poplar trees. Finally, herbage accumulation under pollarded trees was contrasted with herbage accumulated under unpollarded (UP) trees and in open pasture sites (OP) away from direct tree influence.

Pollarding did not impose a unique impact on the root structure of mature willow and poplar trees. However some similarities were found in both species. For instance, pollarding had its main impact in the roots closest to the trunk and above 300 mm soil depth. In these root sections disrupted by pollarding, fine root length and mass of pollarded (P) trees were, one year after above-ground removal, from 2× to 4× less than equivalent unpollarded (UP) trees. However, one year after pollarding, pollarded trees recovered or maintained the initial fine root densities recorded in the same trees prior to pollarding.

The study conducted with young willow and poplar trees grown from cuttings showed that willow trees had a greater ability to recover from damage in the root structure after decapitation. Nine months after decapitation in early autumn, root mass of young willow decapitated trees was 57% greater than prior to decapitation and 64% less than non-decapitated (ND) trees. In contrast, within the same time frame, root mass of young poplar trees decapitated in early autumn was 80% less than ND trees and 52% less than the initial root mass recorded prior to decapitation. Greater resprouting ability of willow trees than poplar trees after decapitation was proposed as the cause for the greater resilience to decapitation observed in willow trees than in poplar ones.

Further evidence for a greater resilience to pollarding of willow trees was found in the root starch dynamics evaluated after tree canopy removal. Pollarded or decapitated willow trees (mature or grown from cuttings) were able to replenish their root starch concentrations similarly to UP or ND trees in the growing season following tree canopy removal. In contrast, both pollarded and

decapitated poplar trees (mature or grown from cuttings) had lesser root starch concentrations than intact trees one year after tree canopy removal.

Pollarding (P) or decapitation (D) at dormancy (DP or DD trees) showed no clear advantages in terms of the tree root structure maintenance or recovery after above-ground removal, over pollarding or decapitating the trees towards the end of the growing season in early autumn (AP or AD trees), when trees still had leaves. With mature willow trees, annual average fine root density (fRD) recovery of DP trees relative to pre-pollarding density was greater than annual average fRD recovery of AP trees. However, this difference was attributed to record moisture restrictions that disrupted the root growth of both AP and UP trees during the growing season following early autumn pollarding. Similarly, young DD and AD willow and poplar trees showed that four and a half months after decapitation, both treatment trees were able to recover or maintain initial root mass recorded prior to decapitation.

The study on herbage accumulation beneath pollarded trees, suggests that 4 years after being pollarded, P willow trees shaded pasture in a similar way to UP trees, as annual net herbage accumulation (NHA) attained in these two environments was statistically not different. Annual NHA under P and UP environments, were, respectively, 30 and 43% less than annual net herbage accumulation recorded in open pasture sites ($4.9 \text{ t DM ha}^{-1} \text{ yr}^{-1}$).

Ability of willow trees to recover, within the first year after pollarding or decapitation, initial root densities recorded prior to canopy removal, and to replenish root starch concentration similar to intact trees, suggests these trees could have pollarding cycles of 2 to 3 years. Short pollarding cycles could lessen herbage accumulation reductions on a pasture-tree stand level as more trees or more frequent repollarding is practised. However, results derived in this thesis from willow trees, need to be confirmed in at least two year lasting studies before recommending shorter pollarding cycles than currently advised of 3 or 4 years.

In contrast, poplar trees require longer pollarding cycles or higher tree stand densities if a pollarding program is instituted, as these trees were not able to recover within the first year after canopy removal, the root values recorded prior to pollarding and/or to replenish the root starch reserves

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Table of Contents

Abstract	iii
Acknowledgements	v
Table of Contents	vi
List of Tables	vii
List of Figures	viii
List of Appendices	xii
Glossary and abbreviations	xiii
Chapter 1. General Introduction.....	1
Chapter 2. Literature review	12
Chapter 3. Root response and carbohydrate dynamics of willow trees pollarded at different phenological stages.	55
Chapter 4. Fine root response and carbohydrate dynamics of poplar trees pollarded in early autumn, at the end of the growing season.....	132
Chapter 5. Above-, below-ground and root non-structural carbohydrate dynamics of willow and poplar plants decapitated at different phenological stages.	175
Chapter 6. Pasture production beneath pollarded and unpollarded willow trees.	215
Chapter 7 General Discussion and Conclusions	246
APPENDICES	268

List of Tables

Table 1.1 General thesis outline	8
Table 3.1 Sampling periods after pollarding	67
Table 3.2 Willow root vertical profile distribution obtained by trenching (average of six trees)	67
Table 3.3 F values of the effects of treatments, sampling positions, soil depths, and sampling times on fRLD and fRMD using a mixed model where blocks were random factor	77
Table 3.4 Resprouting vigour one growing season after trees were pollarded at different phenological phases.	102
Table 4.1 Tree height and diameter at breast height (DBH) at the beginning of the study (mean \pm standard error).....	141
Table 4.2 Tree parameters (mean \pm s.e.) at the beginning of the study and after one year for unpollarded (UP) and pollarded (P) trees.	145
Table 4.3 Differences in tree parameters at pollarding and one year after pollarding.	146
Table 4.4 Vertical root distribution of one ‘Weraiti’ poplar tree in autumn 2012 (total number of roots within a frame 90 cm \times 90 cm in each of three trenches around the tree)	147
Table 4.5 Vertical root distribution of one ‘Shinsei’ poplar tree in autumn 2012 (total number of roots within a frame 90 cm \times 90 cm in each of three trenches around the tree)	147
Table 5.1 Treatments, sampling sequence and number of willow plants decapitated and sampled at each sampling time.	183
Table 5.2 Treatments, sampling sequence and number of poplar plants decapitated and sampled at each sampling time.	183
Table 5.3 Resprouting vigour, above-ground growth and root mass dynamics of willow (<i>Salix matsudana x alba</i> “Tangoio”) plants decapitated at different phenological phases	191
Table 5.4 Resprouting vigour, above-ground growth and root mass dynamics of poplar (<i>Populus deltoides x nigra</i> ‘Dudley’) plants decapitated at different phenological phases	195
Table 6.1 Means of tree parameters measured on pollarded and unpollarded trees \pm SE. Within columns, means with different letters in parentheses are significantly different ($P < 0.05$).....	226
Table 6.2 Mean \pm SE net herbage accumulation (kg DM ha ⁻¹ day ⁻¹) on a seasonal basis, beneath unpollarded (UP) and pollarded (P) trees and in open pasture (OP).	227
Table 6.3 Influence of pollarding in the annual net herbage accumulation (NHA) on pasture-tree stand level under different situations within a 4 year pollarding cycle.	234
Table 7.1 Summary of findings of the impact of above-ground removal on the root structure of willow and poplar trees wide spaced planted for soil erosion control in pastoral hill country of New Zealand.....	254

List of Figures

Figure 2.1 Soil slip shear lines (Reubens et al., 2007)	26
Figure 2.2. Tree root mechanical strength and position on the slope (Danjon et al., 2008)	29
Figure 2.3 Management practices conducted on multipurpose trees. Adapted from Sennerby-Forsse et al. (1992).....	31
Figure 2.4 The two main overstorey environments in a theoretical arrangement of trees in a square grid pattern.....	37
Figure 3.1 Temperature and rainfall data for Moginie site during the study	63
Figure 3.2 Unpollarded and pollarded willow trees	64
Figure 3.3 Treatment layout	65
Figure 3.4 Trenching work carried out to determine the coring depth	69
Figure 3.5 Data processing for statistical analysis. continued	75
Figure 3.6 Fine root length density (fRLD) dynamics of unpollarded (UP) and dormant pollarded (DP) trees, relative to *pre-pollarding densities recorded in late winter 2011. **numbers indicate approximate months after dormant pollarding. ^ means seasons of the year: LW-late winter ESp-early spring, LSp-late spring, LSm-late summer, MA-mid autumn. a,b,c,d,e & f correspond to different soil depths at 40 and 80 sampling positions	80
Figure 3.7 Fixed effects interactions on annual average fine root length density (fRLD) dynamics (means and error standard bars) of unpollarded (UP) and dormant pollarded (DP) trees, relative to pre-pollarding densities recorded in late winter 2011.	81
Figure 3.8 Fine root mass density (fRMD) dynamics of unpollarded (UP) and dormant pollarded (DP) trees, relative to *pre-pollarding densities recorded in late winter 2011. **numbers indicate approximate months after dormant pollarding. ^ means seasons of the year: LW-late winter ESp-early spring, LSp-late spring, LSm-late summer, MA-mid autumn. a,b,c,d,e & f correspond to different soil depths at 40 and 80 sampling positions	82
Figure 3.9 Fixed effects interactions on annual average fine root mass density (fRMD) dynamics (means and error standard bars) of unpollarded (UP) and dormant pollarded (DP) trees, relative to pre-pollarding densities recorded in late winter 2011. A) Treatment by soil depth interaction. *indicates significant differences (P<0.05) between treatments at the same depth. B) Treatment by sampling position (smp) interaction at each soil depth. Different letters means significant differences (P<0.05) within and between treatments, within and between smp at each soil depth.	83
Figure 3.10 Fine root length density (fRLD) dynamcis of unpollarded (UP) and early autumn pollarded (AP) trees, relative to *pre-pollarding densities recorded in early autumn 2012. **numbers indicate approximate months after early autumn pollarding. ^ means seasons of the year: EA-early autumn MA-mid autumn, EW-early winter, LW-late winter, LSp-late spring, LSm-late summer. a,b,c,d,e & f correspond to different soil depths at 40 and 80 sampling positions	88

Figure 3.11 Fixed effects interactions on annual average fine root length density (fRLD) dynamics (means and error standard bars) of unpollarded (UP) and early autumn pollarded (AP) trees, relative to pre-pollarding densities recorded in early autumn 2012. A) Treatment by soil depth interaction. *indicates significant differences ($P<0.05$) between treatments at the same soil depth. B) Treatment by soil depth by sampling position (smp) interaction. Different letters means significant differences ($P<0.05$) within and between treatments within and between smp at each soil depth.89

Figure 3.12 Fine root mass density (fRMD) dynamics of unpollarded (UP) and early autumn pollarded (AP) trees, relative to *pre-pollarding densities recorded in early autumn 2012. **numbers indicate approximate months after early autumn pollarding. ^ means seasons of the year: EA-early autumn MA-mid autumn, EW-early winter, LW-late winter, LSp-late spring, LSm-late summer. a,b,c,d,e & f correspond to different soil depths at 40 and 80 sampling positions.90

Figure 3.13 Fixed effect interactions on annual average fine root mass density (fRMD) dynamics (means and error standard bars) of unpollarded (UP) and early autumn pollarded (AP) trees, relative to pre-pollarding densities recorded in early autumn 2012. A) Treatment by soil depth interaction. *indicates significant differences ($P<0.05$) between treatments at the same soil depth. B) Treatment by soil depth by sampling position (smp) interaction. Different letters means significant differences ($P<0.05$) within and between treatments within and between smp at each soil depth.91

Figure 3.14 Fine root length density (fRLD) dynamics of dormant pollarded (DP) and early autumn pollarded (AP) trees, relative to *pre-pollarding densities recorded in late winter 2011 and early autumn 2012 for DP and AP trees, respectively. **numbers indicate approximate months after pollarding. a,b,c,d,e & f correspond to different soil depths at 40 and 80 sampling positions94

Figure 3.15 Fixed effect interactions on annual average fine root length density (fRLD) dynamics (means and error standard bars) of dormant pollarded (DP) and early autumn pollarded (AP) trees, relative to pre-pollarding densities recorded in late winter 2011 and early autumn 2012 for DP and AP trees, respectively. A) Treatment by soil depth interaction. *indicates significant differences ($P<0.05$) between treatments at the same depth. B) Treatment by soil depth by sampling position (smp) interaction. Different letters means significant differences ($P<0.05$) within and between treatments within and between smp at each soil depth.95

Figure 3.16 Fine root mass density (fRMD) dynamics of dormant pollarded (DP) and early autumn pollarded (AP) trees, relative to *pre-pollarding densities recorded in late winter 2011 and early autumn 2012 for DP and AP trees, respectively. **numbers indicate approximate months after pollarding. a,b,c,d,e & f correspond to different soil depths at 40 and 80 sampling positions96

Figure 3.17 Fixed effect interactions on annual average fine root mass density (fRMD) dynamics (means and error standard bars) of dormant pollarded (DP) and early autumn pollarded (AP) trees, relative to pre-pollarding densities recorded in late winter 2011 and early autumn 2012 for DP and AP trees, respectively. A) Treatment by soil depth interaction. *indicates significant differences ($P<0.05$) between treatments at the same depth. B) Treatment by soil depth by sampling position (smp) interaction. Different letters means significant differences ($P<0.05$) within and between treatments within and between smp at each soil depth.97

Figure 3.18 Root non-structural carbohydrate dynamics after pollarding willow trees at different phenological phases. (ln)natural logarithm back transformed. UP: unpollarded trees, DP: trees pollarded at the end of the dormancy stage on late winter 2011, AP: trees pollarded at the end of the growing season on early autumn 2012. Sampling times: 11 (2011), 12 (2012)..Late winter (LW), Early spring (ESp), , Late summer (LSm), Early autumn (EA), Mid autumn (MA), Late spring (LSp). Months after pollarding: 0, 1, 6, 8, 12, 15. Dormant pollarded trees were sampled from late winter 2011 to late spring 2012. Early autumn pollarded trees were sampled from early autumn 12 to late spring 2012. For each carbohydrate and sampling time, different letters indicate significant differences at $p < 0.05$	101
Figure 3.19 Diameter at breast height (DBH) measured in unpollarded trees (UP), dormant pollarded trees (DP) and early autumn pollarded trees AP. DP trees were pollarded on the 28 th of August 2011 and AP trees were pollarded on the 7 th of March 2012.....	102
Figure 4.1 Layout of the poplar study, including orientation and surrounding topography. Id tree number and clones are highlighted in yellow: K ('Kawa'), S ('Shinsei'), T ('Toa'), Ta ('Tasman'), W ('Weraiti').	138
Figure 4.2 View of poplar trees in the study.....	139
Figure 4.3 Rainfall and mean air temperature during the study compared with mean long-term (1981-2010) records.	140
Figure 4.4 Trenching work to determine root distribution of poplar trees and sample coring depth.	143
Figure 4.5 Sample coring positions around the trees for determining changes in root dynamics after early autumn pollarding.....	143
Figure 4.6 Fine root length and root mass density dynamics of poplar trees unpollarded (UP) and pollarded (P) in early autumn 2012. soil sample volume= 754 cm ³ * indicates significant differences between treatments in overall fine roots (0≤2 mm) at individual sampling times (P<0.05); root diameter categories: 0≤1 mm and >1≤2 mm.....	151
Figure 4.7. Coarse root length and root mass density dynamics of poplar trees unpollarded (UP) and pollarded (P) in early autumn 2012. soil sample volume= 754 cm ³ . Root diameter categories: >2≤5 mm, >5≤10 mm and >10 mm. ln, natural logarithm back transformed data	152
Figure 4.8 Mean (n=3) and standard error bars of root non-structural carbohydrate dynamics of unpollarded (UP) and poplar trees pollarded (P) in early autumn 2012. In late spring, treatment means with different letters are significantly different (P<0.05). *indicates less than concentration in early autumn (P<0.05). (ln) indicates natural logarithm back transformed data.....	154
Figure 5.1 Mean air temperature inside and outside the glasshouse.	182
Figure 5.2 Root recovery process and origin points of 1 st , 2 nd and 3 rd shoots.....	185
Figure 5.3 Fine root non-structural carbohydrate dynamics of willow (<i>Salix matsudana</i> x <i>alba</i> 'Tangoio') plants decapitated at different phenological phases. ND non-decapitated plants AD early autumn decapitated plants. DD dormant decapitated plants.. Dashed lines: assumed trends as from non-decapitated plants values. Different letters at each sampling period mean significant differences between treatments (P < 0.05).	192

- Figure 5.4 Root starch concentration in fine (fR) and coarse (cR) roots of poplar (*Populus deltoides* x *nigra* ‘Dudley’) plants decapitated at different phenological phases. non-decapitated (ND), early autumn decapitated (AD) and dormant decapitated (DD). Different letters at each season and root category means significant differences ($P < 0.05$)197
- Figure 5.5 Root non-structural carbohydrate dynamics of poplar (*Populus deltoides* x *nigra* ‘Dudley’) plants decapitated at different phenological phases. ND non-decapitated plants AD early autumn decapitated plants. DD dormant decapitated plants.. Dashed lines: assumed trends as from non-decapitated plants values. Different letters at each sampling period mean significant differences between treatments ($P < 0.05$).197
- Figure 6.1 Rainfall and mean air temperature during the trial compared with mean long-term (1981-2010) records.221
- Figure 6.2 Herbage accumulation sampling area (red dashed rectangle). Sampling area comprised the area beneath the horizontally projected tree canopy on the south shady side of the trees and extended southerly from the trunk 6.8 m and 9.3 m for pollarded and unpollarded trees, respectively. 1: area directly below the vertical projection of the tree canopies (Adapted from Wall (2006)).223
- Figure 6.3 Mean net herbage accumulation (NHA) ($\text{kg DM ha}^{-1} \text{ day}^{-1}$) on a monthly basis, beneath unpollarded (UP) and pollarded (P) environments and in open pasture (OP). Different letters at monthly sampling times indicate significant differences ($P < 0.05$) between treatments.227
- Figure 6.4 Mean botanical composition (% of DM) of swards beneath unpollarded (UP) and pollarded (P) trees and in open pasture (OP).228
- Figure 6.5 Sampling area in the present study (red dashed rectangle) and in previous studies with intensive sampling strategies. Zone 1: area directly below the vertical projection of the tree canopies. Zone 2: (area midway between the centre of the vertically projected canopy gap (Zone 3) and its respective limits at the vertically projected edges of the tree canopies. Zone 3: at the centre of the vertically projected canopy gap. (Adapted from Wall (2006)) Ellipses (dashed outline) are the assumed area under the influence of either pollarded or unpollarded trees, derived from the mean canopy diameter of the trees and the length of the sampling transect (red rectangle). Annual NHA on the ellipsoidal area of tree influence on the south-shady side was assumed to be the same for the same ellipse area extension on the north side of the trees.233

List of Appendices

Appendix 3.1 Coarse root length and mass density recorded in willow trees (pollarded and unpollarded) after being pollarded at different phenological stages.	269
Appendix 4.1 Coarse root densities of unpollarded and pollarded poplar trees from pollarding in March 2012 to March 2013.....	273
Figure A.1 Image analysis software WinRHIZO (Regent Instruments, Inc 2012, Canada) where there are small segments of both fine (b) (< 2 mm diameter- delineated in red and yellow) and coarse (a) roots (> 2 mm diameter, delineated in green) that for practical reasons were not possible to dissect from the main root either a coarse or a fine root.....	274

Glossary and abbreviations

ANOVA: analysis of variance

Canopy: part of a tree above the trunk consisting of branches and foliage

Coarse roots (cR): roots with a diameter greater than 2 mm

Complete or total pruning: removal of all branches leaving intact the main stem single leader (mostly practiced in alley tree-crop systems)

Coppicing: cutting a mature tree at the base of the trunk at a height of 10-30 cm

DBH: tree diameter at breast height (1.40 m) over the bark

DM : dry matter

Fine roots (fR): roots with a diameter less than 2 mm

GLM: general lineal model

ha: hectare

Hill country: any land with slopes exceeding 15⁰ and located below 1000 metres above sea level

kg: kilogram

LSD: least significant difference

m: metre

m⁻³:per cubic meter

Mass movement: erosion of soil or rock occurs when stresses (downslope component of gravity pulling soil down the slope, pore water pressure, loading by vegetation, seismic waves propagating through the soil) exceed resistances (in-slope component of gravity holding soil to the slope, friction and cohesion of soil particles, reinforcement by vegetation roots)

mm: millimetre

Mudstone: a sedimentary rock composed of silt and clay particles and weakly cemented together by a small quantity of lime.

N/A: not applicable

N/Av: not available

NHA: net herbage accumulation

NSC: non-structural carbohydrates

Open pasture (OP) hill country pastureland where trees were far away.

PAR: photosynthetically active radiation.

Partial Pruning: removal of branches at a particular height.

Pasture-tree system (PT): pastureland located on a steep slope in hill country where willow or poplar trees have been planted 10 to 15 m apart to each other as a way of biological control shallow landslides.

Pollarding: complete removal of tree canopy at a 1.8 to 2.0 meter height above-ground

Pruning: removal of selected parts of the tree (as otherwise indicated, it was used for branches).

Root length density (RLD): length of the roots per unit volume of soil.

Root mass density (RMD): dry mass of the roots per unit volume of soil.

Sandstone: a sedimentary rock composed of sand grains, compacted and weakly cemented by a small quantity of lime.

SAS: statistical analysis system.

Thinning: the removal of some of the trees within a stand at some time after being planted with purposes of reducing tree stand density.

Wide-spaced tree planting: Trees that are planted 10 to 15 m spaced apart to each other.