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RESEARCH BRIEF 02

Influence of tree shading by *Populus ×euramericana* 'Veronese'

Poplar on understorey pasture production on a hill slope

Summary

We measured and modelled pasture production over a 10-month period under poplar trees aged either 11 or 22 years (TP) and in open pasture (OP), to determine the effect of spaced conservation trees on pasture production. We measured pasture production at different positions under the trees as well as in the open. Tree spacing was similar in both situations, at 10–11 m. Canopy cover reached 29% for 11-year-old trees and 78% for 22-year-old trees.

The study confirms that space-planted poplars reduce understory pasture production. Understorey pasture growth decreased with increasing tree age as woody material percentage and percentage canopy closure increased. Annual pasture production under the trees was significantly lower than in OP (77% under 11-year-old trees, 44% under 22-year-old trees). Total pasture production (TP+OP) for the two pasture systems was 93% (11-year-old) and 56% (22-year-old). Selectively removing trees to increase tree spacing to 20 m in the mature tree-pasture system would change the light environment such that annual pasture production would increase from 56% to 89% of open pasture, other factors being equal.

We developed a model using pasture and photosynthetically active radiation (PAR) data and long-term climate data to predict pasture production under the trees and in the open. The model successfully predicted the seasonal pattern of pasture production under both TPs. Models that are more refined could be used to incorporate the effects of different tree spacing and leaf area densities on pasture production.

Tree management is necessary to minimise pasture production as trees age. Tree management by a) pruning when trees are younger, and b) selective tree removal when trees are older, will reduce shading, increase light to pasture, and lift pasture productivity beneath the trees.

Introduction

Space planting of poplar trees for the sustainable management of pastoral land has numerous benefits, from stabilising landmasses through drying out and binding of the soil, to increasing the soil nutrient status within the immediate vicinity of the tree and root system, to providing shelter and forage material to livestock in dire situations. When used effectively, poplar trees will reduce soil erosion by 50–95%, and this reduction increases with tree age.

Shading from these poplar trees reduces pasture production, with previous research indicating a reduction in understorey pasture growth of 20–40%, dependent upon planting distances and the surrounding environment.

Field-based research on the impact that poplar trees have on understorey pasture production has mainly been conducted around young trees up to 8 years, or with mature trees greater than 25 years old. Landowners adopting tree-planting programmes will appreciate better information when balancing soil conservation and pasture production, although it has been widely argued that the benefits of the trees exceed the costs.

We did this experiment to determine the impacts space-planted poplars of different ages have on the understorey pasture growth (TP) compared with open pasture (OP), considering light transmission through the canopy cover as the major variable, together with soil moisture and other soil parameters.

Field sites

Two pastoral hill sites (Figure 1) with similar slope angle, aspect and climatic conditions were selected, each partially planted with Populus ×*eumericana* 'Veronese' poplars at similar spacing but differing in tree age (subsequently referred to as tree-pasture sites TP). The sites were comparable with regard to stock grazing management and fertiliser history. Both study sites were located in Rongomai, near Eketahuna on the lower East Coast of the North Island, New Zealand. TP site B is approximately 2 kilometres south of TP site A.

Site	Aspect	Slope	Soil type	Drainage	Tree age (years)	Tree diameter at breast height (cm)	Tree spacing (m)	Mean canopy closure (%)
A	west	22.4°	Mahoenui Silt Loam	Moderately good	11	26-31	11	29
B	west	23.5°	Purimu Silt Loam	Imperfect	22	51-54	10	78

Table 1. Site parameters for poplar treed sites (open sites differed only in having no tree shading).

At each TP, pasture cages, light sensors, time-domain reflectometry (TDR) probes, and a data logger were installed within a single square area (Figure 2) defined by a tree at each corner. The OP pasture cage at each location was situated beyond any shadowing effect of the trees. Pasture dry matter (DM) production was measured in May, July, September, November 2012, and in January 2013. We used mean values for July and November DM as a proxy for September data (missing) in Table 2.

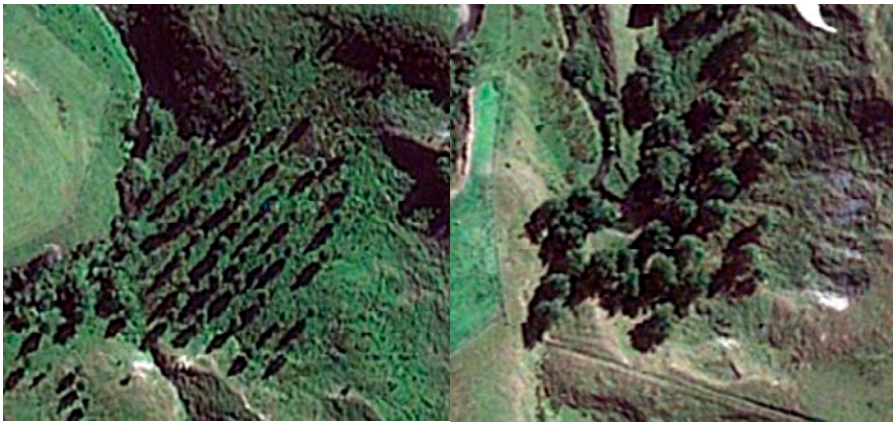


Figure 1: Location of site TP A (left) and TP B (right), illustrating the relative poplar canopy spread at the two sites

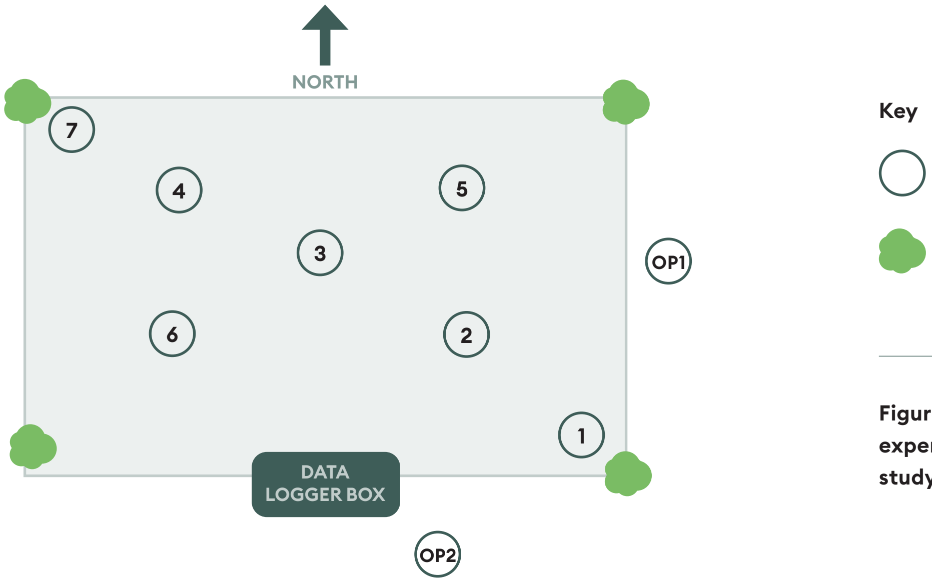
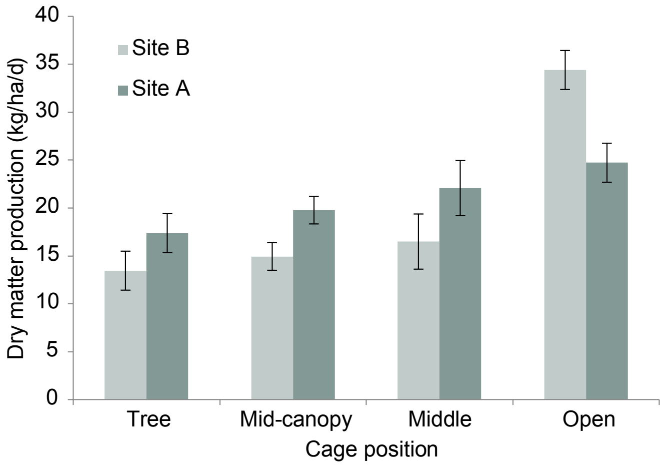


Figure 2: Pasture cage layout within the experimental unit for the mature poplar study site (TP B)

Results

Measured impact of trees on net pasture production

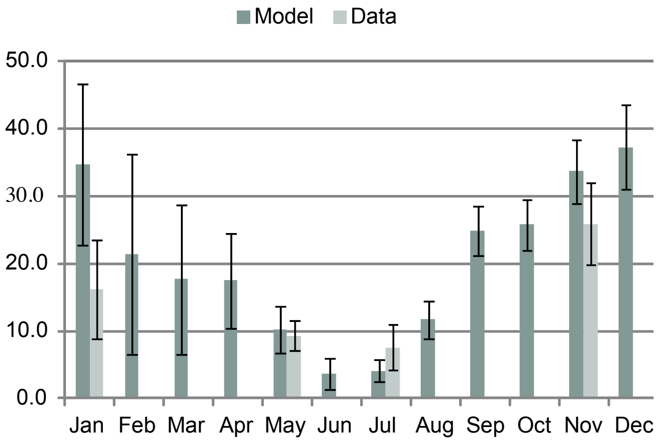
Pasture production within the young TP and mature TP was lower than pasture production in the matching OP. Total pasture production in the 11-year-old TP averaged over all months, at the tree, mid-canopy and middle cage positions, was 70%, 80% and 97% respectively of the OP production (Figure 4). At site B TP, total pasture production at the tree, mid-canopy and middle positions was much lower, being 40%, 47% and 52% of OP pasture production. Mean annual pasture production within the 11-year-old and 22-year-old trees was calculated to be 77% and 44% of open pasture production, respectively.



Mean dry matter production (kg/ha/d) at the two poplar sites and four cage positions, averaged over the period of the experiment. Error bars represent one standard error of the mean.

		Position			
Site	Month	Tree	Mid-canopy	Middle	Open
TP B	May-12	7.8	9.4	11.8	39.5
	Jul-12	5.0	7.9	11.8	15.0
	Sept-12	13.3	17.8	19.7	26.5
	Nov-12	21.5	27.6	27.6	38.0
	Jan-13	19.5	14.8	14.7	45.1
TP A	May-12	7.1	17.4	16.3	24.7
	Jul-12	6.0	9.7	10.9	8.5
	Sept-12	18.2	15.0	17.9	15.2
	Nov-12	30.3	20.2	24.9	21.8
	Jan-13	26.0	31.9	36.2	43.9
SEM		**4.1**	**2.9**	**5.8**	**4.1**

Table 2. Mean dry matter production (kg/ha/d) of the understory pasture at the two poplar sites, for four different cage positions and four sample times. SEM represents one standard error of the mean. Site B has mature trees and Site A has young trees.



Modelled impact of trees on net pasture production

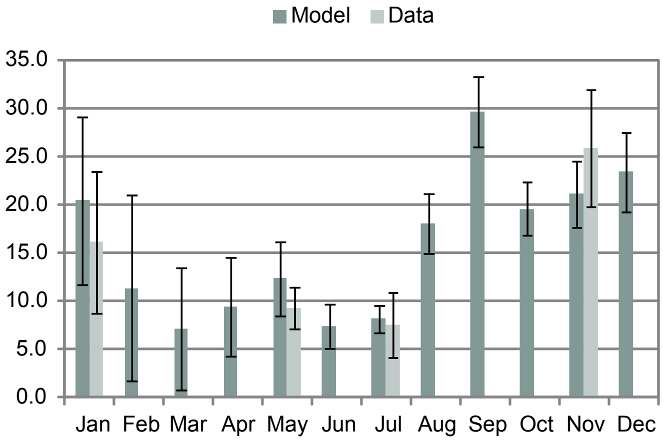


Figure 5. Modelled pasture production (kg/ha/day) over 12 months for 11-year-old poplar tree sites TP (upper graph) and 22-year-old TP based on data of pasture production measured for the exclusion cages and long-term weather data (January 2000–January 2013). We calculated an annual pasture production of 7400 kg/ha for the 11-year-old TP and 5700 kg/ha for the 22-year-old TP.

There was a significant seasonal difference in mean dry matter production in the different months ($p<0.001$, Table 2), between cage positions ($p<0.001$) and between month x site ($p= 0.001$) and month x position ($p=0.006$) (Table 2). Differences in mean dry matter production between sites were not significant ($p = 0.28$), although notably the 11-year-old TP had significantly greater production than the 22-year-old TP in January 2013 (Table 3). This could have been due to increased water stress on the pasture, and/or to greater tree transpiration, and increased shading from the larger canopy of the more mature trees.

	Site	
Month	**22 yr TP**	**11 yr TP**
May-12	17.1b	16.4b
Jul-12	9.9a	8.8a
Nov-12	28.7cd	24.3c
Jan-13	23.5c	34.5d
SEM	**2.2**	**2.2**

Table 3: Mean dry matter production (kg/ha/d) averaged over all cage positions for two poplar sites and four sample months. Means with the same letter are not significantly different (5% LSD comparison). SEM = standard error of the mean.

Discussion

Difference in pasture production between TP and OP

TP annual pasture production under the trees was significantly lower than in OP (77% at Site A, 44% at Site B). Pasture production decreased with proximity to the tree trunk. This is consistent with previous research conducted under poplar stands.

Pasture production within TP was limited by available light compared with that in open pasture. Tree leaf area increases during the growing season, further reducing understorey pasture growth. Leaf fall led to an increase in light transmission from 20% (Site A) and 13% (Site B) at full leaf canopy to 36% (Site A) and 30% (Site B) following leaf fall.

Difference in pasture production with TP units of different ages

Tree age is a major limiting factor for surrounding pasture production, as the proportion of woody material and leaf material increases with tree age, up to 4 m annually when grown from a pole (Wilkinson 1999), leading to an increase in shade. Our modelling predicts an annual pasture production rate of 7400 kgDM/ha in 11-year-old TP) and 5700 kgDM/ha in 22-year-old TP. On average with the same poplar clone and planting distances, we calculate an annual decrease of about 140 kg DM/ha in understory pasture production. It would also be beneficial to investigate the influence of slope and aspect on understory pasture production in a space-planted setting. Furthermore, it would be informative to improve the model to incorporate tree spacing as a variable to investigate the effects of increasing spacing by removal of some trees on pasture production. Increasing the tree spacing of the 22-year-old trees from 10 m to 20 m by tree removal will reduce canopy cover to 19–20%, giving a huge gain in pasture production both overall and under the trees.

Comparison of pasture production overall in the tree-pasture system

Pasture production in the 11-year-old tree-pasture system was 93% of what would be expected from open pasture when ignoring factors other than shading. Pasture production in the 22-year-old tree-pasture system was 56% compared with that in open pasture. Adjusting the 22-year-old tree spacing to 20 m by selectively removing trees would reduce canopy cover to 19–20% and increase pasture production in the tree-pasture to 89% compared with open pasture production. Douglas and McIvor (2010) found that poplars with DBH >60 cm at 20-m spacing provided close to 100% slope protection on pastoral country in severe storms.

Conclusion

This study confirms that space-planted poplars reduce understory pasture production. Understorey pasture growth decreased with increasing tree age as woody material percentage and percentage canopy closure increased. Tree management by a) pruning when trees are younger, and b) selective tree removal when trees are older, will reduce shading, increase light to pasture, and lift pasture productivity beneath the trees.

The model successfully predicted the seasonal pattern of pasture production under both TPs. More refined models, incorporating different tree spacings and leaf area densities, will enable us to determine the impacts of tree density on pasture production.

For more information

This is two in a series of research briefs about Poplars and Willows that can be found at poplarandwillow.org.nz

Prepared by The New Zealand Institute for Plant and Food Research Limited.

Contact

Ian McIvor, Plant & Food Research
ian.mcivor@plantandfood.co.nz

Trevor Jones, Plant & Food Research
trevor.jones@plantandfood.co.nz