TREE RECRUITMENT IN A POPLAR BOX WOODLAND

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Abstract

The density of recruitment of poplar box and shrub seedlings was measured in intact poplar box woodland vegetation and adjacent woodland areas that had been subject to various impacts. In the intact woodland paired observations were obtained in naturally open patches and adjacent more dense vegetation in a replicated design comprising six blocks. Soil properties were determined for each sample site. The impacted sites included experimental plots previously subject to experimental treatments involving different levels of tree clearing and grazing. Observations in impacted areas were designed to sample all observable compositions of vegetation. The results are used to demonstrate the dependence of the recruitment of poplar box on the density and hence life cycles of the trees.

Introduction

General observations can be used to identify patterns of tree recruitment in eucalypt woodlands but there are few detailed observations. For eucalypt forests extreme events, such as clear felling and fire, can produce episodic recruitment and floods are known to do likewise with eucalypt woodlands. Such episodic recruitment can produce even aged stands of trees comprising cohorts. However, a converse pattern of apparently regular recruitment can be seen around isolated eucalypt trees located in grassland. There can be a decrease in size of the recruits with distance from the parent tree.

Germination of limited numbers of poplar box seedlings was observed during experiments over 15 years in an area of poplar box woodland in SW Queensland but none of these individuals survived. However, it was apparent that patches of tree recruitment had occurred around 20 years earlier. Sparse seedling germination appeared to be reasonably regular but the size classes of trees indicated that tree recruitment was highly episodic.

Observations of the spatial distribution of different size classes of trees led to the hypothesis that the recruitment of trees was controlled by the condition of the existing vegetation as well as fluctuations in climate. In intact woodlands patches of trees could be recognised by the size classes of the constitute individuals with each patch usually containing two, and a maximum of three tree size classes. Similarly to rain forests, it appeared that recruitment of new individuals depended on the death of mature trees producing patches with low densities of trees. The size of such patches was generally around 0.1 to 0.2ha

A return to the research area after 20 years identified significant recruitment of poplar box trees and that, as previously surmised, the level of recruitment depended on the density of the mature poplar box trees. This study examined the level of recruitment in relation to the abundance of pre-existing vegetation and the soil properties.

Methods

Observations were obtained at what was identified by Moore and Walker (1972) as the Wycanna Woodland Experiment centre near Talwood (lat. 28^0 50'S., long. 149^0 30'E) in southern Queensland. Most of the vegetation was monospecific poplar box (Eucalyptus populnea) in the tree layer but with small areas adjacent to drainage lines being dominated by brigalow (*Acacia harpophylla*) and belah (*Casuarina cristata*). A large part of the paddock was uncleared but all had been subject to grazing by livestock. Grazing pressure varied but was inevitably extreme during droughts despite the area being 2km distant from the nearest watering point.

All of the area is subject to substantial overland flow of water during periods of high rainfall. This flow increases the accession of water and also has the potential to ensure that poplar box seeds are distributed throughout the area.

Parts of the experimental area had been subject to different forms of disturbance, such as intensive grazing with and without clearing, and there were also plots containing intact and thinned vegetation where livestock had been excluded for thirty years. The observations reported here were obtained in uncleared (intact) poplar box woodland subject to normal property livestock grazing levels unless otherwise specified. All sites were remote from watering points.

The main comparison was between localised open patches of woodland containing poplar box seedlings and immediately adjacent areas having a 'normal' density of mature trees. Three replicates of such paired observations were obtained for 6 separate blocks with all bar one block located completely within the intact woodland. The sixth block was located along the edge of a clearing. Additional to these 36 sites, another 64 sites were recorded to encompass the full range of vegetation composition encountered in the paddock. This included observations in the prior experimental plots.

Measurements obtained for mature trees at each site were height, crown cover, crown depth, and the % foliage cover of crowns. Shrub measurements were height, crown cover and % foliage cover of crowns. Grass measurements were visual estimates of the % foliage cover and biomass. The estimation methods were generally as given by Walker and Hopkins in McDonald et. al. (1984) but with grass cover determined using successive approximation. The % cover of bare ground and grass were successively estimated until the different estimates correspond. Tree and shrub seedling densities were recorded by counting the number of plants for each of three size categories (<0.1, 0.1 – 1, and >1m) within plots generally and at least $400m^2$ in size. The large tree seedlings were a distinct cohort. The smaller sizes could reflect two distinct cohorts and/or differences in the size of individuals for one cohort.

The vegetation measurements allow calculation of various measures of the abundance of the different components. The percent foliage cover of components is given by the product of the % crown cover and % foliage cover of crowns. The relative abundance of tree foliage can also be estimated as the product of the crown cover, crown depth and % foliage cover of crowns. Given the very different life forms the foliage estimates provide a better basis for comparison than biomass estimates. Foliage also provides the best indication of the potential for plant production.

Soils samples were obtained at each site for the A1, A2 and B2 horizons using a 7.5cm diameter hand auger and the thickness recorded for the A horizon. Soil texture was determined using the field method (McDonald et al., 1984) but recorded as a pseudo-continuous variable (Table 1). Chemical analyses conducted in the field on 1:5 soil:water suspensions were pH, oxidation reduction potential (Eh) and electrical conductivity (EC). The Eh provides a measure of the level of hydration. Conversion of Eh from an activity to a concentration (pe= (Eh+244)/ 59.2) allows calculation of the ratio of pe to pH which affects the solubility of compounds.

Results

The means and standard errors for the main vegetation and soil property measurements are given in Table 2 and the significance of effects is summarised in Table 3. Differences between open patches and 'normal' poplar box tree densities were highly significant. This is to be expected as it was the basis for the selection of sample sites and effectively represents the treatment. Differences between blocks in the foliage cover of tree crowns were significant and the block-treatment interactions were also significant. However, the block effects and block-treatment interactions were weak compared with those for the treatment. Shrub foliage shows a significant but weak treatment effect and grass abundance a weak but significant block effect.

Results for derived estimates of tree foliage cover (product of % crown cover and % foliage cover of crowns) and tree foliage abundance (product of % crown cover, crown depth and % foliage cover of crowns) are similar to those for the cover measurements but do not show a significant block effect. Overall, there is a large difference between treatments in the abundance of mature trees but little difference in the abundance of shrubs and grasses, and the abundance of shrubs and grasses is low compared to the trees.

Differences in the densities of tree seedlings are generally highly significant for blocks, treatments, and block – treatment interactions. Effects are greatest for the differences between treatments with the seedling density in the open areas generally being more than 10 times that where the abundance of mature of trees is 'normal'. Differences in shrub seedling densities are not significant except for large shrubs showing a significant block effect.

The soil results are generally opposite to those for vegetation with essentially no significant treatment effects or treatment-block interactions. Only the oxidation reduction potential shows a significant treatment effect for the A2 and a significant interaction for the A2 and B horizons. However, 9 of the 13 measurements show significant differences between blocks. Overall the soil properties differed significantly between blocks but not between treatments.

Highest tree seedling densities occur when the tree foliage abundance is close to zero (Fig. 1) and the recruitment levels effectively decline exponentially with increase in the abundance of tree foliage. While tree seedlings can occur at reasonably high densities of mature trees, tree recruitment is only high where the abundance of mature trees is low. Comparison of the total number of tree seedlings and total vegetation abundance (sum of the % foliage cover for trees, shrubs and grasses) differs in that highest tree seedling densities occur at low but not at zero vegetation abundance (Fig. 2).

Tree recruitment was apparently unaffected by the abundance of shrubs but effectively only occurred at low levels of grass abundance (Fig. 3). Shrub seedling density did not exhibit a relationship with the abundance of trees (Fig. 4).

Discussion

Recruitment of poplar box depends strongly on the abundance of mature poplar box trees and no tree recruitment occurred at very high levels of mature tree abundance. While tree recruitment can occur at most levels of mature tree abundance, high levels of recruitment are only associated with low levels of mature tree abundance. This pattern of recruitment does not depend on soil properties but the significant interaction between blocks and treatment in tree recruitment means there could be a soil effect.

Highest levels of tree recruitment occurred at effectively zero mature tree abundance but not at zero total vegetation abundance. Tree recruitment was highest at a level of total vegetation abundance of 7.5% of the observed range. The reason for this positive dependence of tree recruitment on the presence of low amounts of vegetation is not apparent from these results but may relate to soil compaction (Tunstall and Cunningham, 2005).

Shrub recruitment did not depend on the abundance of mature trees but did vary with blocks indicating a possible dependence on soil properties.

The recruitment of poplar box trees was associated with periods of high rainfall and is therefore largely determined by fluctuations in climate. However, recruitment also depends on the condition of the existing vegetation. A large number of the pre-existing trees must die to reduce the abundance of trees to less than 20% of the observed maximum before there is appreciable recruitment.

Unlike rainforests the death of a single tree in the poplar box woodland does not produce conditions favourable for tree recruitment. A number of adjacent trees must die. This tree mortality is not spatially uniform and the stand of vegetation develops open patches favourable for recruitment. The patch size needed for this recruitment is around 0.1ha.

The growth of a substantial number of new trees in a previously open patch produces a dense tree cover which suppresses further tree recruitment. No significant recruitment will occur until the death of most of the new recruits. This produces a cycle in the development of vegetation whereby patches tend to contain trees of two size classes representing different cohorts. The control of tree recruitment by existing trees produces a spatial mosaic of vegetation development related to the life cycles of the trees rather than the environment.

The ability of the trees to recruit in the presence of existing trees helps perpetuate the community and maintains the dominance of poplar box. There are indications that tree recruitment is aided by a low level of trees suppressing competition by grasses, which helps explain the patterns of recruitment around isolated eucalypts in the open. For example, the recruitment of trees in cleared paddocks was restricted to a narrow band adjacent to intact vegetation despite the opportunity for tree seed to be spread across the entire cleared area. However, the data presented here cannot be used to support such conclusions other than to note that tree recruitment effectively only occurred at low levels of grass abundance.

References

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Moore, R. M. and Walker, J. (1972) Eucalyptus populnea shrub woodlands. Control of regenerating trees and shrubs. Aust J. Expt. & Animal Husb. 12:436-440

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Table 1. Descriptors for soil texture grades

1	coarse	Gravel	9	fine	Sandy-loam	17		Sandy-clay
2	medium	Gravel	10	clay	Sandy-loam	18		Silty-clay
3	fine	Gravel	11	fine sandy	Loam	19		Light-clay
4	coarse	Sand	12		Loam	20	medium	Light-clay
5	fine	Sand	13	silty	Loam	21		Medium-clay
6	loamy	Sand	14	sandy	Clay-loam	22	heavy	Medium-clay
7	clayey	Sand	15	silty	Clay-loam	23		Heavy-clay
8		Sandy-loam	16		Clay-loam	24	very	Heavy-clay

Table 2. Means and standard errors for the main vegetation and soil property measurements.

	Unit	Treat Mean	Control Mean	SE
PB foliage cover	%	4.08	16.07	0.213
PB canopy cover	%	31.0	113.4	1.87
Shrub foliage cover	%	1.77	5.02	0.24
Grass biomass	kg/m2	0.104	0.119	0.0038
PB seedlings	plants/ha			
Small		693	74	26.1
Medium		933	44	24.9
Large		523	15	36.3
Total		2149	133	58.6
Shrub seedlings	plants/ha			
Small		176	286	40.5
Medium		170	105	7.8
Large		109	75	8.9
Total		455	465	47.6
Soil				
Thickness A	mm	294	318	0.55
Texture A1	grade	16.3	16.0	0.08
Texture A2	grade	18.6	18.9	0.062
Texture B	grade	21.6	21.3	0.057
pH A1		6.74	6.76	0.023
pH A2		7.04	6.93	0.025
pH B		7.53	7.37	0.032
pe A1		7.9	7.8	0.006
pe A2		7.3	7.6	0.008
pe B		7.3	7.5	0.008
pe/pH A1		1.09	1.12	
pe/pH A2		1.05	1.10	
pe/pH B		0.97	1.03	
EC A1	µS/cm	11.1	12.2	0.30
EC A2	µS/cm	10.0	11.7	0.29
EC B	µS/cm	58.4	70.0	3.63

Table 3. Significance of effects for the main measured and derived variables.			
	Block	Treatment	Block x Treat.
Trees			
Canopy %	0.128	<0.0001	0.001
Canopy foliage %	0.036	<0.0001	0.01
% Foliage cover	0.086	<0.0001	0.009
Tree abundance	0.128	<0.0001	0.004
% Shrub foliage	0.14	0.015	0.5
Grass biomass	0.013	0.34	0.52
Tree seedlings			
Small	0.0012	<0.0001	0.0072
Medium	<0.0001	<0.0001	<0.0001
Large	0.088	<0.0001	0.147
Total	0.0015	<0.0001	0.0023
Shrub seedlings	0.11	0.58	0.62
Small	0.018	0.10	0.32
Medium	0.11	0.45	0.33
Large	0.0018	0.37	0.76
Total	0.08	0.96	0.41
Soil			
Thickness A	0.0018	0.37	0.76
Texture A1	0.14	0.41	0.55
Texture A2	0.11	0.37	0.08
Texture B	0.042	0.24	0.41
pH A1	0.012	0.09	0.15
pH A2	0.0003	0.34	0.97
pH B	0.0013	0.33	0.32
pe A1	0.0027	0.29	0.56
pe A2	0.0012	0.025	0.02
pe B	0.0007	0.069	0.48
pe/pH A1	0.0001	0.208	0.21
pe/pH A2	0.017	0.89	0.13
pe/pH B	0.0002	0.12	0.13
EC A1	0.93	0.46	0.22
EC A2	0.67	0.25	0.67
EC B	0.045	0.52	0.62

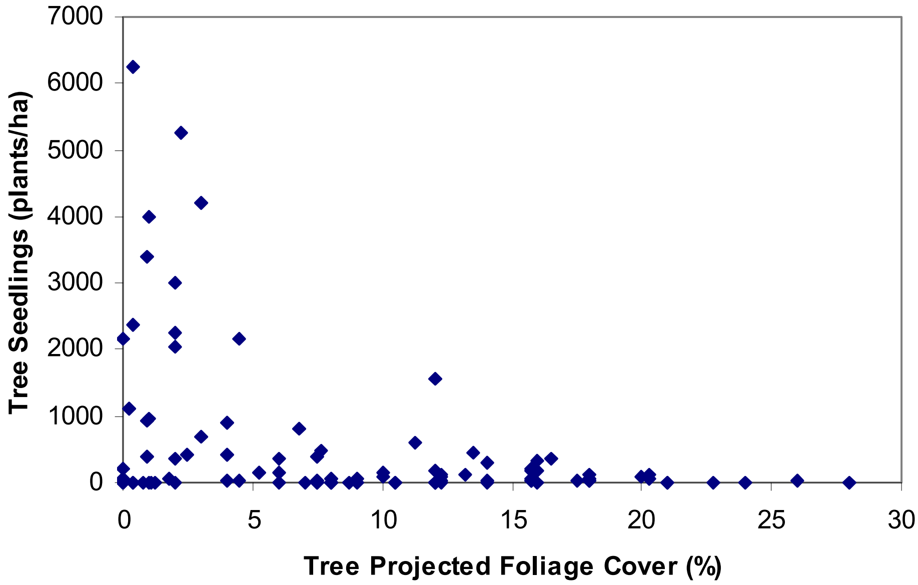

Fig. 1. Density of poplar box seedlings in relation to the projected foliage cover of mature poplar box trees.

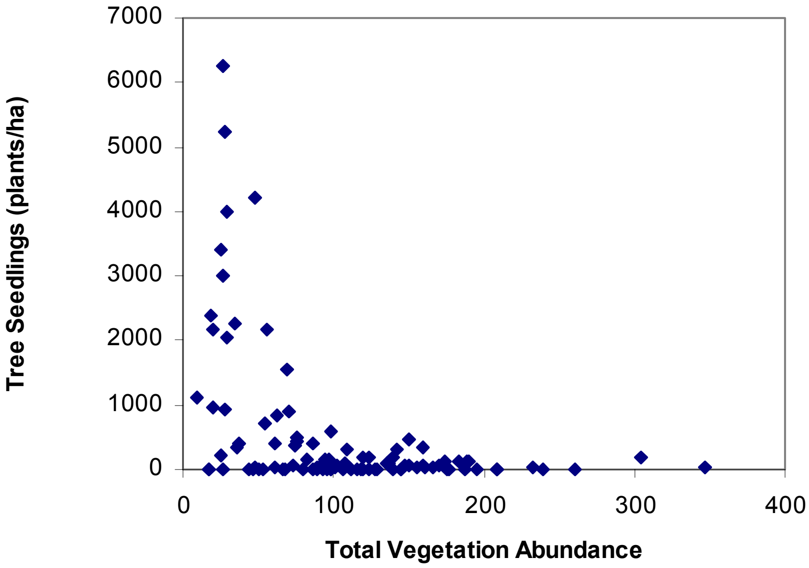

Fig. 2. Density of poplar box seedlings in relation to the combined abundance of mature poplar box trees, shrubs and grasses.

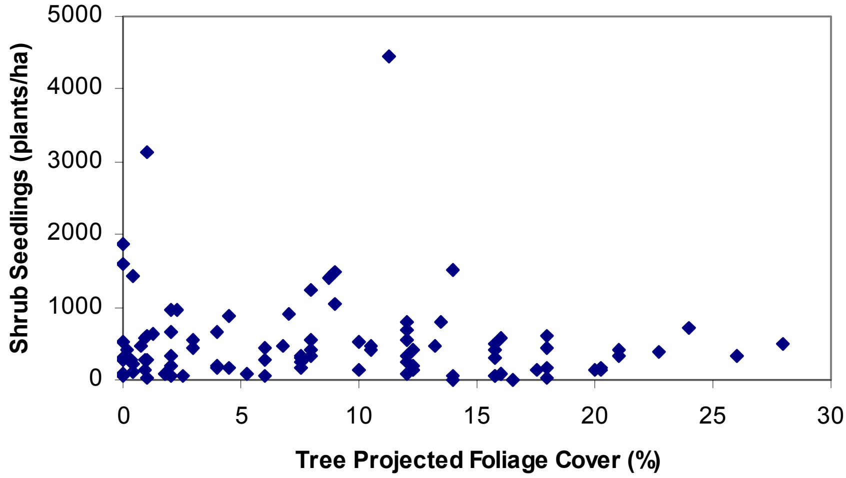

Fig. 3. Density of shrub seedlings in relation to the projected foliage cover of mature poplar box trees.

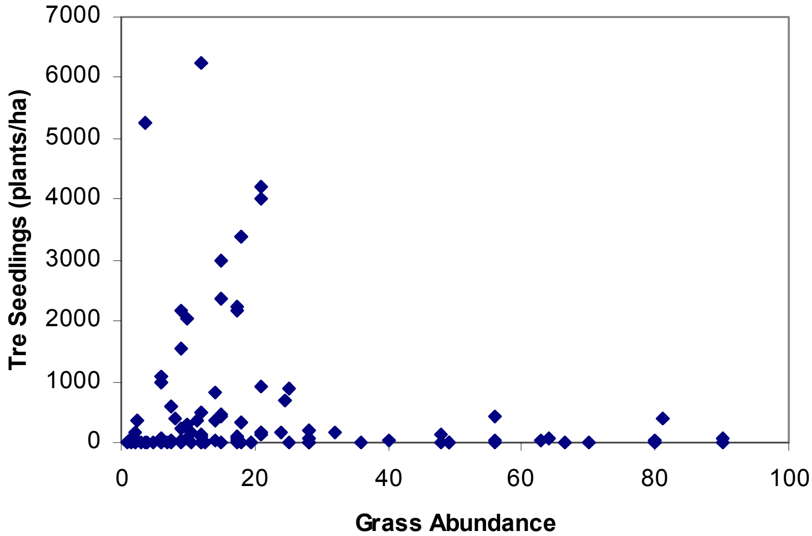

Fig. 4. Density of poplar box seedlings in relation to the relative abundance of grass.