Project B7: *Eucalyptus* decline in the absence of fire: what is the role of phosphorus demand?

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The study set out to test the following hypotheses:

(1) An accumulation of nitrogen (N), carbon (C) and organic carbon (OC) occurs in forest soil with an increasing absence of fire
(2) As a result of N (and OC) accumulation in the soil with the absence of fire, plant and microbial soil demand for phosphorus increases (and nutrients become increasingly organically-bound); this will be directly indicated by increased soil acid-phosphatase enzyme activity (PME)
(3) Increased demand for phosphorus (P) with the absence of fire, combined with a limited soil capacity to supply this (relatively immobile) nutrient will lead to falls in total soil P and plant-available (extractable) soil P
(4) A reduced soil capacity to supply P with an increasing absence of fire will lead to P stress in *Eucalyptus*; this will be indicated by reduced foliar P concentrations and increased foliar N:P ratios
(5) Long undisturbed rainforest areas experiencing overstorey eucalypt decline would be characterised by soils with higher concentrations of N and C, and lower amounts of P. Foliar P concentrations would be lower in rainforest areas and foliar N:P ratios higher

Study areas were identified in the high-altitude *E.delegatensis* forests of NE and NW Tasmania where a well catalogued chrono-sequence (2 – 46 years) of forestry coupe burns provided an analogue wildfire disturbance (Fig.1). Alongside the historical coupe burns were discrete areas of undisturbed rainforest, each with a declining eucalypt overstorey. Samples were made of *E.delegatensis* foliar and soil material, which were analysed for nutrient levels and acid-phosphatase activity.

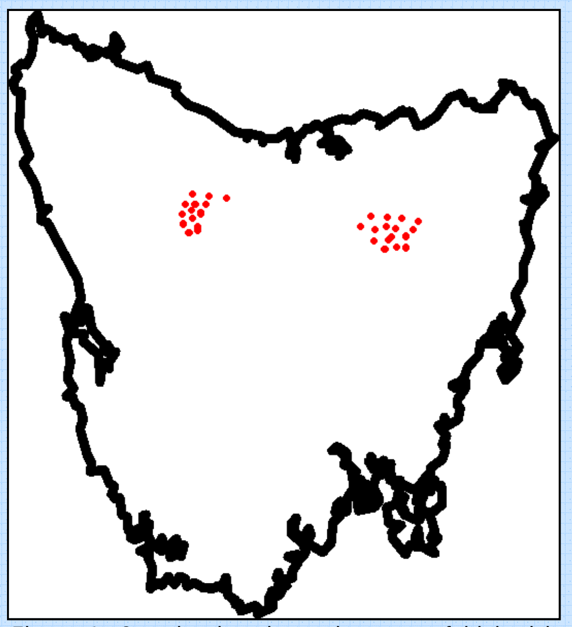

Figure 1: Sample sites in study areas of high-altitude *E.delegatensis* forests of NE and NW Tasmania (n = 44)

Results

(1) Nutrient and carbon accumulation

Total Soil N and C increase significantly with the absence of fire (Fig. 2). The rate of increase is particularly rapid during the first 5 years of re-establishment. Total Soil P did not show any trend throughout the chrono-sequence.

(2) P demand and availability

Soil acid-phosphapatase (PME) activity significantly increases with the absence of fire, most rapidly in the first 20 years of re-establishment (Fig. 3a). Conversely, plant available (Extractable) Soil P falls in the first 20 years of re-establishment, but increases after this point (Fig. 3b).

(3) P supply and nutrient limitation

Foliar P concentrations fall for the first 20 years, then increase beyond this point (Fig. 4). Foliar N:P ratios are the inverse of this relationship; P limitation rises initially then falls with absence of fire.

(4) Undisturbed rainforest areas

Total Soil N, PME activity and Extractable P were significantly higher in rainforest areas, compared with the non-rainforest historical coupes (Figs. 5a,e,f). The other variables also showed increases, but these were non-significant. The transition profile (of age-categories with time) towards rainforest suggests that a 'plateau' of increasing soil nutrient and carbon levels may be developing as rainforest establishes (Figs. 5a,b,c,d,e).

Conclusions

- The absence of fire is associated with an accumulation of primary nutrients and carbon in the soil
- The greatest P demand exists during the first 40 years of post-fire re-establishment
- The greatest changes in nutrient dynamics occur during the first 20-30 years of post-fire re-establishment
- 'Declining' rainforest areas are characterised by a high 'plateau' in the accumulation of soil nutrients and carbon, combined with reduced P demand.
- *E. delegatensis* may be well adapted to thrive during the dynamic post-fire re-establishment period (0-40 years), where N and C accumulation is low and P demand is relatively high

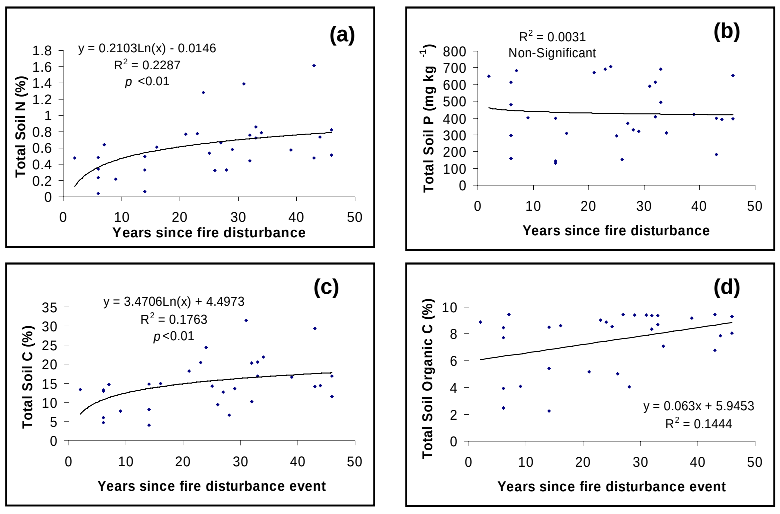

Figure 2: Scatterplots of the change in total soil nutrients and carbon with time since fire (a) Total Soil N, (b) Total Soil P, (c) Total Soil C, (d) Total Soil Organic C. n = 31

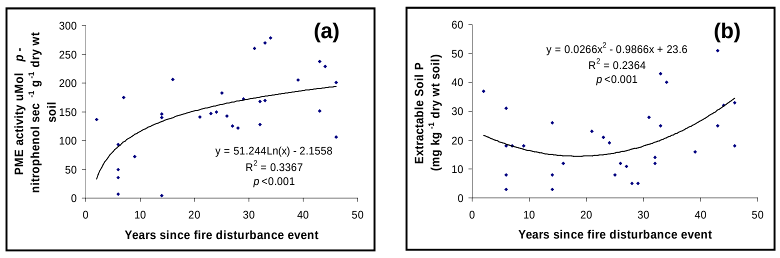

Figure 3: The change in soil PME activity and P availability with time since fire. (a) Soil PME activity, (b) Extractable soil P. n = 31

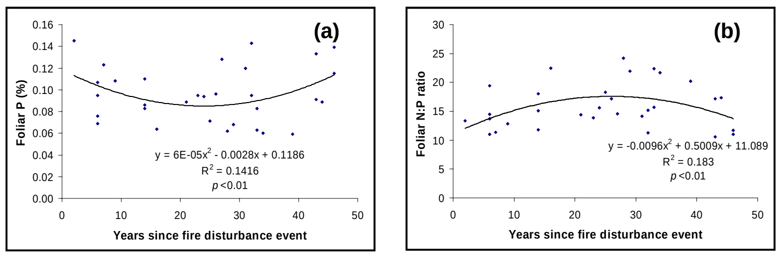

Figure 4: The change in foliar P concentration and foliar N:P ratio with time since fire. (a) Foliar P concentration, (b) Foliar N:P ratio. n = 31

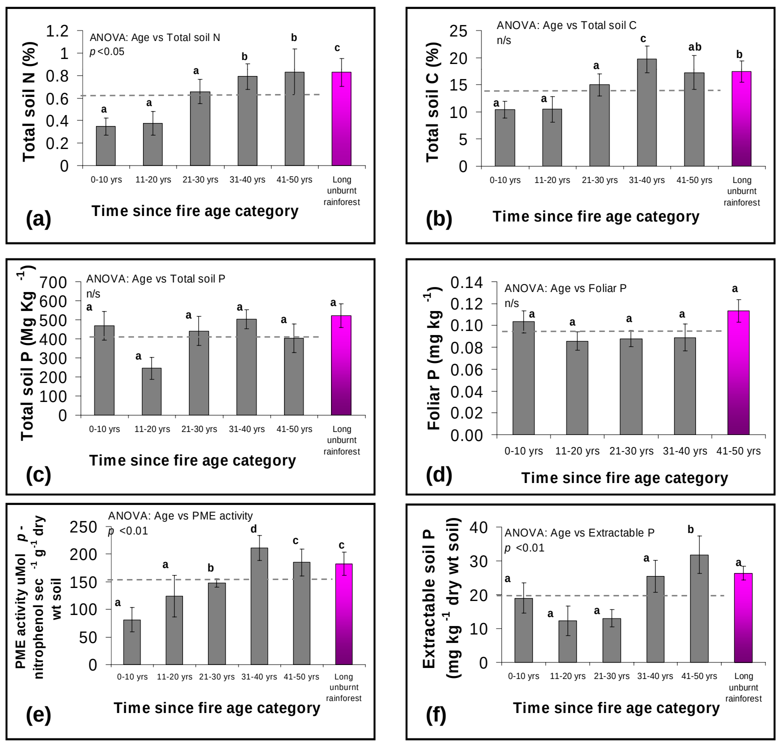

Figure 5: The change in nutrient dynamics and soil carbon with time since fire. decadal categories – including undisturbed rainforest compartments. Mean: (a) Total Soil N, (b) Total Soil C, (c) Total soil P, (d) Foliar N:P ratio, (e) PME activity, (f) Extractable soil P. Standard error bars (1 s.e. of the mean). Significant differences (p <0.05) between categories denoted by differing letters, according to Tukey LSD test. n = 44. Entire 'non-rainforest group' mean indicated by dashed grey line