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Plant functional types as a tool for predicting vegetation change with time since fire

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Background

Fire is a disturbance that shapes vegetation patterns and plant community composition. Fires consume biomass and promote plants with functional traits that enable survival, recruitment and/or reproduction during and shortly after fire. How species respond to aspects of a fire regime, such as time since fire, will be determined by their functional traits, with the critical functional traits in a fire-prone environment including:

(1) individual longevity

(2) the degree of individual persistence (resprouting or non-resprouting after canopy scorch);

(3) seed bank persistence and storage type (persistent in the canopy - serotiny, persistent in the soil or transient seed bank); and

(4) plant height (reflecting a competitive hierarchy during the inter-fire period).

Plant functional types (PFTs) are groupings of plant taxa that share particular combinations of functional traits relevant to a specific disturbance and model of vegetation change. For fire, the traits listed above are combined into PFTs in Table 1.

Examples of key traits used to define Plant Functional Types in fire-prone environments: (from left) **individual persistence** e.g. resprouting after fire in *Banksia rufa* subsp. *chelomacarpa* (photo 1); **seed bank persistence** e.g. serotinous seed bank in *B. media* (photo 2); **plant height** e.g. canopy dominance by mallee *Eucalyptus* spp. (photo 3) compared to the ground-layer *Conostylis petrophiloides* (photo 4); **longevity** e.g. the short-lived post-fire ephemeral *Gyrostemon prostratus* (photo 5)

The PFT approach postulates that species with the same combinations of traits will respond in a similar and predictable way to time since fire. We aimed to determine if a PFT classification based on fire response traits could predict changes in richness and dominance with time since fire in mallee shrubland and mallee-heath. If PFT response can be predicted, PFTs could be used to support decisions on the timing and type of fire management interventions for biodiversity conservation beyond the sites and species studied here.

Table 1. Key traits (numbered, **bold**) that combine to form plant functional types (PFTs) (RStree etc; see Table 2 for expanded abbreviations) in fire-prone environments. For each combination of the traits of (1.) **longevity**, (2.) **individual persistence** and (3.) **seed bank persistence and storage type** there are three potential placements in the competitive hierarchy based on (4.) **Plant Height**: tree, shrub and low. Dash indicates no representatives known in our communities. For the purposes of our study, some PFTs were merged across persistent and transient seed bank types ([A]) or seed bank type, individual persistence and plant heights ([B]).

1. **Longevity**	2. **Individual Persistence**	3. **Seed Bank Persistence and Storage Type**: Persistent canopy	Persistent soil	Transient soil
Long (> 6 yrs)	Resprouter	RStree	[RNtree[A]]	
		RSshrub	[RNshrub[A]]	
		-	[RNlow[A]]	
	Non-resprouter	NStree	NNtree	-
		NSshrub	NNshrub	-
		-	NNlow	-
Short (≤ 6 yrs)	Resprouter	-	[Ephem[B]]	
	Non-resprouter	-		

Predicted responses

Assuming that all plant species became established immediately after fire, each of PFTs was predicted to respond to *increasing time since fire* as follows (Table 2):

- Due to their limited longevity (1. Longevity) and fire-stimulated germination, post-fire ephemerals were predicted to decline rapidly in richness and cover.
- The capacity to resprout (2. Individual Persistence) generally confers resistance to change in both richness and cover, as individual plants are often both highly persistent and recover biomass rapidly after fire. Resprouting PFTs were thus predicted to change little in richness or cover with time since fire.
- For non-resprouting serotinous PFTs (3. Seed Bank Persistence and Storage Type), high longevity in individuals relative to typical inter-fire intervals is crucial for population persistence; so we predicted stable richness and increasing cover as individuals develop from seedlings to adults. As persistent soil-stored seed PFTs do not need to be present as live adults at the time of fire for population persistence, high individual longevity is less crucial. Non-resprouting, non-serotinous PFTs were thus predicted to have declining above-ground richness, and cover declining or peaking at an intermediate time since fire.
- Dominant tree and shrub layers (4. Plant Height) were predicted to competitively suppress low vegetation over the inter-fire period, leading to reduced richness and cover in low PFTs with increasing time since fire.

Table 2. Plant functional types and their predicted response in richness and cover to increasing periods since fire (from 2 to > 55 years post-fire) in mallee and mallee-heath (heath). =, stable; ↓, decrease; ↑, increase; Y, responded as predicted; N, did not respond as predicted; -, PFT not present.

Plant functional type (Table 1 code)	Predicted richness	Result mallee	Result heath	Predicted cover	Result mallee	Result heath
Resprouting serotinous trees (RStree)	=	N	Y	= or ↑	Y	Y
Non-resprouting serotinous trees (NStree)	=	Y	Y	↑	N	Y
Resprouting non-serotinous trees (RNtree)	=	-	Y	= or ↑	-	Y
Non-resprouting non-serotinous trees, climbers (NNtree)	= or ↓	Y	Y	↑ then ↓	N	Y
Resprouting serotinous shrubs (RSshrub)	=	Y	Y	=	Y	Y
Non-resprouting serotinous shrubs (NSshrub)	=	Y	N	↑	N	Y
Resprouting non-serotinous shrubs (RNshrub)	= or ↓	Y	Y	= or ↓	Y	Y
Non-resprouting non-serotinous shrubs (NNshrub)	↓	N	Y	↑ then ↓	N	Y
Resprouting non-serotinous dwarf shrubs, herbs, graminoids (RNlow)	= or ↓	Y	Y	↓	N	N
Non-resprouting non-serotinous dwarf shrubs, herbs, graminoids (NNlow)	↓	N	Y	↓	N	Y
Post-fire ephemeral herbs, graminoids, shrubs (Ephem)	↓	Y	Y	↓	Y	Y

Findings

PFTs defined by fire response traits successfully predicted changes in richness and cover with time since fire in mallee-heath, a community dominated by serotinous non-resprouters (Table 2), but were less successful in doing so in mallee, a community dominated by serotinous resprouters.

Management Implications

- PFTs are useful for predicting and interpreting vegetation changes associated with time since fire in shrubland communities dominated by serotinous non-resprouters.
- Specification of PFTs enable prediction of generalised responses of vegetation to particular fire regimes, so can be used to predict the outcomes of fire management actions in a broad range of shrubland communities

Further information: Gosper CR, Yates CJ and Prober SM (2012) Changes in plant species and functional composition with time since fire in two Mediterranean-climate plant communities. *Journal of Vegetation Science* 23, 1071-1081.

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