Multi-century changes in plant diversity, composition and vegetation structure after fire in gimlet woodlands

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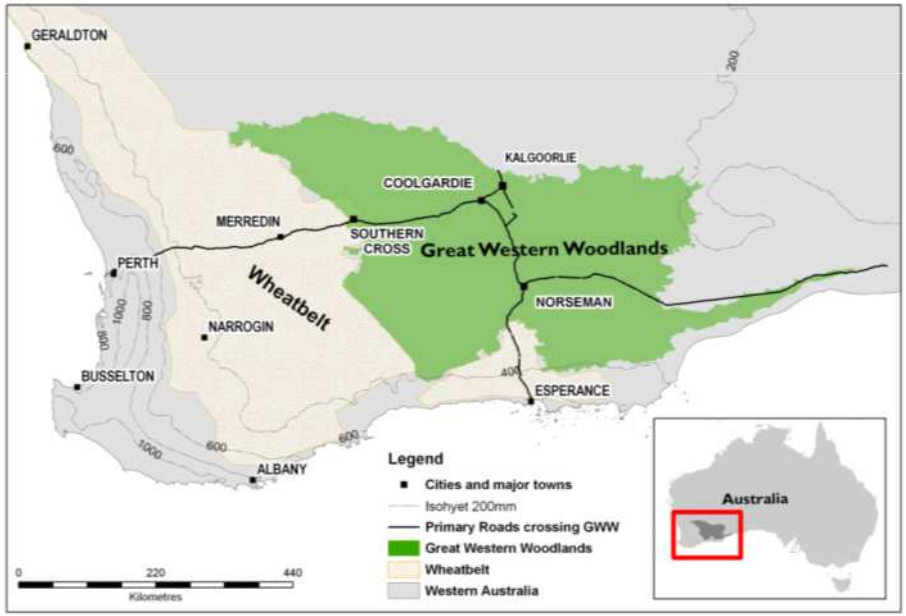
The Great Western Woodlands

- World's largest extant Mediterranean-climate woodland (16 M ha)
- Largely intact, diverse
- Mosaic of woodlands, mallee, shrublands, ironstone and greenstone ranges & salt lakes
- Woodlands at as low as 220mm MAR



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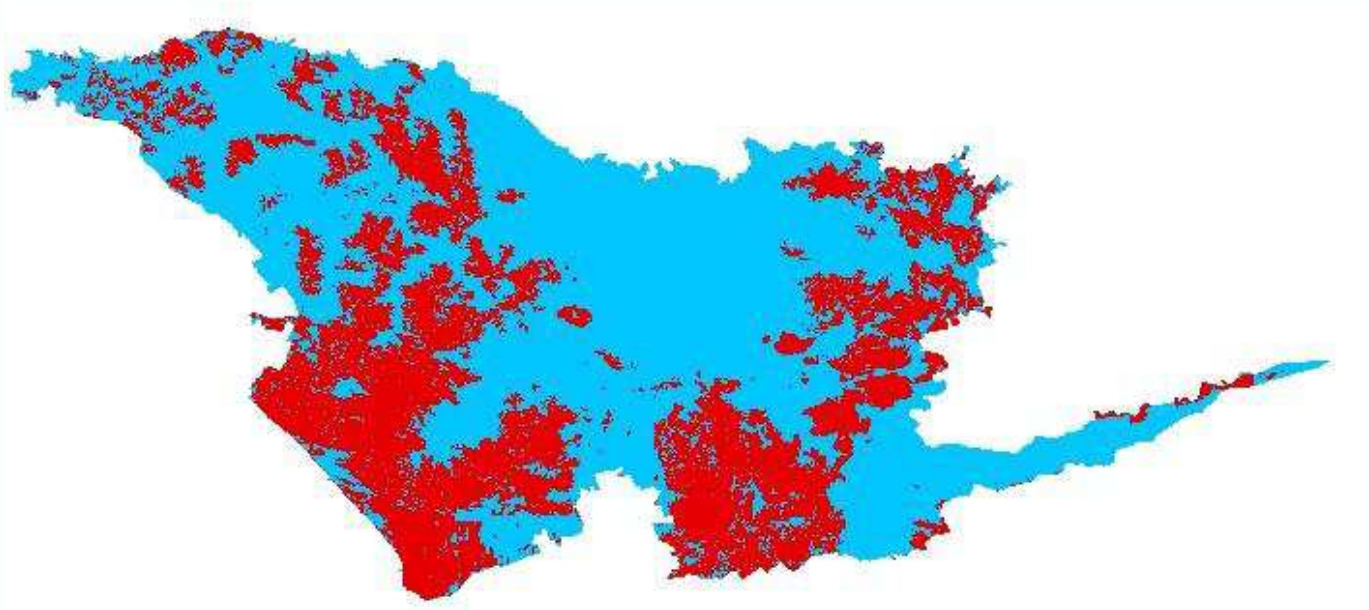
Fire in GWW

- Fire is a key process driving vegetation composition, structure and recruitment
- Poor understanding of historic fire regimes, including fire intervals
- Woodland communities fire sensitive
- Canopy fires

Fire in GWW

- Recent decades have seen many large fires
- Impacts on lives and infrastructure
- Increasing fire a concern, especially with climate change



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Aims:

1. Establish a series of permanent plots along a time-since-fire gradient
2. Develop a method to estimate time since fire of long-unburnt stands
3. Estimate the current stand age structure of *Eucalyptus* woodlands
4. Assess how plant diversity and composition change with time since fire
5. Measure how vegetation structure and flammable fuel change with time since fire

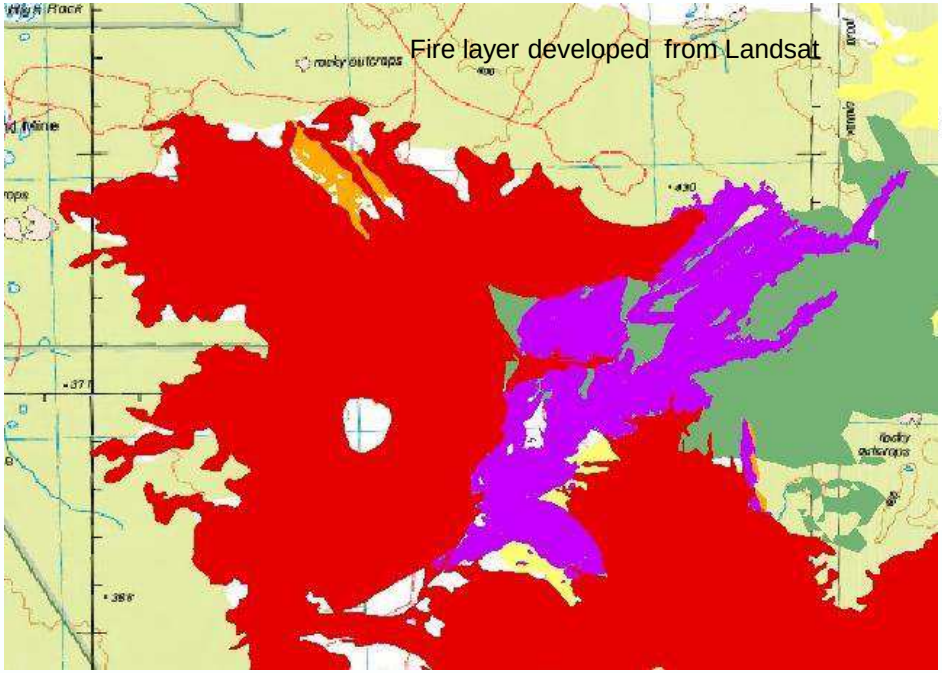
Gimlet (*E. salubris*) woodlands

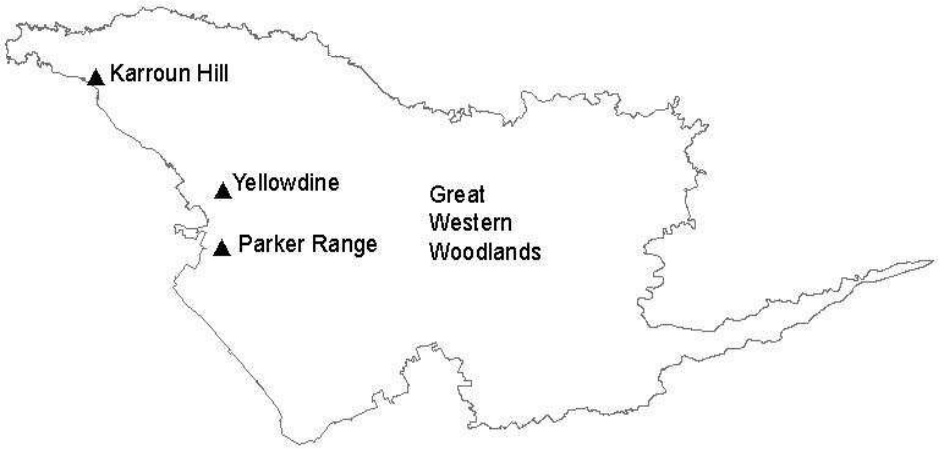
- Serotinous non-resprouter
- Recruit after fire in even-aged stands, very slow growing
- Sparse understorey of sclerophyllous shrubs, chenopods, grasses and annuals: fire resistant

Aim 1: Establishing permanent plots

- 72 plots stratified by time-since-fire using Landsat imagery covering the period 1972 to 2010
- 3 broad areas of similar climate and sufficient fire-age diversity

Time since fire (years)	# plots
2-10	17
11-38	6
38-60	13
>60	36





Aim 2: Estimating time since fire

1. post-1972 fires dated from Landsat imagery

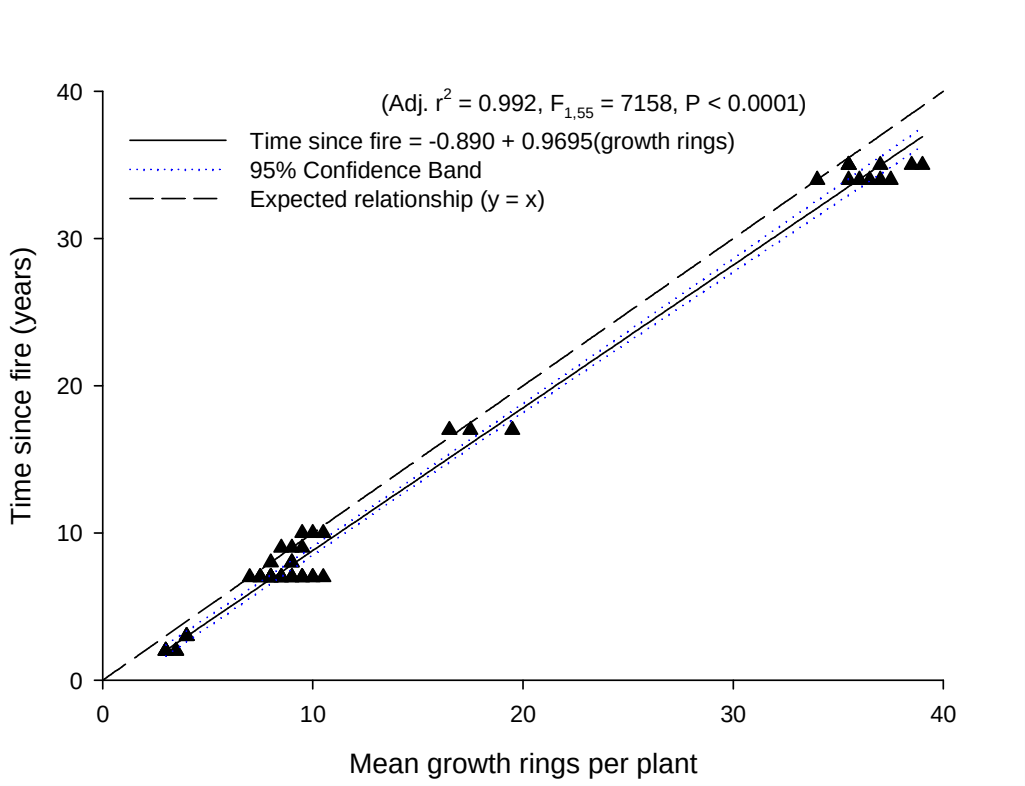
2. growth ring counts to estimate post-1910 fires

3. Use growth ring counts to develop size-age relationships to estimate age in stands with hollowed trees (pre-1910)

Aim 2: Estimating time since fire

- Strong positive relationship between time since fire from Landsat and growth rings

- Slight tendency to overestimate time since fire

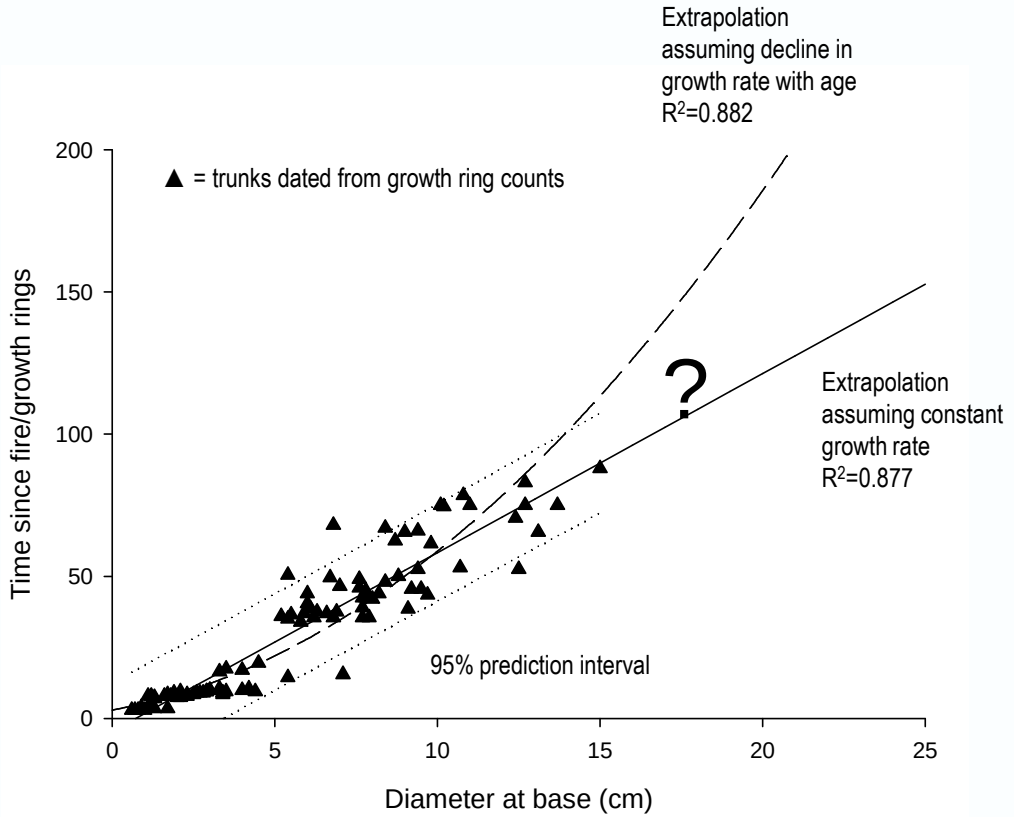


Aim 2: Estimating time since fire

- Strong positive relationships between growth rings and plant size (diameter at base and/or tree height)

- Uncertainty over best model form beyond limits of growth ring record

- Estimated maximum stand times since fire of 370 years (constant growth rate) or 1460 years (declining growth rate)



Aim 2: Estimating time since fire

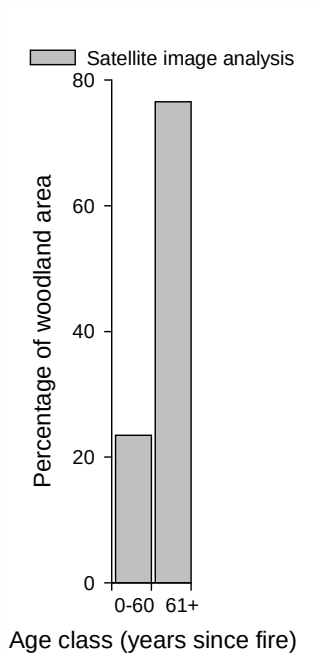
Key findings:

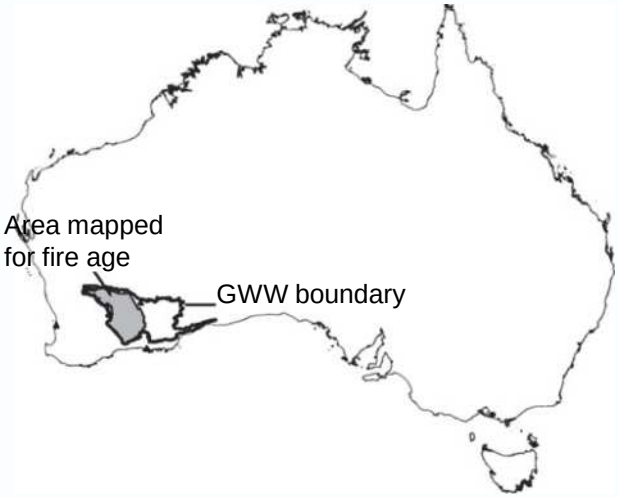
- Gimlet tree rings and size can be used to estimate stand time since fire
- Extends time since fire record well beyond that able to be discerned from Landsat imagery
- Allows the investigation of time since fire effects on ecological processes, using relative age after 100 years

Aim 3: Age-structure in GWW woodlands

- Understanding the age structure of GWW woodlands could provide clues as to whether recent levels of fire are unprecedented

- To provide a crude assessment of the age structure of woodlands, we extrapolated the results of Landsat fire mapping to the regional scale, by assuming that the distribution in age classes older than 60 years is proportional to our random samples



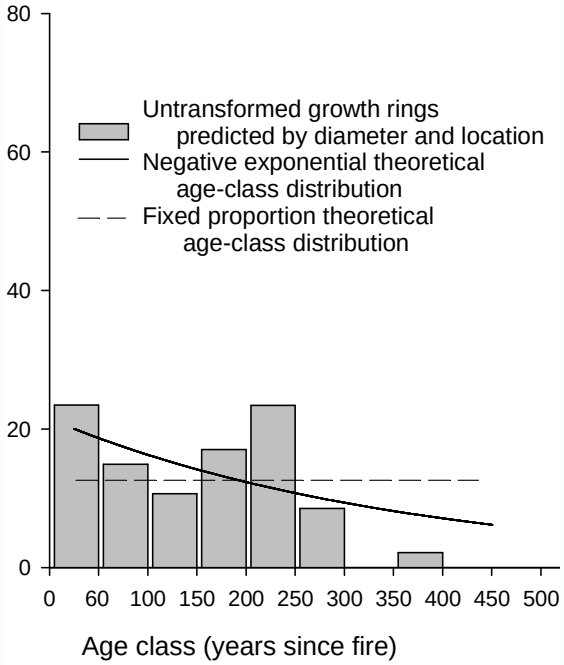


Landsat-derived age-class distribution

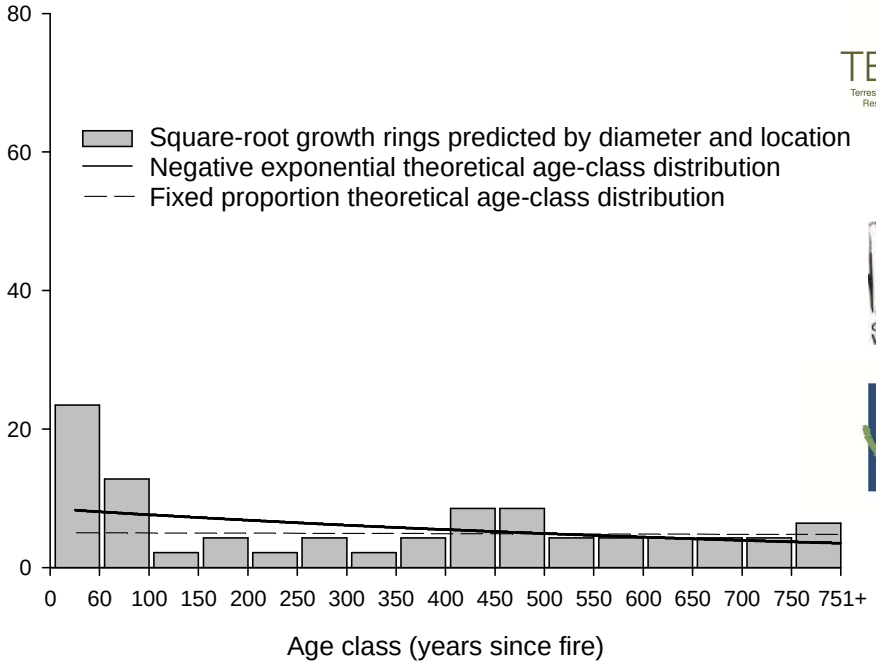
Aim 3: Age-structure in GWW woodlands

Key findings:

- Estimated age-class distributions can be compared to theoretical distributions to determine fire management interventions.
- Irrespective of model used, recently-burnt vegetation is over-represented on a fixed proportion basis but less so compared to a negative exponential function.
- We are working on improving these estimates



Constant growth rate



Decline in growth rate

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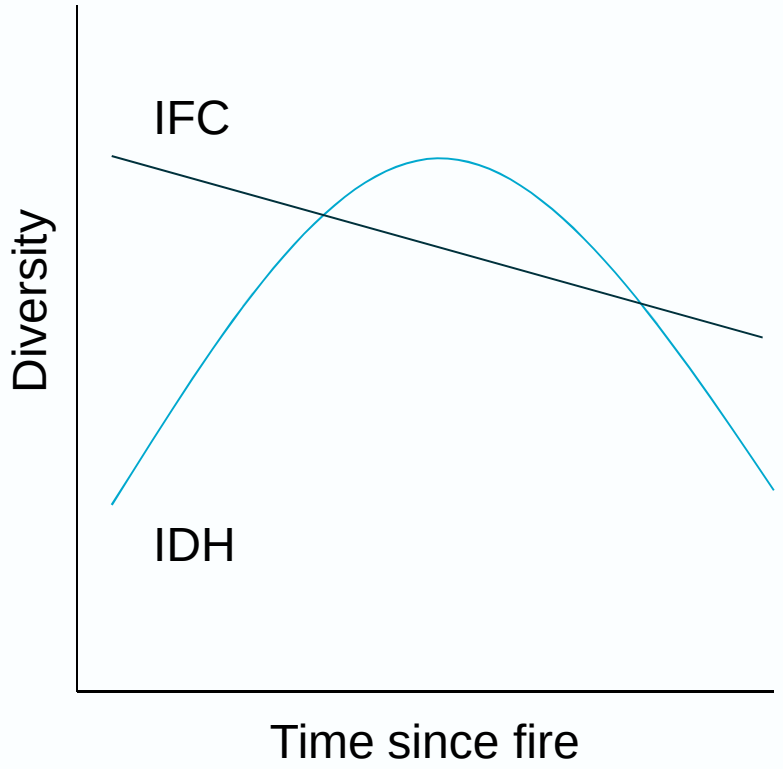
Aim 4: Multi-century changes in plant diversity

Hypotheses:

- Initial floristic composition (IFC) hypothesis: declining diversity with time

- Intermediate disturbance hypothesis (IDH) : highest diversity at intermediate time since fire

Both hypotheses imply a need for recurrent fire to maintain diversity

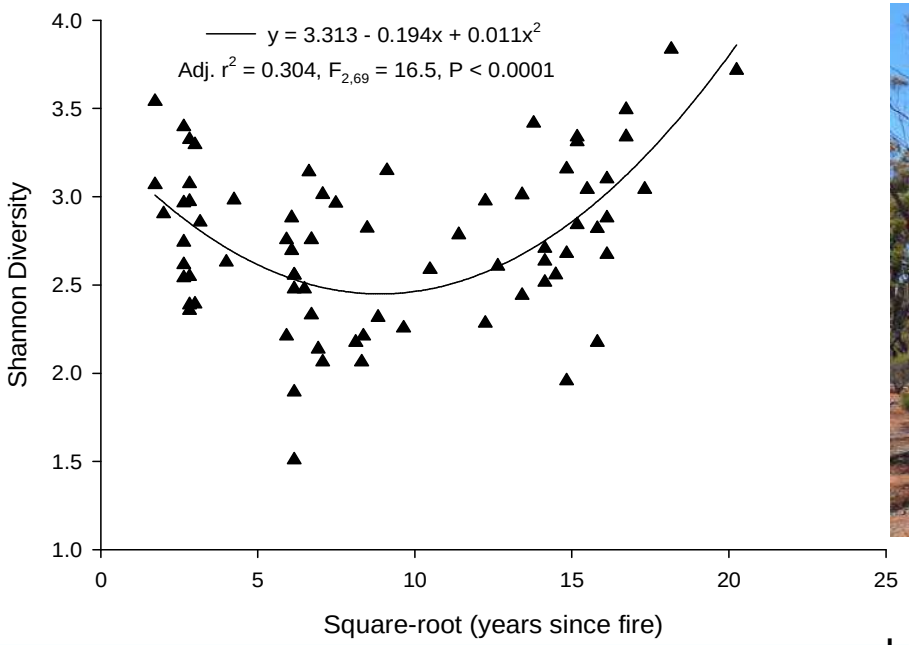


Aim 4: Multi-century changes in plant diversity

•72 50 x 50 m plots sampled for species composition and cover

• diversity indices – richness, diversity, evenness

Young



Mature

Intermediate

- graph uses model for stand age assuming constant growth rate

Results

- globally rare ‘U’-shaped relationship between diversity and time since fire is likely to be driven by dominant trees and shrubs having maximum competitive influence at intermediate times since fire
- did not match IFC or IDH

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Aim 4: Multi-century changes in plant diversity

- Traits used to define Plant Functional Types were selected on the basis of competition and recruitment over the period between fires being important processes driving vegetation change
- PFTs defined according to plant growth form (7 categories) and seed dispersal distance potential (2 categories) to form 12 PFTs

Life forms

Aerial parasite (Aerial)

Phanerophytes – trees (> 8 m height) (Tree)

Phanerophytes – shrubs (1–8 m height) (Shrub)

Chamaephytes (shrubs 0.1–1 m height) (Low shrub)

Hemicryptophytes (persistent buds at soil surface) (Hemicryp)

Geophytes (Geo)

Therophytes (annuals) (Annual)

Dispersal potential

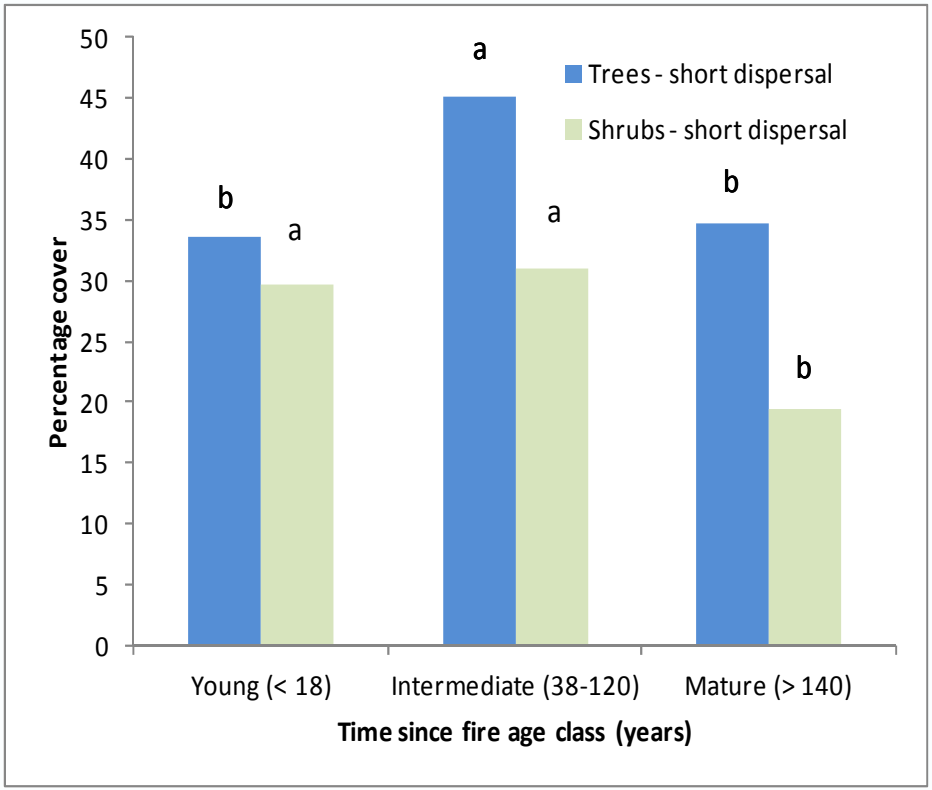
Long (Endozoochory, Epizoochory, Anemochory) (L)

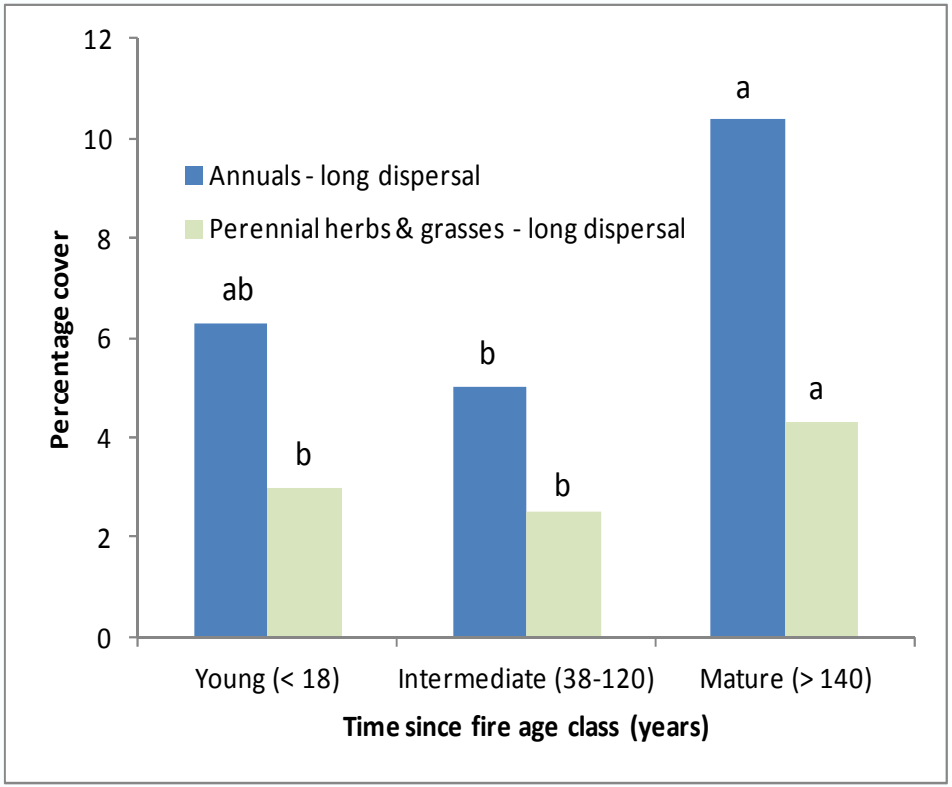
Short (Myrmecochory, Barochory) (S)

Aim 4: Multi-century changes in plant diversity

Results:

• Richness and cover of many PFTs changed with time since fire.





Aim 4: Multi-century changes in plant diversity

Results:

• ground-layer PFTs had greatest cover in mature vegetation while tree and shrub-layer PFTs had peak cover at intermediate times since fire
• ground-layer PFTs taking advantage of increasingly litter-free ground surface

• short dispersal potential PFTs decreased with increasing time since fire while long dispersal potential PFTs increased
• long-dispersal potential PFTs have the capacity to disperse to suitable micro-sites for recruitment between fires

Aim 4: Multi-century changes in plant diversity


Photo: L. McCaw

Management implications

• Important changes in diversity occurred beyond times since fire able to dated by remote sensing

•No evidence for fire initiating community change

Aim 4: Multi-century changes in plant diversity

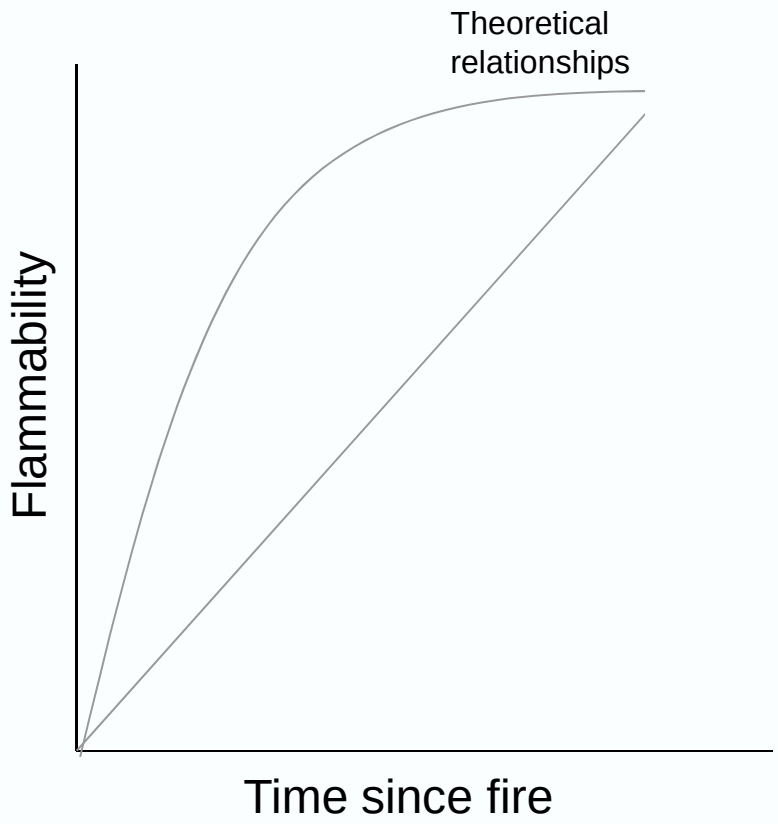

Photo: L. McCaw

Management implications

- As diversity was highest in mature woodlands, there is no support for gimlet woodlands requiring recurrent fire to maintain plant diversity
- Intense stand-replacing fires at intervals of < 200 yrs would have adverse implications for biodiversity conservation.

Aim 5: Changes in fuel with time since fire

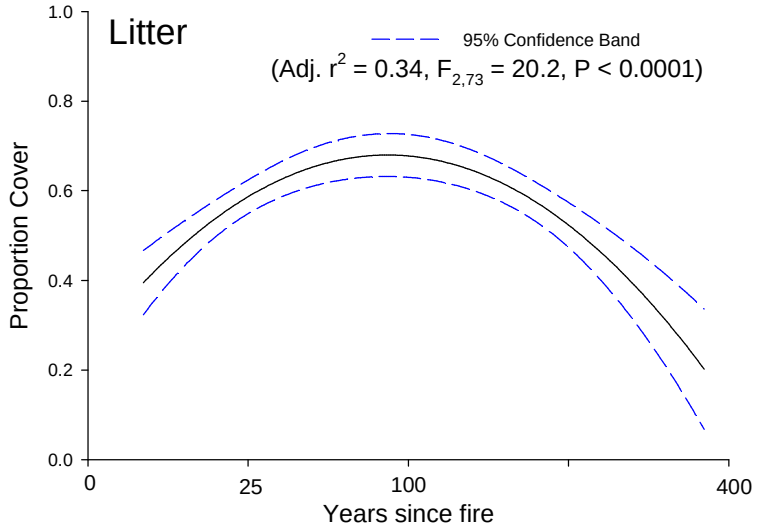
- After fire, changes occur in the composition and structure of vegetation affecting the mass, spatial arrangement and condition of fuels
- Flammability is often assumed to increase monotonically with time since fire
- Understanding changes in fuels are important for protection of human assets and biodiversity conservation
- Sampled tree density and size, ground cover and the vertical distribution of vegetation



Aim 5: Fuel changes with time since fire

Results:

- Canopy and litter cover peaked at intermediate times since fire (~35 to 150-250 years)
- Discontinuous litter cover in young and mature woodlands reduces flammability
- Connectivity of fuels from litter to the canopy was greater in intermediate-aged woodlands
- Gaps in foliage increased with time since fire



Young

Intermediate

Mature

Aim 5: Fuel changes with time since fire

Management implications

- Important changes in fuel structure occurred beyond times since fire able to dated by remote sensing
- Non-monotonic changes in fuel
- Adjusted fire behaviour ratings
- Woodlands at an intermediate time since fire are likely to support fires under more benign weather conditions
- Community flammability is also influenced by seasonal conditions

Aim 5: Fuel changes with time since fire

Management implications

• Replacement and fragmentation of mature woodlands with lower flammable fuel by higher-fuel intermediate time since fire woodlands potentially instigates a self-reinforcing fire regime shift favouring larger and/or more uniform fires.

• As a consequence of recent large widlfires, large areas of regenerating woodlands will soon be passing into a more flammable stage of post-fire development

Future Directions

- Evaluate time-since-fire impacts on ants and soil processes
- Improve estimates of woodland age structure
- Measure changes in carbon content of woodland with time since fire

Further information:

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Fire in gimlet woodlands. NatureMap: http://naturemap.dec.wa.gov.au/default.aspx

Thank you

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