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Restoring an appropriate fire regime to fragmented vegetation: a vital attributes approach

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South-West Western Australia: a global biodiversity hotspot

- High richness and endemism in vascular plants
- Highly threatened
- Mediterranean climate
- Fire-prone landscape
- Poor understanding of historic fire regimes
- Fire is a key process driving vegetation composition, health and recruitment
- Many plants possess traits that enable them to persist following fire

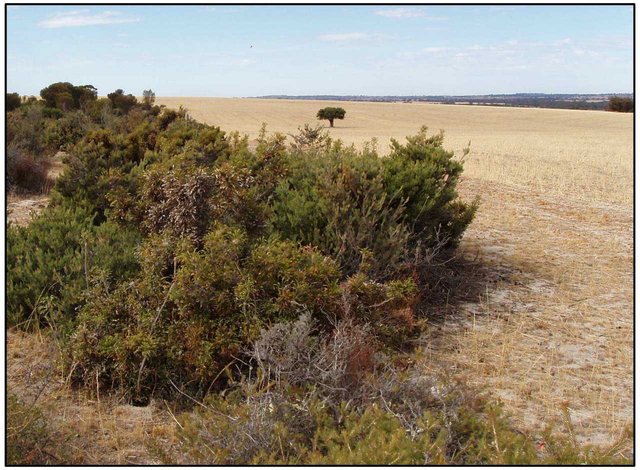
The WA wheatbelt

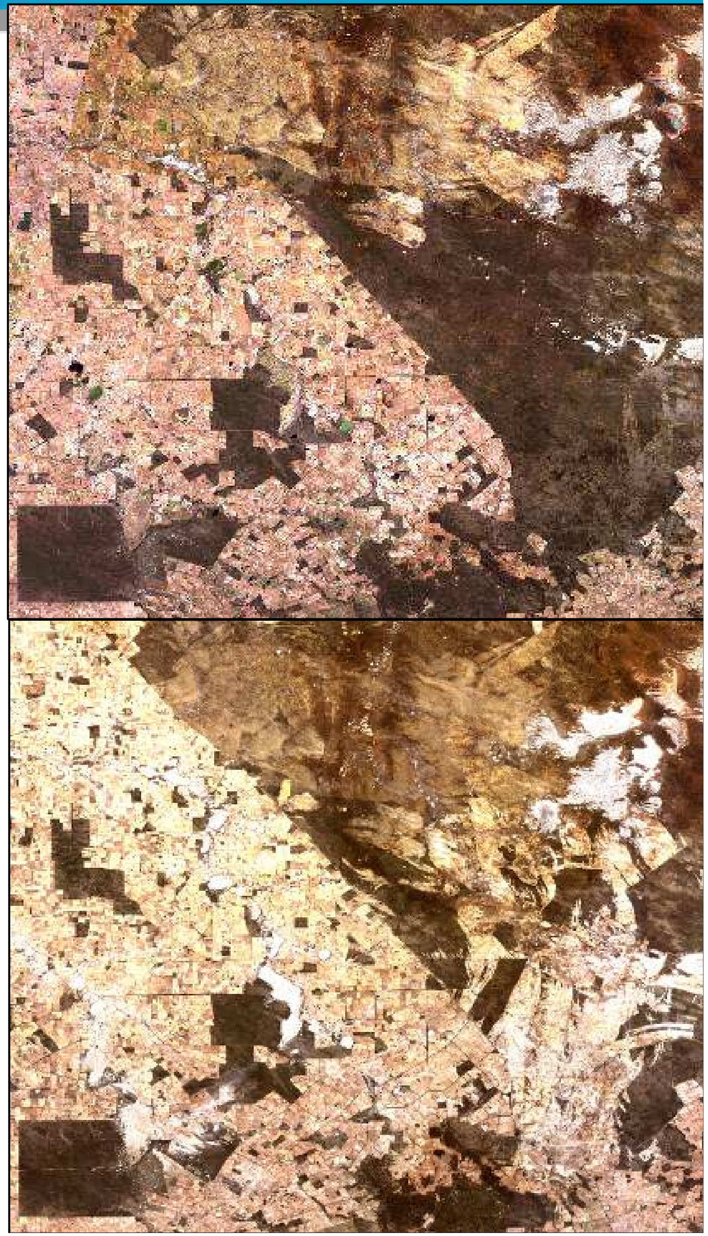
Highly fragmented

As little as 2-3% cover in some districts

Altered disturbance regimes

- Fire frequency, season, extent &/or intensity
- Different sources of ignition
- Loss of connectivity (for passage of fire)
- Fire exclusion and suppression
- Different parts of the landscape appear to be experiencing different fire intervals





Restoring fire?

Conservation risks of infrequent fire:

- Vegetation community change
- Senescence
- Lack of recruitment opportunities

Uncertainty as to what constitutes an appropriate fire regime for biodiversity conservation

Study aim:

Can appropriate fire intervals for plant communities be reconstructed from sampling the vital attributes of fire-sensitive examples of key Plant Functional Types?

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Species selection

Functional types vulnerable to fire interval

- Focus on processes and mechanisms that fire impacts species
- Means of persistence through fire (sprouter vs. obligate seeder)
- Means of seed survival (persistent soil-stored vs. canopy-stored)

Serotinous species

- Seed bank survival reliant on adult survival
- Seed bank exhausted in each disturbance
- Recruit predominately after disturbance

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Serotinous species selection

Obligate seeders

Reliant of recruitment from seed for persistence after fire

Vulnerable to fire intervals:

- less than juvenile period
- greater than adult longevity (senescence)

Sprouters

Rely on adult survival, often having low rates of recruitment

Vulnerable to:

- Adult mortality (competitive interactions, disturbance, disease)

Paired contrasts

Family	Obligate seeders	Sprouters
Proteaceae	*Banksia violacea*	*B. pteridifolia*
Proteaceae	*Hakea pandanicarpa*	*H. incrassata*
Proteaceae	*Petrophile glauca*	*P. seminuda*
Myrtaceae	*Beaufortia micrantha*	*Leptospermum spinescens*

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Methods

- Stratification by time since fire
- 9 vegetation ages
- Range: 2 to > 46 yrs post-fire
- Species sampled at 4 sites per fire age (more for > 46 yrs)
- 10 individuals per site

Field measurements:

- Mortality
- Fruit number

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Study community

Tallerack mallee-heath

- Tallerack *Eucalyptus pleurocarpa*
- Scattered mallees over dense shrub layer
- Myrtaceae and Proteaceae dominant
- This and similar communities (kwongan) are widespread across Mediterranean-climate SW Western Australia

Acceptable fire intervals

We use two methods to estimate minimum and maximum fire intervals

Minimum fire intervals

- Time to maturation and commencement of accumulation of seed bank
- Primary (obligate seeders) or secondary (sprouters) juvenile period
- Our estimates derived from (i) the proportion of individuals with fruit and (ii) mean fruit crop size

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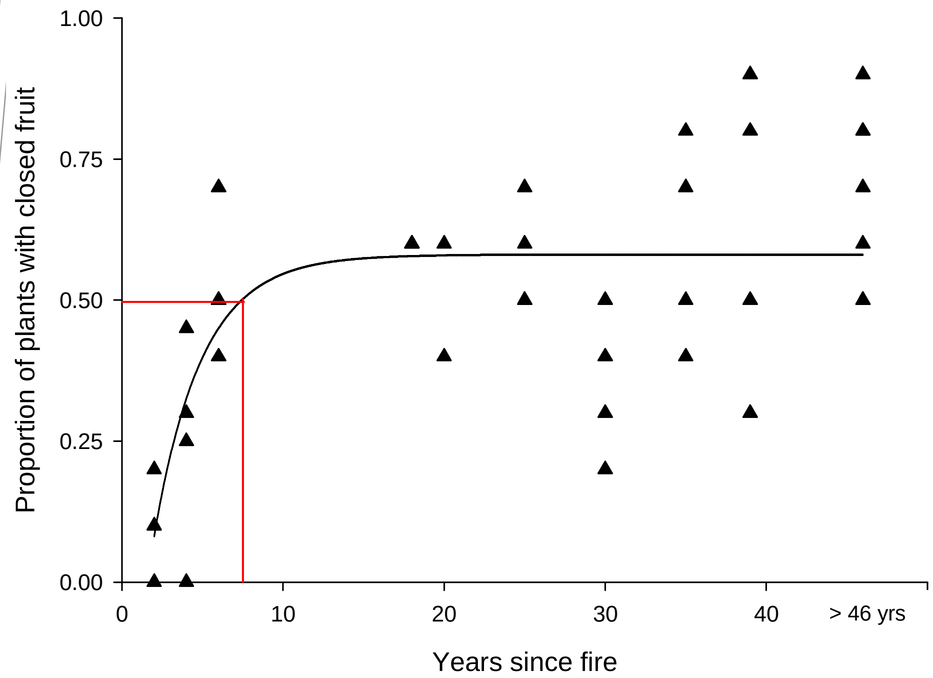
Minimum fire intervals – method 1

Sprouter - *Banksia pteridifolia*

Proportion of individuals with fruit

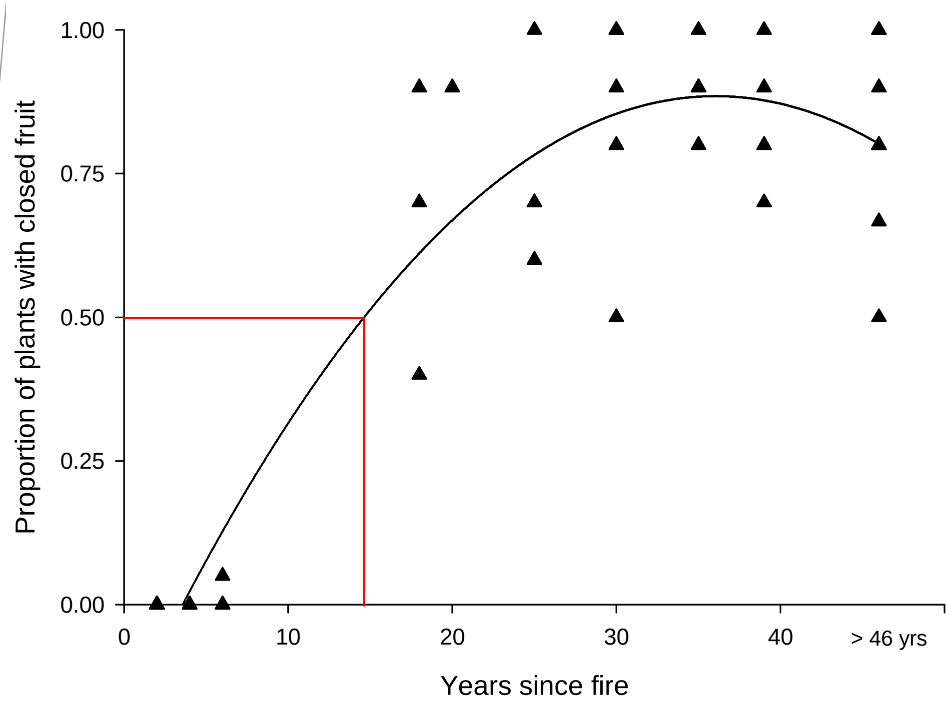
- Time since fire when ≥ 50% of individuals carry fruit
- Derived from regression of the proportion of sampled individuals carrying fruit per site with time since fire



Secondary juvenile period ~ 8 yrs

Minimum fire intervals – method 1

Obligate seeder - *Petrophile glauca*



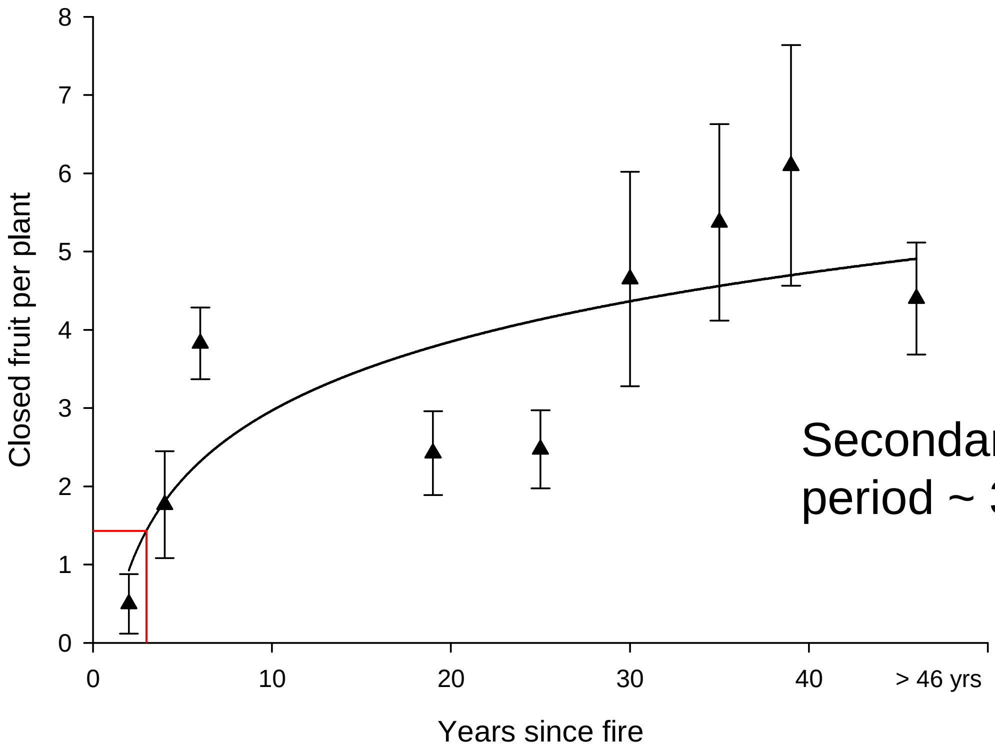
Primary juvenile period ~ 15 yrs

Minimum fire intervals – method 2

Sprouter - *Banksia pteridifolia*

Mean fruit number

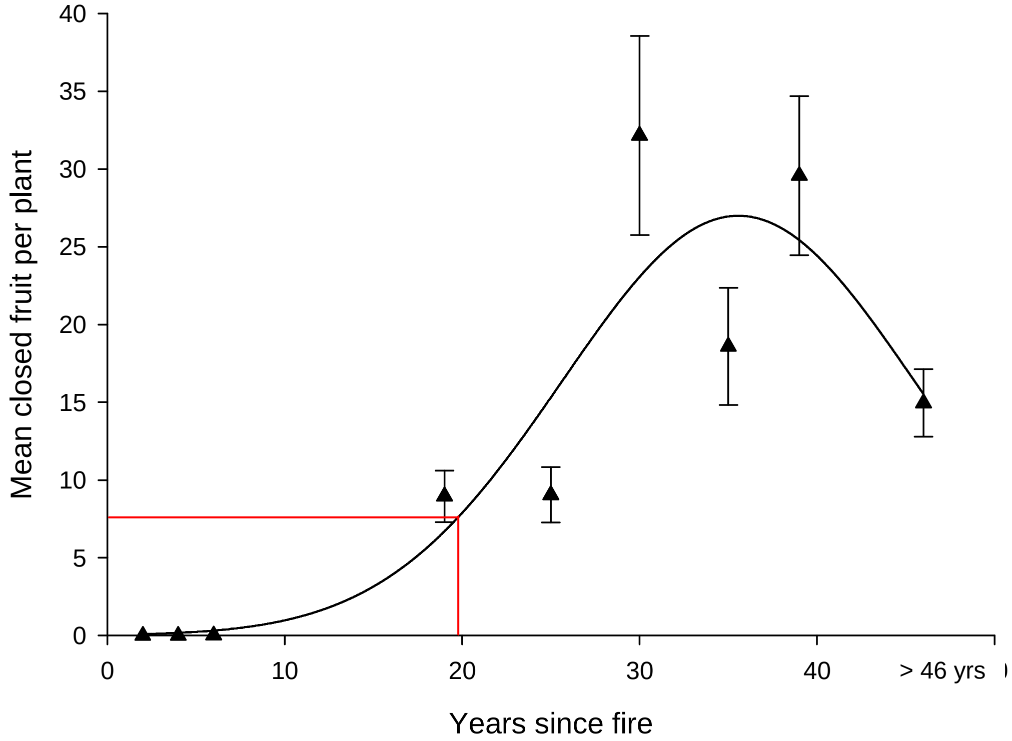
- Time since fire when mean number of fruits per plant reaches 25% of maximum
- Derived from regression of count data with time since fire (sites combined)



Secondary juvenile period ~ 3 yrs

Minimum fire intervals – method 2

Obligate seeder - *Petrophile glauca*



Primary juvenile period ~ 20 yrs

Acceptable fire intervals

Maximum fire interval

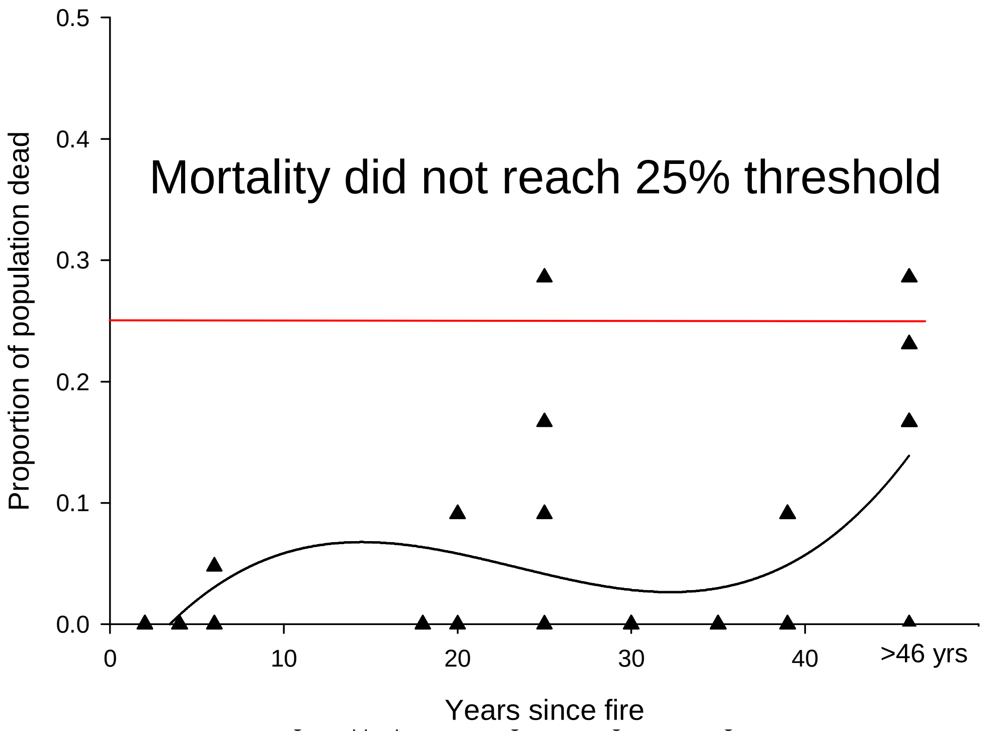
- Period when time since fire exceeds plant and/or seed bank longevity
- Appropriate metrics have not been well defined
- Our estimates derived from (i) the proportion of dead individuals and (ii) mean fruit crop size (measuring decline of the seed bank)

Maximum fire intervals – method 1

Sprouter - *Banksia pteridifolia*

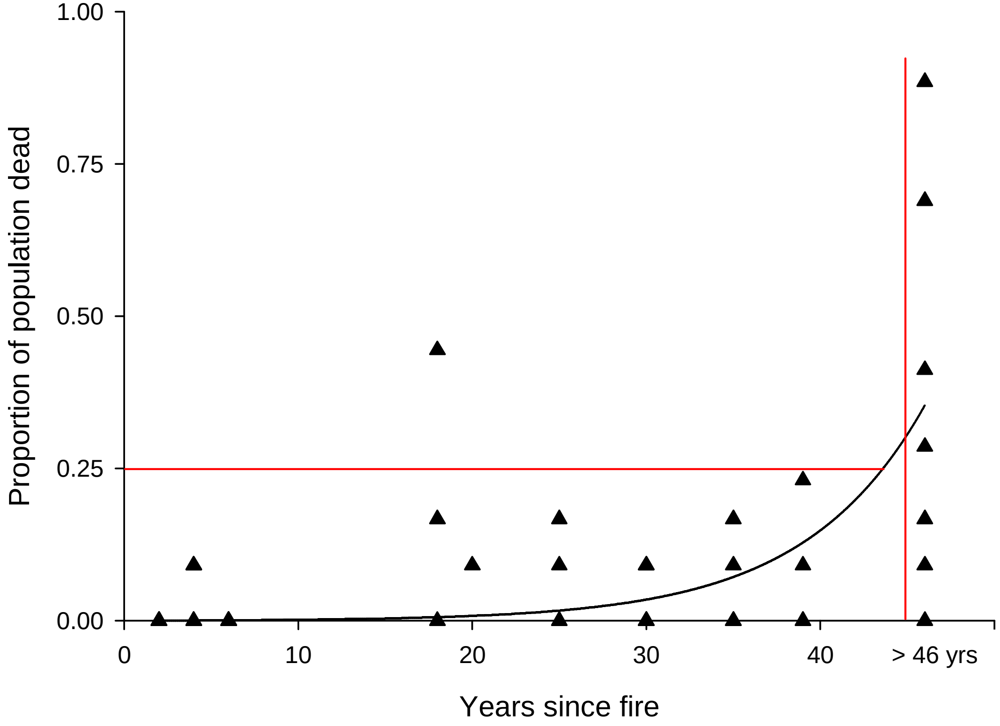
Proportion of dead individuals

- Time since fire when ≥ 25% of individuals are dead
- Derived from regression of the proportion of dead individuals per site with time since fire



Maximum fire intervals – method 1

Obligate seeder - *Petrophile glauca*



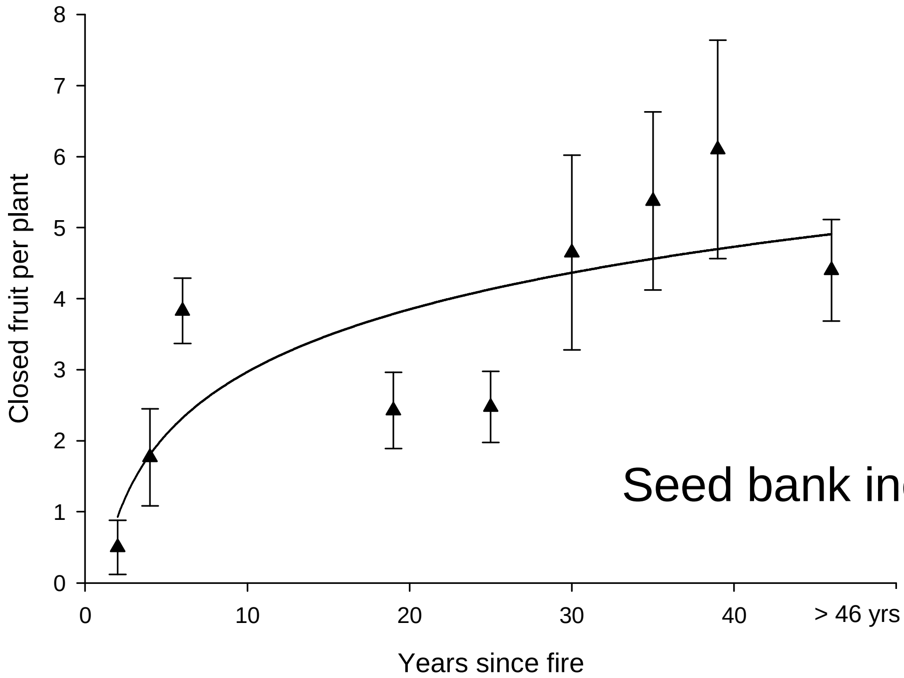
Max. interval > 46 yrs

Maximum fire intervals – method 2

Mean fruit number

Sprouter - *Banksia pteridifolia*

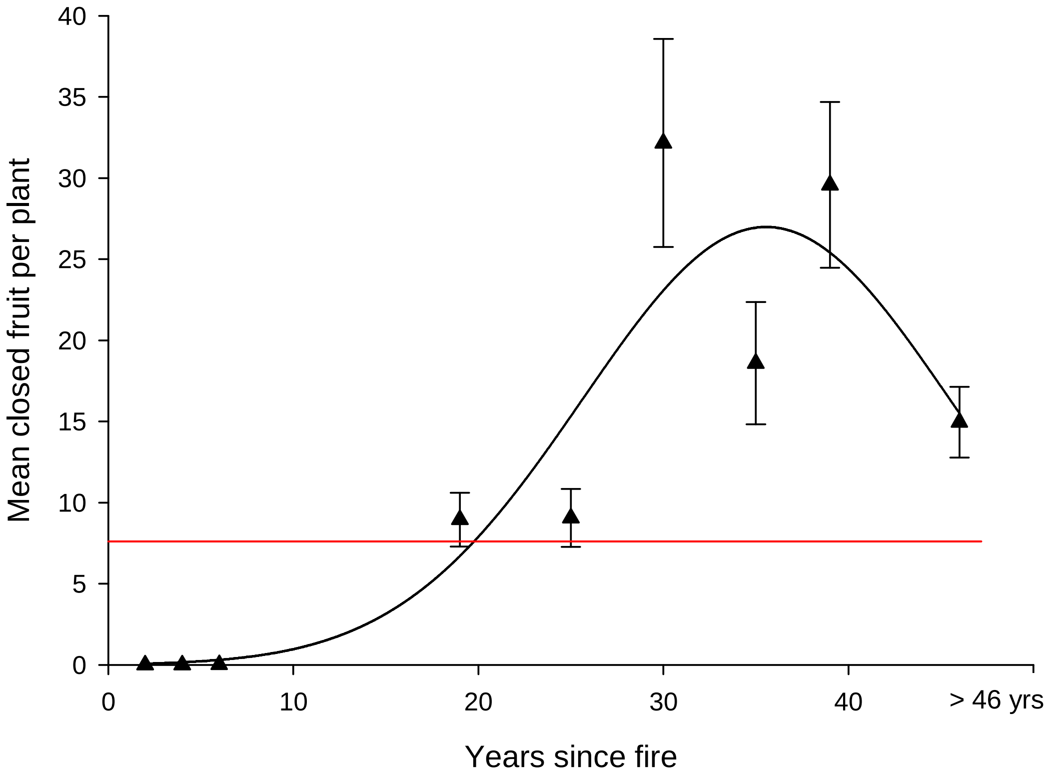
- Time since fire when mean number of fruits per plant declines to 25% of maximum
- Derived from regression of count data with time since fire (sites combined)



Seed bank increased over time

Maximum fire intervals – method 2

Obligate seeder - *Petrophile glauca*



Fruit crop declined in long unburnt vegetation, but did not reach 25% threshold

Minimum fire intervals – all species

Time since fire to:	≥ 50% of popn.	25% of max. crop
Obligate seeder (primary juv. period)		
Banksia violacea	Did not reach	19 yrs
Hakea pandanicarpa	36 yrs	36 yrs
Petrophile glauca	15 yrs	20 yrs
Beaufortia micrantha	8 yrs	14 yrs
Sprouter (secondary juv. period)		
Banksia pteridifolia	8 yrs	3 yrs
H. incrassata	No relationship	No relationship
P. seminuda	No relationship	No relationship
Leptospermum spinescens	7 yrs	5 yrs

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Maximum fire intervals – all species

Time since fire to:	25% mortality	25% of max. crop
Obligate seeder		
Banksia violacea	> 46 yrs#	No decline
Hakea pandanicarpa	> 46 yrs	> 46 yrs
Petrophile glauca	> 46 yrs	> 46 yrs#
Beaufortia micrantha	> 46 yrs#	> 46 yrs#
Sprouter		
Banksia pteridifolia	> 46 yrs#	No decline
H. incrassata	No relationship	No relationship
P. seminuda	30-40 yrs#	No relationship
Leptospermum spinescens	20-25 yrs	19-39 yrs

#Significant relationship with time since fire (increase in mortality, or reduction in fruit crop, in vegetation of a certain age), but did not reach relevant threshold

Appropriate fire intervals

- Based on the species sampled, an appropriate minimum fire return interval ~36 yrs
- Among obligate seeders, several show senescence under very long fire-return intervals (>> 50 yrs)
- Among sprouters, higher mortality and lower fruit crop size of some species at intermediate ages suggests than repeated intermediate intervals would lead to population declines
- From a plant vital attribute perspective, an appropriate fire return interval range may be variable, but within the range 36 - >>50 yrs

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Restoration of fire interval

How do these estimates compare to recent fire regimes?

- Recent average fire intervals vary with landscape context (Blair Parsons unpubl. data):
  - Small remnants: ~340 yrs
  - Large remnants: ~70 yrs
  - Continuous vegetation: ~40 yrs
- Active fire introduction may be appropriate in small remnants
- A increase in fire interval may be desirable in continuous vegetation
- Challenges in fire regime restoration in remnants:
  - Weed invasion
  - Operational constraints

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Vital attributes approach

Vital attributes:

- useful for deriving estimates of minimal fire intervals
- less useful in deriving estimates of maximum fire intervals, due to the lack of long-term fire history data
- do not provide any information on other aspects of fire regime that would provide guidance in restoring fire regimes in remnants (season, patchiness, extent, intensity)

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All photos: C. Gosper. Fire age polygons kindly provided by DEC Fire Management Services.

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Thank you

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