The role of fire in plant conservation in fragmented wheatbelt reserves

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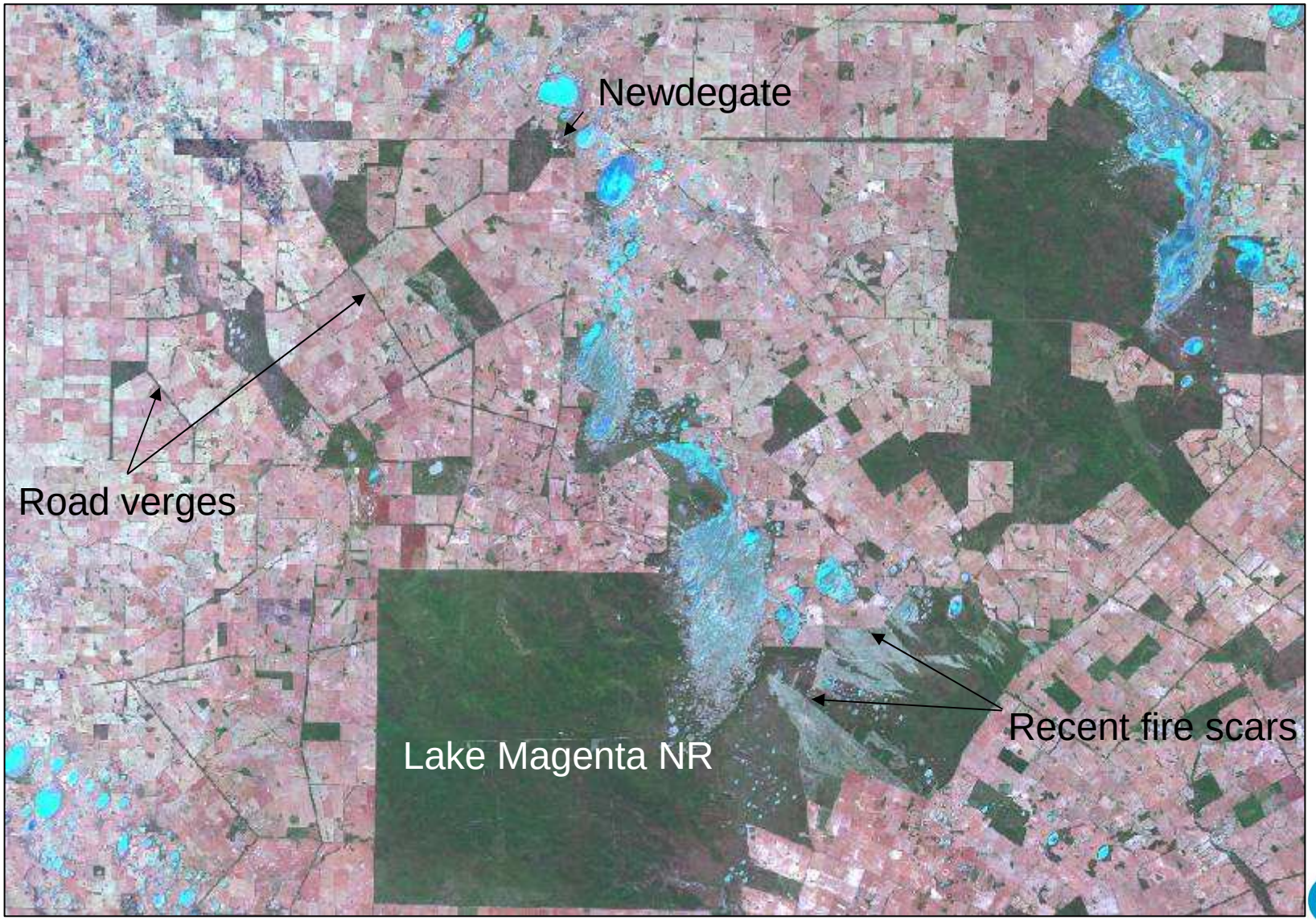
SW WA: a global biodiversity hotspot

- Southwest Australian Floristic Region
  - 1 of 25 global biodiversity hot spots
  - Only global hot spot in Australia
  - 7000 + taxa of vascular plants
  - ~ 50% endemic to floristic region
  - Fire-prone landscape
  - 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: a fragmented and threatened landscape

- The degree of fragmentation
  - ~10.8% extant native vegetation cover in SW Floristic Region biodiversity hotspot
  - Native vegetation cover in IBRA regions of the wheatbelt: Avon-Wheatbelt 14.6%, Mallee 54%
  - As little as 2-3% cover in some districts
- Fragmentation effects on flora
  - Smaller plant population sizes
  - Reduced gene flow (through loss of connectivity and dispersal agents)
  - Altered disturbance regimes
  - Increased edge effects (*e.g.* nutrient enrichment)
  - Altered hydrological processes

The WA wheatbelt: a fragmented landscape



Life on the edge of wheatbelt nature reserves

Fire-related processes affecting plant conservation in remnant vegetation:

- Inappropriate fire regimes
  - Altered frequency, season, extent or intensity of fires
  - Different sources of fire ignition
  - Loss of connectivity (for passage of fire)
- Fire mitigation methods
  - Fire exclusion and suppression
  - Scrub rolling
- Weed invasion

Inappropriate fire regimes - 1

Conservation risks of lower fire frequency

- Lack of recruitment opportunities
  - Period between fires may exceed plant and seed longevity
  - Adult plants senesce
  - Seeds released or seed viability declines with time
  - Obligate seeders (especially serotinous species) and some sprouters affected
- Ecologically dysfunctional abundance of fire-sensitive plant species
  - Competitively exclude other species

Inappropriate fire regimes - 2

Conservation risks of higher fire frequency

- Lack of opportunities for reproduction and recruitment
  - Period between fires may be less than that required for a plant to mature and produce seed or the capacity to sprout
  - Depletion of seed bank over time
  - Obligate seeders (especially serotinous species) and some sprouters affected
- Significant issue for fire refugia
  - *E.g.* granite outcrops

Plant functional types

Conceptual framework

Grouping plant species by their response to fire:

- Means of persistence through fire: sprouting or seed
- Means of seed survival (in soil or on plant)
- Plant longevity and growth form

Sprouters

- Characteristics
  - Many adult plant survive fire
  - Resprout from above or below-ground organs
  - Less dependent on recruitment after fire, so often less vulnerable to changes in fire regimes in the short term
  - May have canopy-stored (serotinous) or soil-stored seed
- Examples
  - Mallee *Eucalyptus*, *Xanthorrhoea,* many *Banksia* ser. *Dryandra*

Obligate seeders

- Characteristics
  - Adult plants killed by fire
  - Recruit from seeds stored on the plant (serotinous) or in the soil
  - Dependent on recruitment after fire for persistence at the site, so often immediately vulnerable to changes in fire regimes
- Examples
  - Many *Banksia* and *Hakea*, mallet *Eucalyptus* (serotinous)
  - Many *Acacia, Grevillea* and peas (soil seed bank)

Post-fire ephemerals

- Characteristics
  - Adult plants killed by fire
  - Recruit from seeds stored in the soil
  - Adults are short-lived, growing and reproducing rapidly after fire
  - Long-lived seed banks; less vulnerable to short-term changes in fire regimes
- Examples
  - *Gyrostemon* and *Tripterococcus*
  - Many *Goodenia,* daisies and grasses

Key research questions

1. What are the upper and lower limits of temporal variability in fire regimes needed to maintain plant community diversity? How does plant composition and vegetation structure change over time after fire?

2. How do current methods to manage fire risk affect plants?

3. Does fire facilitate exotic grass invasions?

Study system: Mallee and mallee-heath communities in the Newdegate area

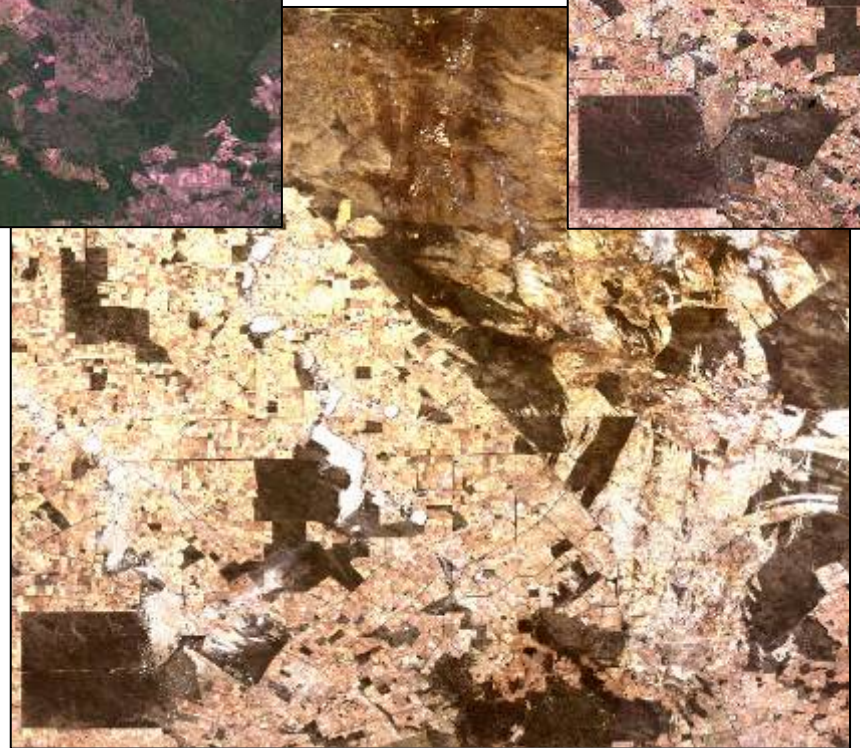
Fire regimes

- Remnants in the wheatbelt appear to be experiencing different fire regimes from uncleared portions of the landscape
- Unknown consequences for flora susceptible to fire-related decline
- Uncertainty as to what constitutes an appropriate fire regime for flora conservation

Fragments get fewer and smaller fires

1980

2000



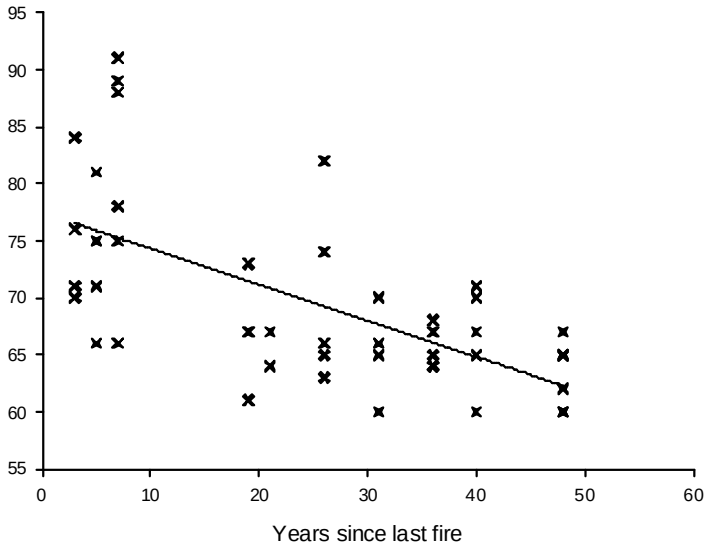
2004

How do fire regimes affect plant communities

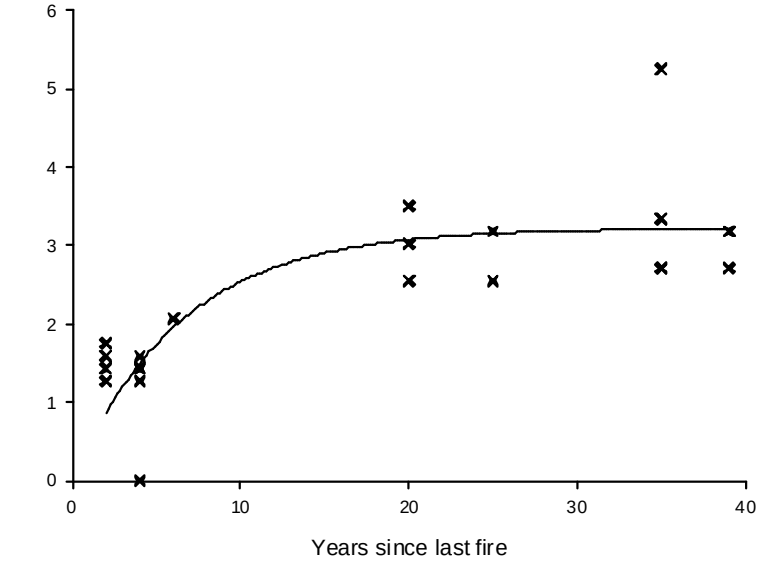
- Study region stratified by time since last fire
- 8 fire ages
- 5 floristic plots per age

Community changes with time since fire

- Steady decline in above-ground species richness
- Steady increase in structural components



$y = 77.5 – 0.3x$; $r^2 = 0.42$; $F = 33.7$, $P < 0.0001$



$y = 3.219(1-e-0.155x)$; $r^2 = 0.64$; $F = 39.1$, $P < 0.0001$

Fire mitigation methods - Scrub rolling

- How?
  - Strip of vegetation 40-100m in width chained
  - Chained vegetation then burnt
  - Fires conducted under moderate weather conditions and planned to extinguish a short distance into adjoining vegetation

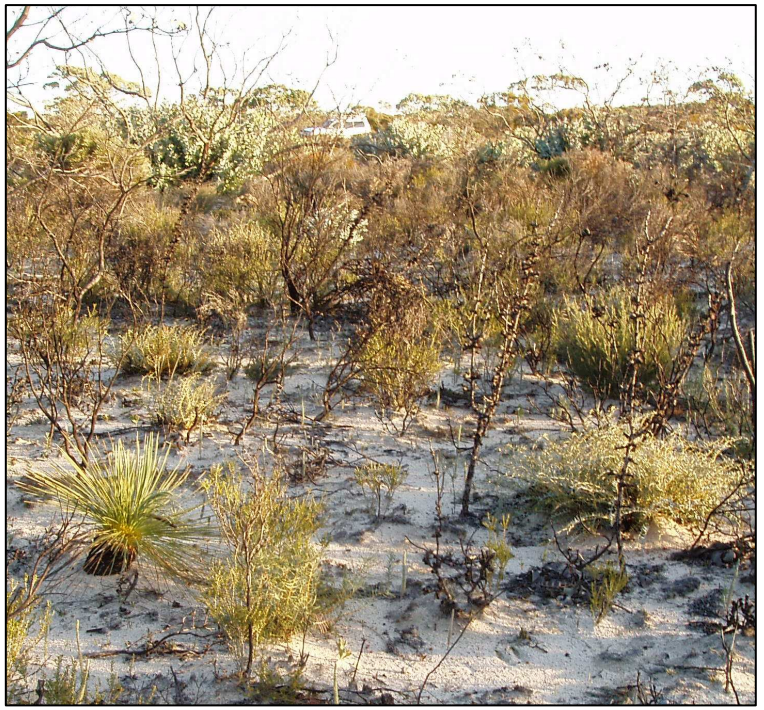
- Why?
  - Used as a planned fuel reduction buffer strip
  - Minimise the risk of unplanned wildfires
  - Vegetation burns more completely
  - Lower flame heights render fire easier to control

- Where?
  - Usually along remnant boundaries or internal access tracks
  - Blocks of vegetation > 5000 ha in size in eastern Wheatbelt
  - ~ 1000 ha of vegetation affected in study area since 2001

Scrub rolling

- How might scrub rolling affect plants?
  - Combines two disturbance events know to cause plant mortality and stimulate recruitment
  - Potentially different impacts on plants with different fire responses

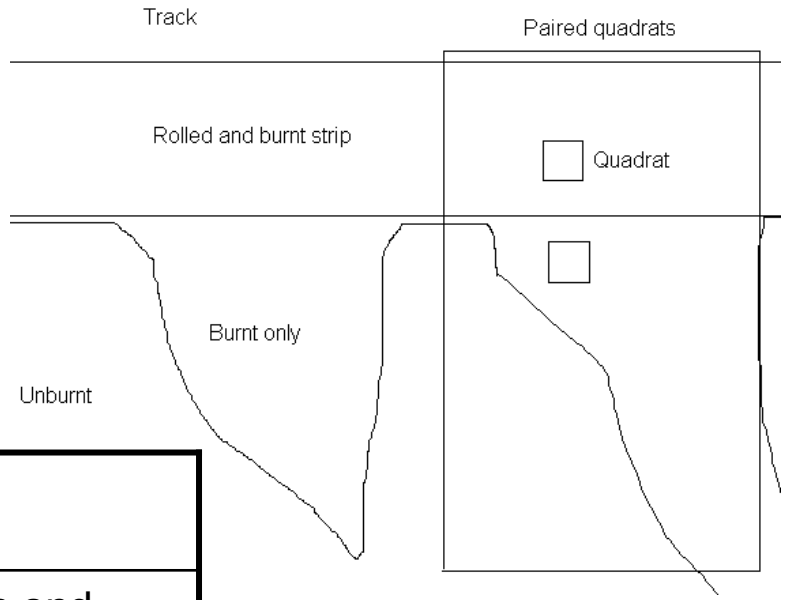
Rolled and burnt



Burnt only

Scrub rolling – study methods

- Methods
  - Paired 10 by 10 m quadrats
  - Number of recruiting or resprouting individuals counted
- Study species



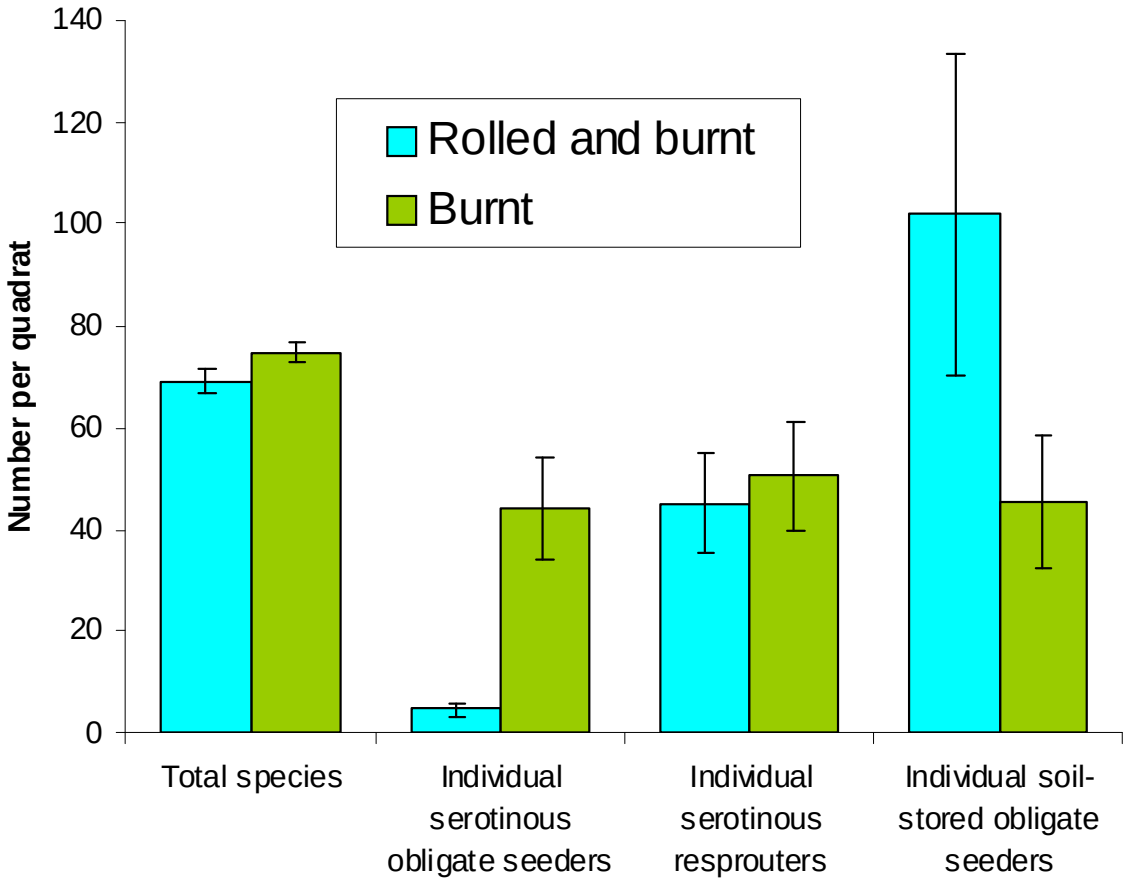
Plant functional type	Study genera
Serotinous obligate seeders	*Banksia* ser. *Dryandra* and *Hakea*
Serotinous sprouters	*Banksia* ser. *Dryandra* and *Hakea*
Obligate seeders with soil-stored seed bank	*Acacia, Grevillea, Gastrolobium and Daviesia*

Scrub rolling – impacts

Results

Rolled and burnt strips have:

- Fewer total plant species
- Fewer recruits of serotinous, obligate seeders
- Similar numbers of resprouting individuals
- More recruits of obligate seeders with soil-stored seed banks



Scrub rolling impacts

- Why?
- Serotinous obligate seeders vulnerable due to seed release between rolling and burning
- Hotter fire stimulating release from dormancy in more soil-stored seed?

Weed invasion

Key research questions:

Does fire enhance weed invasions?

- Increased light, nutrients, water, germination stimuli?

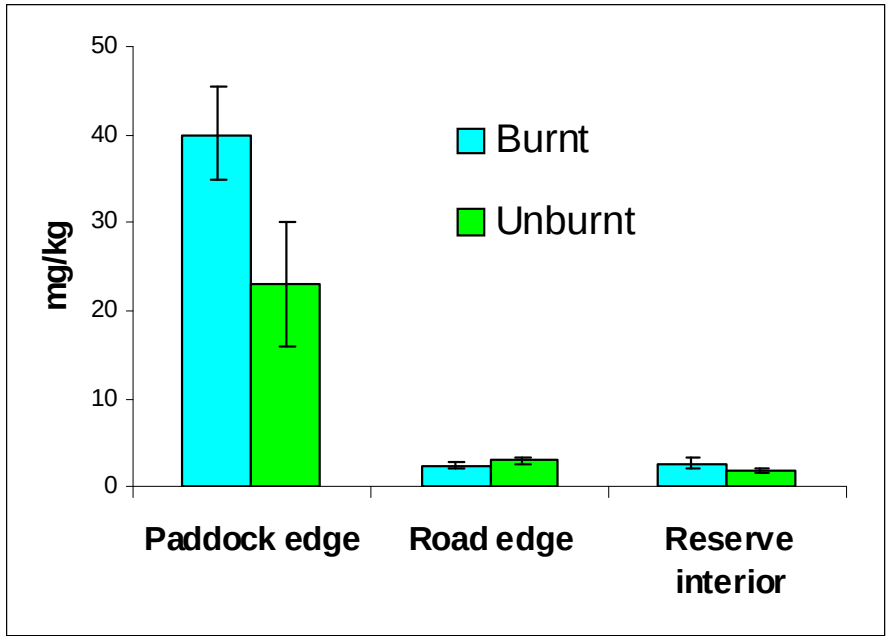
Why do some edges have greater weed invasion post-fire?

- Soil nutrients (fertiliser enrichment)?
- Greater source of weed propagules (paddock management, methods of seed dispersal)?
- Greater vegetation disturbance before and/or after burning (native and stock herbivores, vehicles)?
- Vegetation type burnt?

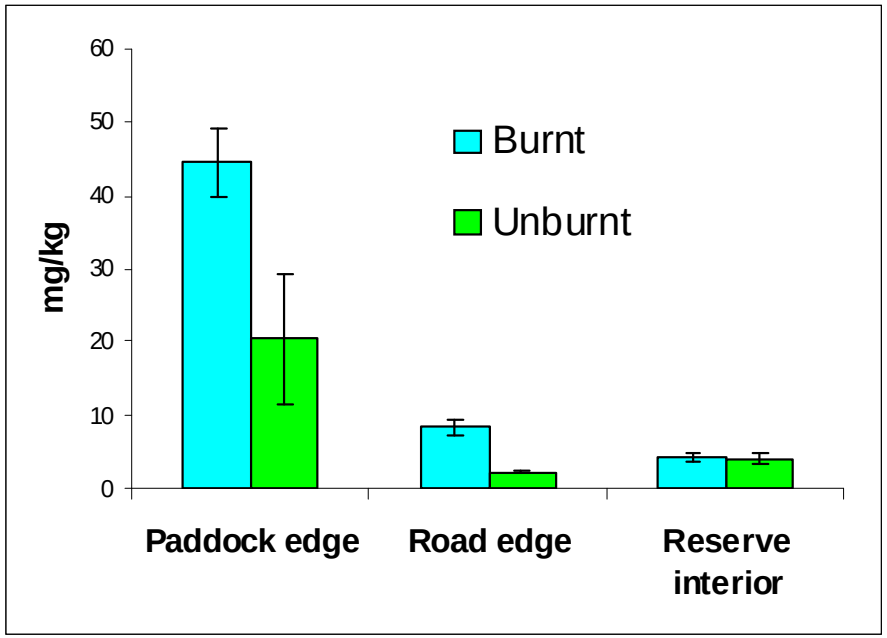
Soil properties

- Both fire and landscape context affect soil nutrient status

Phosphorus



Ammonium



Conclusion

- Appropriate fire management is essential for conservation
  - Remnants in the wheatbelt appear to be experiencing different fire regimes from uncleared portions of the landscape
  - Unknown consequences for flora susceptible to fire-related decline
- Edges of remnants are especially prone to fire-related degradation
  - Fire management methods consisting of two temporally separated disturbance events adversely affects some species
  - Changed soil nutrient status
  - Weed invasion after fire?
  - Breakdown of effective edge vegetation (*e.g.* spray drift, mechanical damage, erosion and nutrient enrichment) may lead to increased penetration of disturbance effects into remnants

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

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