THE UNIVERSITY of ADELAIDE

LECTURE 1: FIRE AS AN ECOLOGICAL FACTOR

Ecological Issues 1

Dr John G Conran

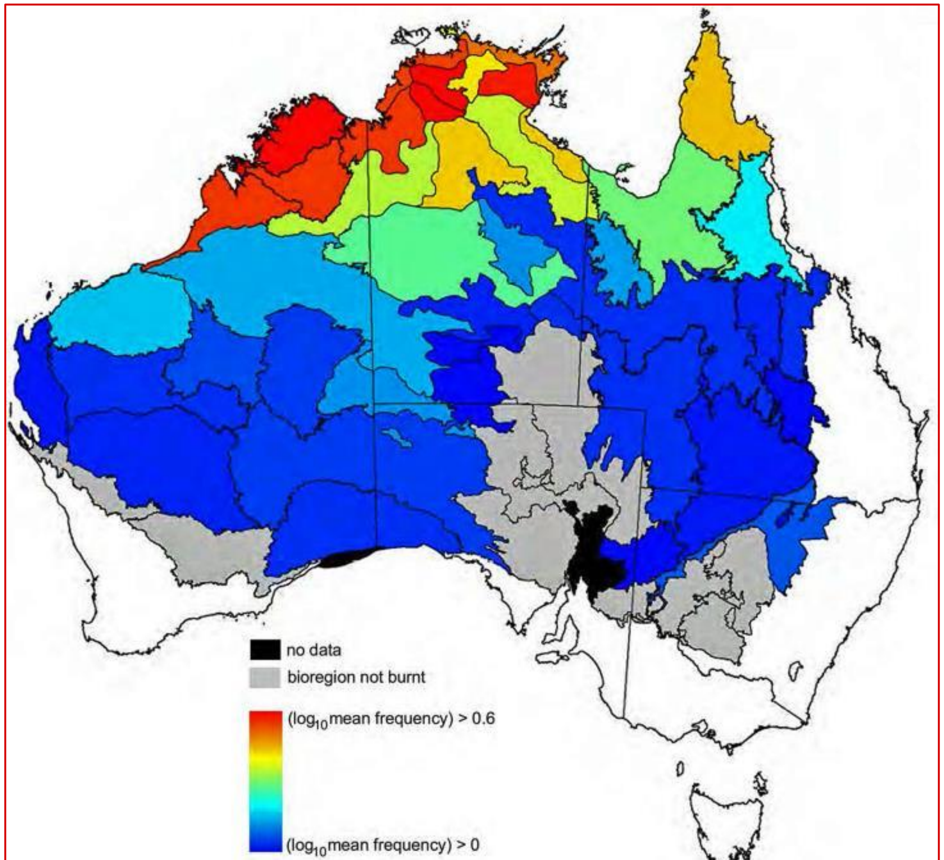
Room 109 Benham Building

john.conran@adelaide.edu.au

Fire as an ecological factor

- Fire is an essential part of the Australian landscape
- Major evolutionary driving force
- Important for millions of years; long before the arrival of humans
- However, we have altered the nature and frequency of fires in natural systems

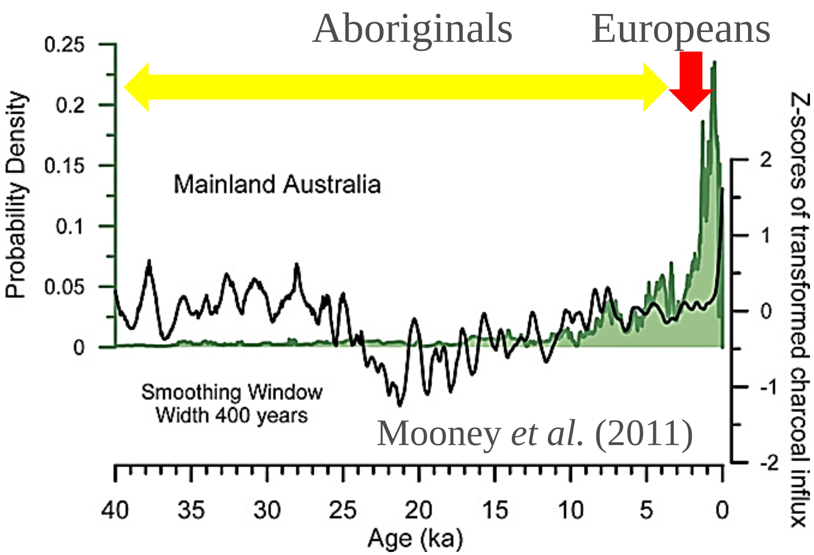
Fire management

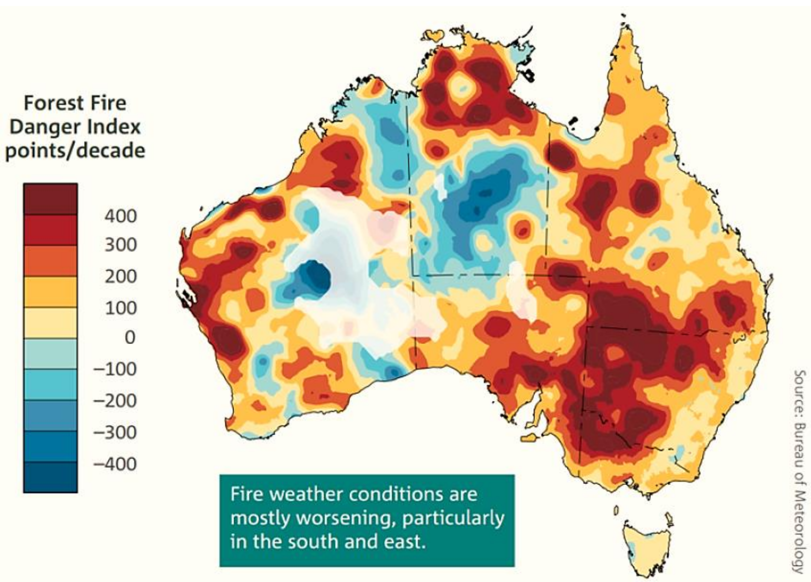


Morton *et al.* (2011)

- Some places try to exclude fire in nature reserves for management and/or political reasons
  - cause build up of materials with time
  - fire is more severe when it finally happens
- Elsewhere, high fire frequency
  - NT burning annually to encourage grasses and remove forest cover
- Other places burn at regular intervals to reduce fuel for long-term fire risk management.

Fire frequency

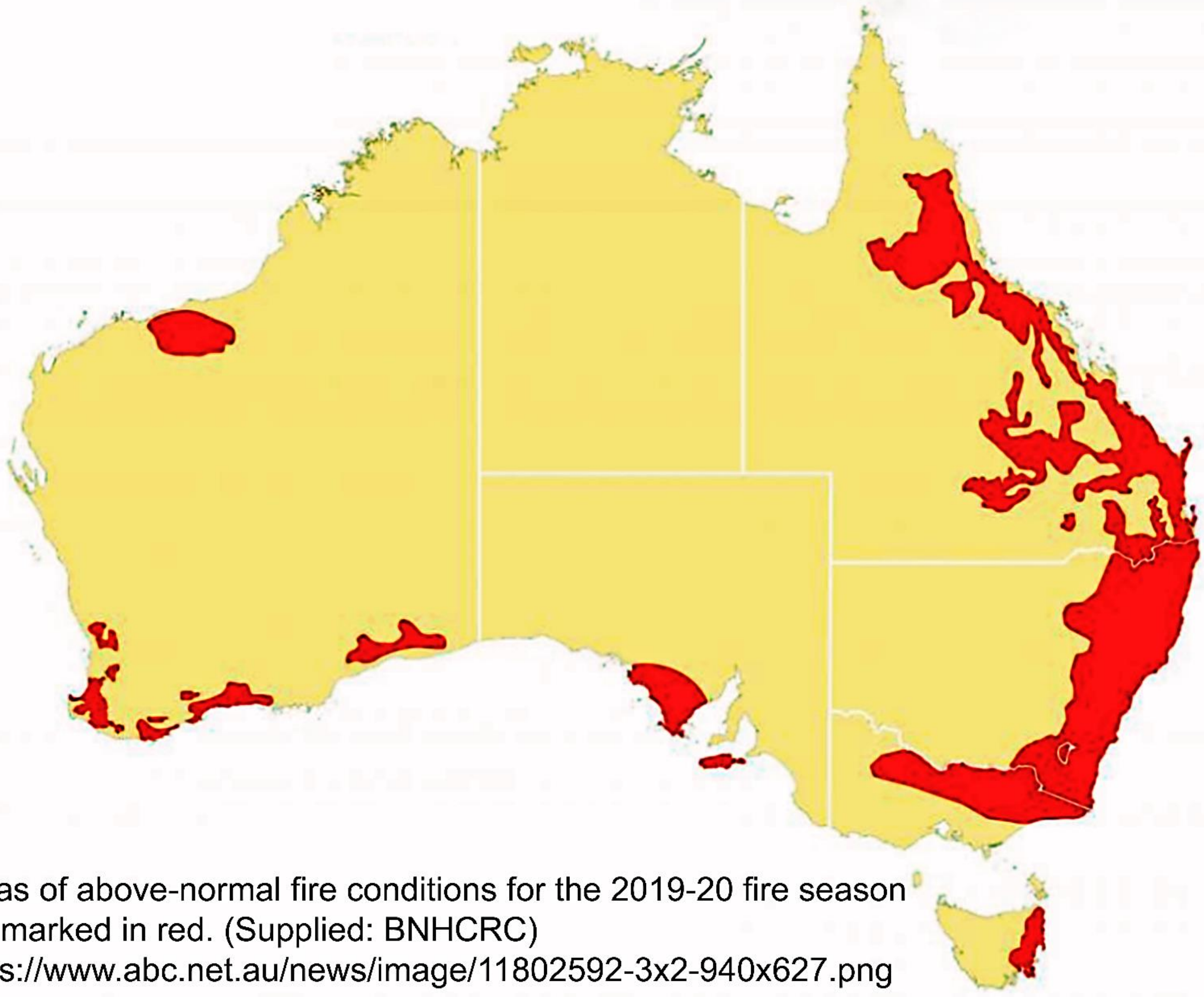




BoM (2018): Forest Fire Danger Index, 1978–2017.
Red and yellow = longer and worse fire seasons

- No evidence for long-term human-induced Aust fire régimes (Mooney *et al.* 2011)
- Humans did NOT cause the fire-adapted flora, but HAVE changed vegetation patterns
- Since European settlement, fire frequency and intensity has increased dramatically (Bradstock *et al.* 2002)
- With ongoing climate change, fire danger, frequency and intensity are increasing

The new reality...

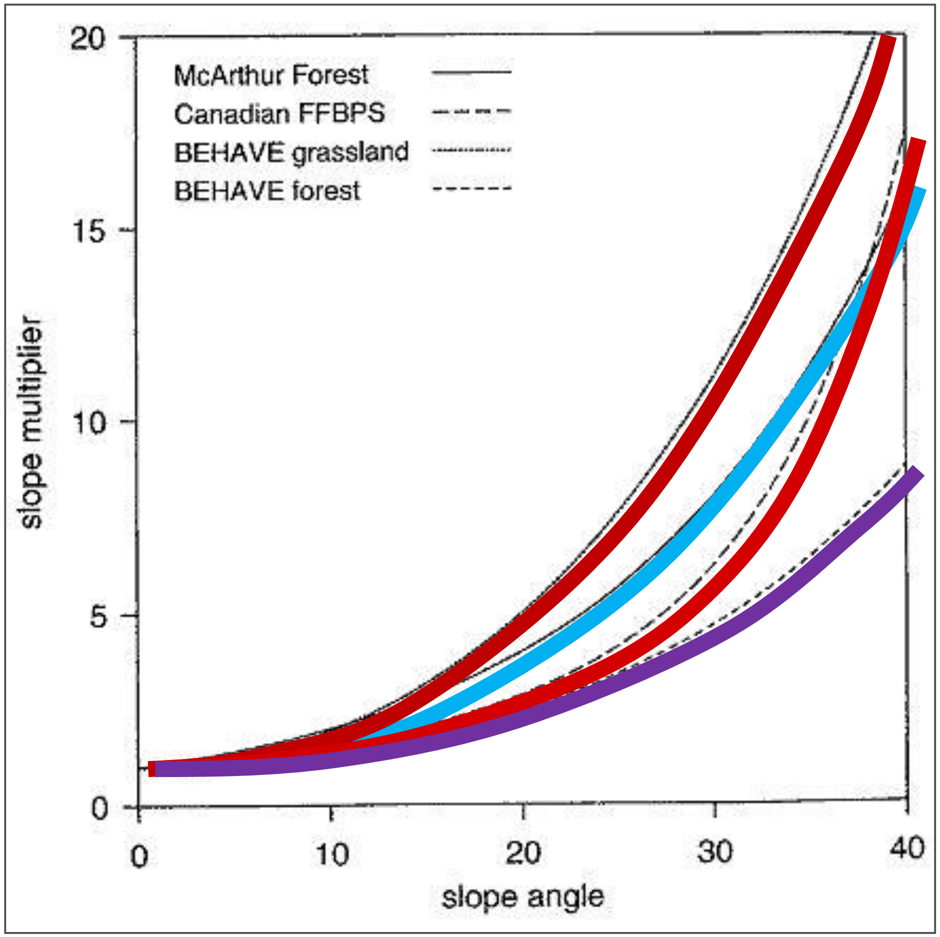


Areas of above-normal fire conditions for the 2019-20 fire season are marked in red. (Supplied: BNHCRC)
https://www.abc.net.au/news/image/11802592-3x2-940x627.png

Fire intensity

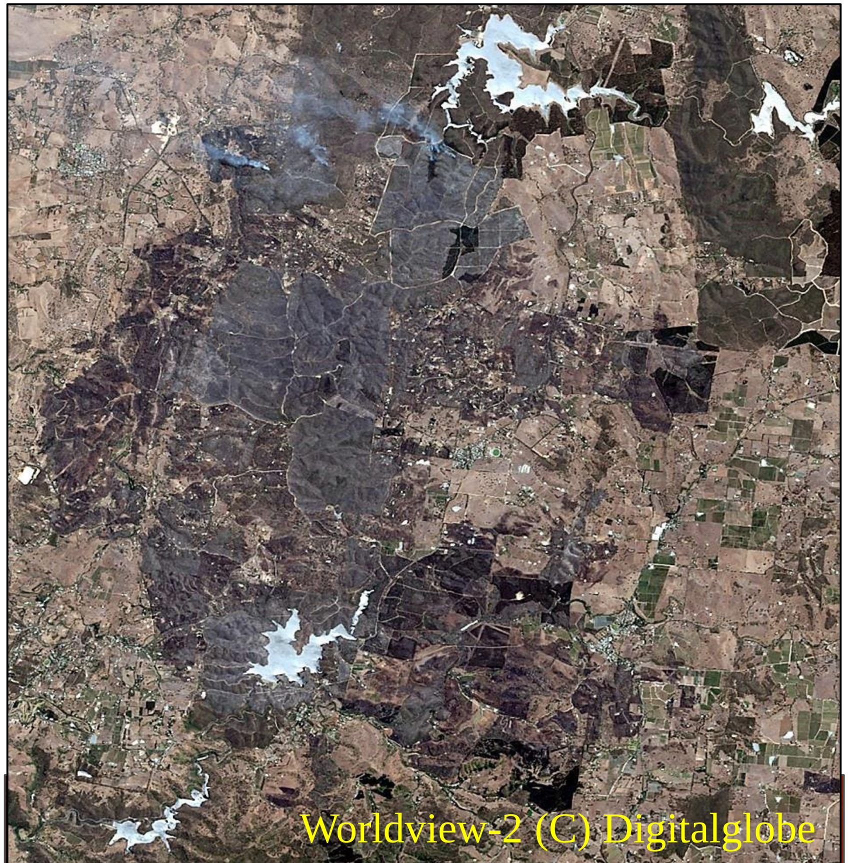
- depends on amount of fuel
- moisture content
- arrangement
- wind speed
- weather (temp and humidity)
- topography and atmospheric conditions

Fire exclusion



Modifed from Bradstock *et al.* (2002)

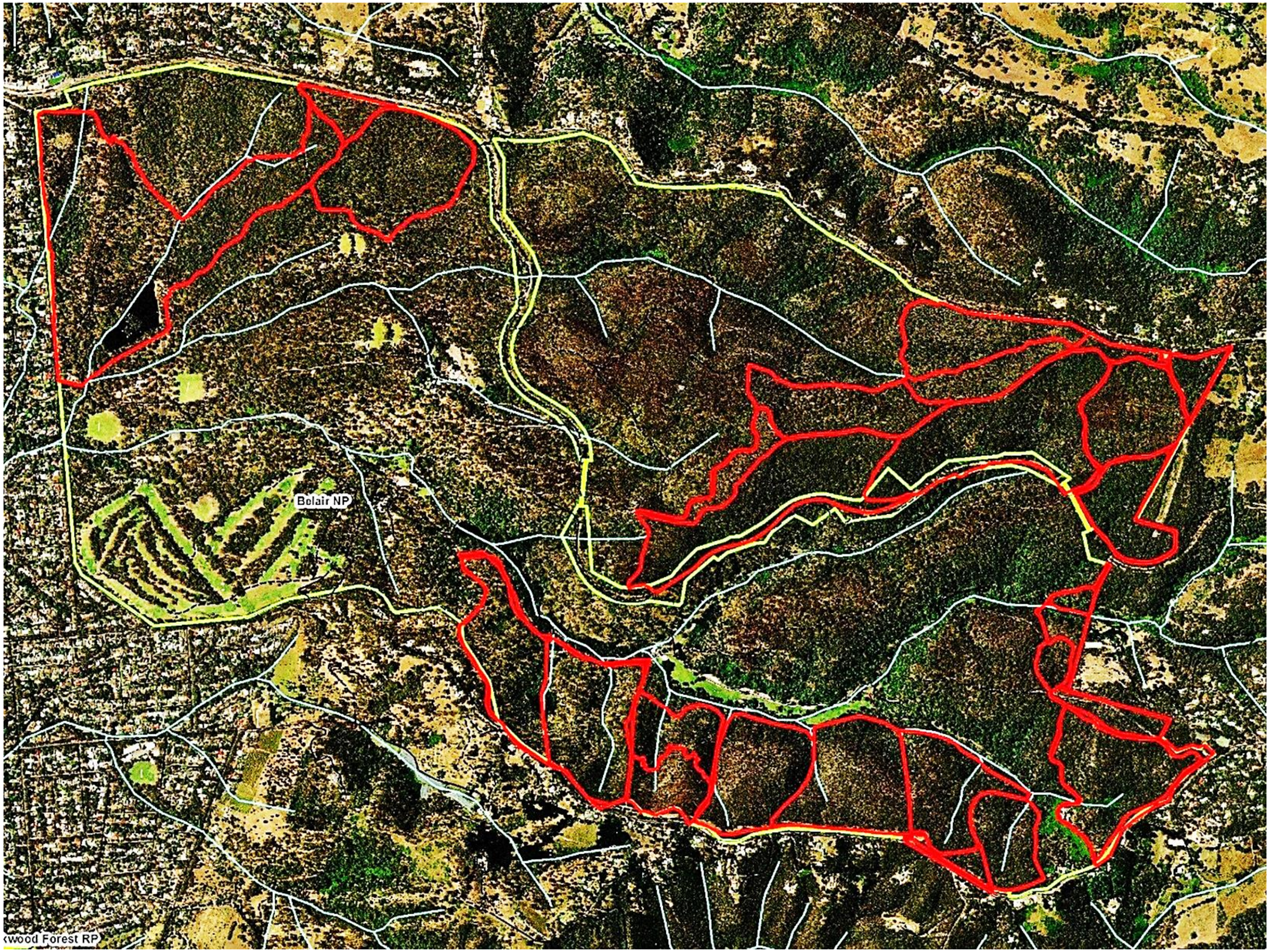
- Build-up of lots of dry matter in most forests
- Dry conditions means there is little decay
- Fuel is easier to burn
- In an open forest, can be ~20,000 kg$^{\text{ha-1}}$ of litter
- Material off the ground burns faster and better (bark, branches etc..) – creates a canopy fire
- Hot, dry, windy weather intensifies fires, as do steep slopes (chimney effect)



Exclusion can lead to catastrophe

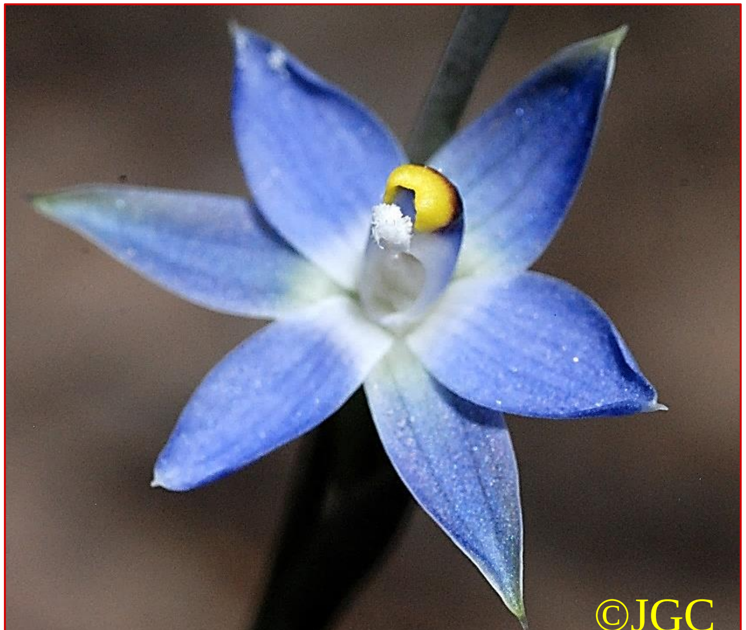
- Exclude fire for too long and the system becomes dangerously flammable
- Too much fuel means entire regions can burn – Vic. & SA (Ash Wed. 1983), ACT (Aust. Day 2006); SA Sampson Flat (Jan 2015)
- Catch-22: we want the forests, but don't want the fires they need to survive
- No easy resolution between ecology and politics

Prescribed burning: how often, how much?



Prescribed burning map, Belair NP (Sheath 2015)

When to burn?

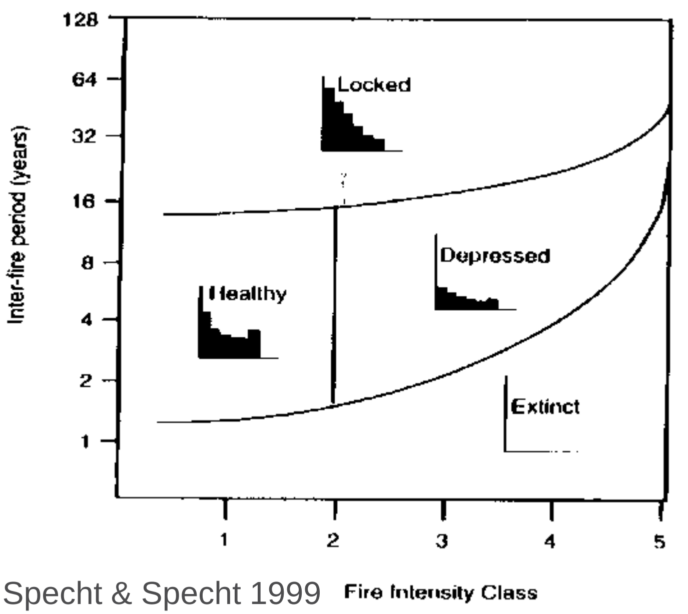


- Orchids in Vic. decreased by up to 100% after autumn and winter burns, *but not spring and summer burns*.
- Plant height, leaf and flower size also all decreased
- Prescribed burning during active growth damaged both the orchids and their assoc. mycorrhizal fungi
- The least damaging *practical* time for burning was late spring, after seed dispersal (Jasinge *et al*. 2018)

Traditional practice

- NT aborigines have strict rules about burning off: when, where, how
- No fire should, go for more than 1 day: too hard to control
- Mosaic burning: whole area burnt through the season, but in patches
- Animals have places to move to for shelter and food
- ‘Fire-stick’ farming

Long-term fire exclusion



Specht & Specht 1999

- Causes fire-requiring or successional stage species to disappear
- Causes fire-intolerant species to dominate
- e.g. *Callitris* (native desert pine) seedlings are fire sensitive, but the adults tend to survive fires
- Once in, they can overtake the system unless excluded by fire when young
- Few and/or weak fires = *Callitris* becomes dominant
- Frequent and/or intense fires = no *Callitris*

Fires recycle nutrients

- Essential to release nutrients trapped in standing biomass: e.g. P, K, and micronutrients like Mn and Mo.
- However, some critical nutrients like N&S lost as the heat volatalises them
- Many seeds use the gaseous nitrates from the fires as germination triggers
- Smoke, not the fire causes germination of many Aust native plants (whereas many spp seeds killed by high temperatures)

(CC) http://allthingsplants.com/plants/photo/73597/

https://c1.staticflickr.com/5/4130/4950544121_8ec75142f2_b.jpg (CC)

Legume nodules

- Fire depletes soil nitrogen
- Early colonisers often legumes or other N_2 fixers
- Convert N_2 to NO_{3-}
- Help to replenish N in the burnt soil
- Used by other plants in the ecosystem as well, so community as a whole benefits
- Succession can proceed as soil fertility changes

Recovery

- First re-colonisers are often N-fixing species.
- Fire not only recycles nutrients, but removes many seed predators
- Opens the canopy for light
- Clears the ground of litter
- Reduces soil pathogens
- All types of strategy (avoid and tolerate) require fire to be infrequent enough to allow them to flower and reseed between burns

Spinifex desert *post* fire

Plate 1. Spinifex (*Triodia pungens*) sandplain south of Alice Springs, recently burnt (Peter Latz/CCNT) Latz (1995)

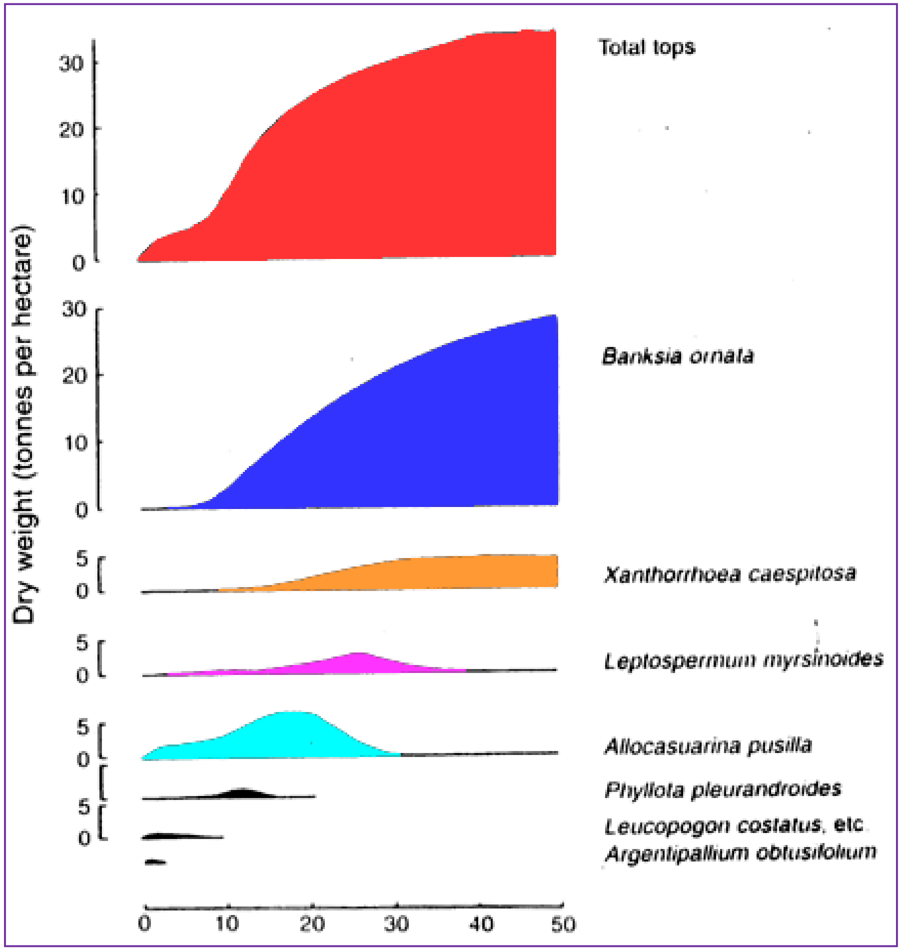
Plate 2. Same area, six months after the fire (Peter Latz/CCNT) Latz (1995)

Plate 3. Same area, two years after the fire (Peter Latz/CCNT) Latz (1995)

Plate 4. Same area, eight years after the fire (Peter Latz/CCNT) Latz (1995)

- Even desert areas are fire-adapted
- Recovery is quick after rain
- Species change rapidly over just a few years
- Habitat for native animals is fire-age dependant
- Vegetation provides shelter and food

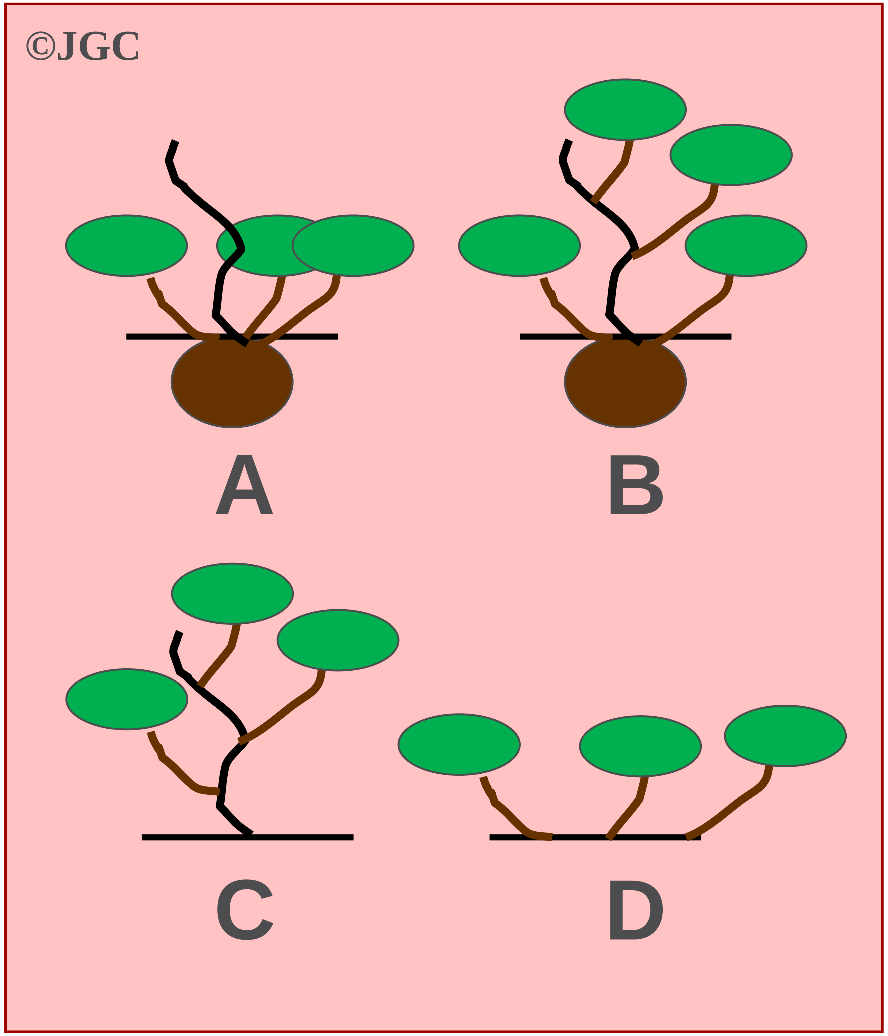
SE Sth Aust fire recovery



Specht & Specht (1999)

- Different species recover and dominate at different rates
- Succession to gradual domination by long-lived shrubs
- System responds over a ~50-year cycle
- Exclude fire beyond this and tends to be replaced or shrubland begins to die off
- Fire essential for seedling regeneration

Recovery strategies



A. Subterranean resprouter (e.g. geophytes, lignotubers, rhizomes)
B. Combination aerial stem and subterranean
C. Aerial stem resprouter (epicormic growth)
D. Obligate reseeder (parent killed by fire)

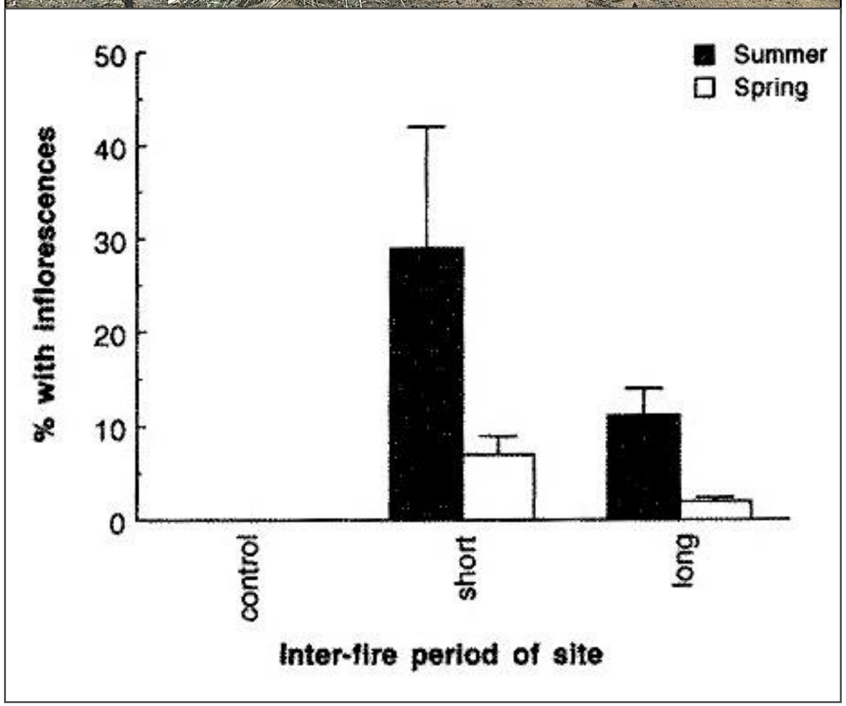
Avoid or tolerate?

- Avoiders include geophytes (plants with underground tubers, rhizomes etc..)
- e.g. many orchids and 'lilies'
- Die down in the dry season and resprout in the wet
- Probably evolved originally for drought avoidance
- Fire more common in dry seasons
- Enable plants to survive fire
- Gases in fire can trigger flowering (e.g. ethylene)

Epicormic growth

- Many trees have dormant buds in their bark (epicormic buds) from which they resprout
- Others, like mallees, do so from underground woody rootstocks (lignotubers)
- But, if fire too intense, the trees can be killed

Fire-induced flowering



- e.g. Yakkas (*Xanthorrhoea*)
- Hot summer fire triggers flowering in next spring (but seen as bad for control burning due to risk of fire spreading)
- Cooler spring fires reduce flowering (but seen as better for controlled burning)
- Plants are fire-proof, need fire at right time to flower
- Management dilemma!

Bradstock *et al.* (2002)

Reseeders

- Reseeders die in the fire and come back from seeds in the soil (seedbank) or in the canopy (serotiny).
- Seeds have thick coats to prevent early germination
- The coat may require to be cracked by heat (wattles)
- Or germination may require exposure to nitrates in smoke (e.g. *Anigozanthos*, *Blancoa* and *Macropidia*: Kangaroo Paws)

Reseeders in South Africa

- Many areas dominated by reseeding species e.g. grass-like restiads
- Not just herbs and graminoids though
- Proteaceae (*Protea* and *Leucodendron*) and *Erica* (heath) shrubs and small trees mostly all reseeders (Holmes *et al*. 2000)
- System vulnerable to invasion by fire-tolerant resprouters (e.g. *Hakea*)

Serotiny

- Serotinous plants protect the seed in woody capsules (e.g. eucalypts, banksias and relatives)
- Need the branch to die, and/or the heat of the fire to open the fruit valves for the seeds to be released.
- *Banksia* cones – fire-proof, need high heat to open
- Heat breaks the seal, but seeds not released for several days
- Ash has time to cool or seeds would burn

Evolution of flammability

- Flammability can evolve, but it is an incidental or emergent property of species or ecosystems
- Confers no extra advantage to individual flammable plants
- In contrast, anti-flammability could be both selected for and evolve (Midgley 2013)

Conclusions

- Much of the Australian vegetation was pre-adapted to fire probably as a result of low-nutrient soils and its biology reflects this
- Fire management practices need to account for the consequences of fire frequency, scale, and intensity on plants and animals
- The impact of fire frequency and intensity for the plants and animals of the ecosystem being managed and their biology must be known if biodiversity is to be maintained

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