And now for something completely different ...

Interpreting ecosystem scale fluxes of carbon and water

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Talk outline

1. Ecological processes relevant to flux studies
   - Disturbance regimes and succession
   - Recruitment
2. Case study – tropical savanna flux program
   - Seasonality of carbon and water dynamics
   - Impact of fire on C dynamics
   - Impact of cyclones

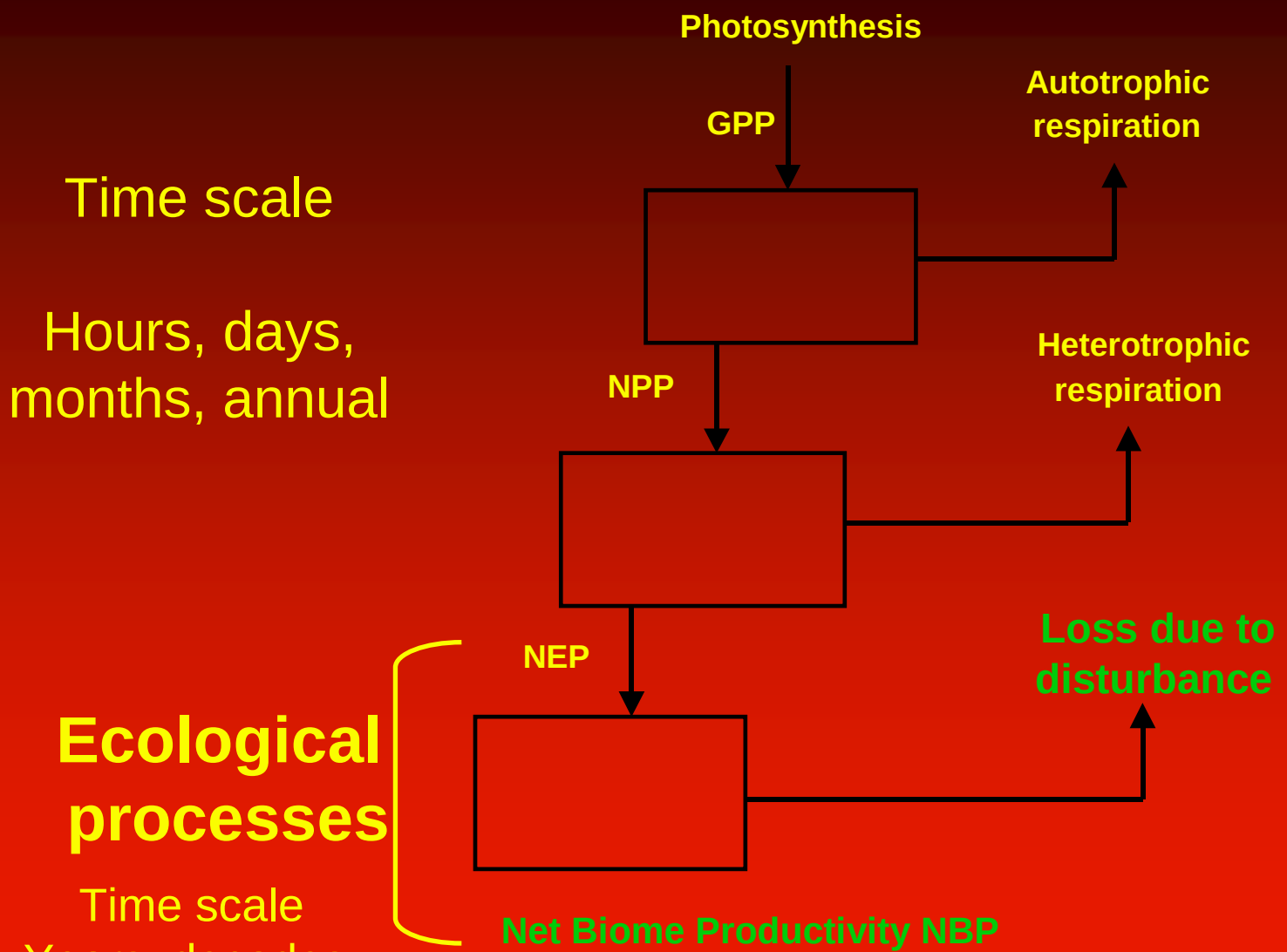
Ecological processes relevant to flux studies

- Flux measures as an ecological tool ?
  - Towers limited spatial and temporal domains
  - ‘Snap-shot’ in time
  - Even decadal flux series may not capture ecological processes

2. Ecological processes relevant to flux studies

- Ecological processes that influence land-atmosphere exchange
  - Disturbance and succession
  - Recruitment
- Influences rates of carbon gain over time
- Understanding site history contributes to our interpretation of functional ecology
- *Understand the past to interpret the present to predict the future*

Terrestrial ecosystem carbon flow

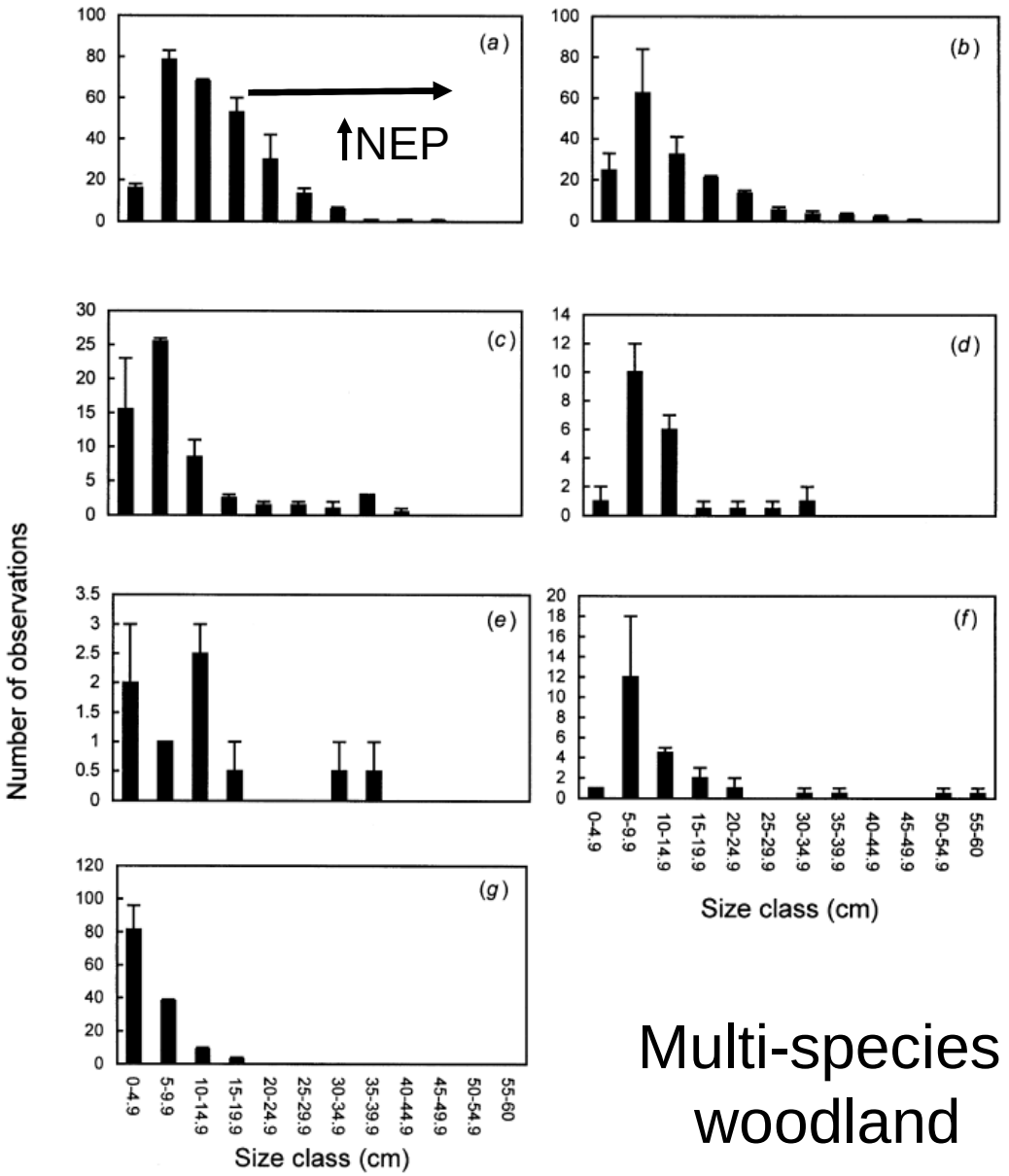


Recruitment

- Recruitment is the process of developing the next generation of organisms
- For vegetation, successful reproduction requires positive carbon balance
- Results in persistence and/or biomass change over time and space
- Recruitment limitations - loss of productivity
- For woody vegetation, assess via size demographics, e.g. size class distributions

Recruitment – size class distribution

- Even-aged stands, bell-curve, j-curve
- Distribution species dependant
- Assess recruitment pulses

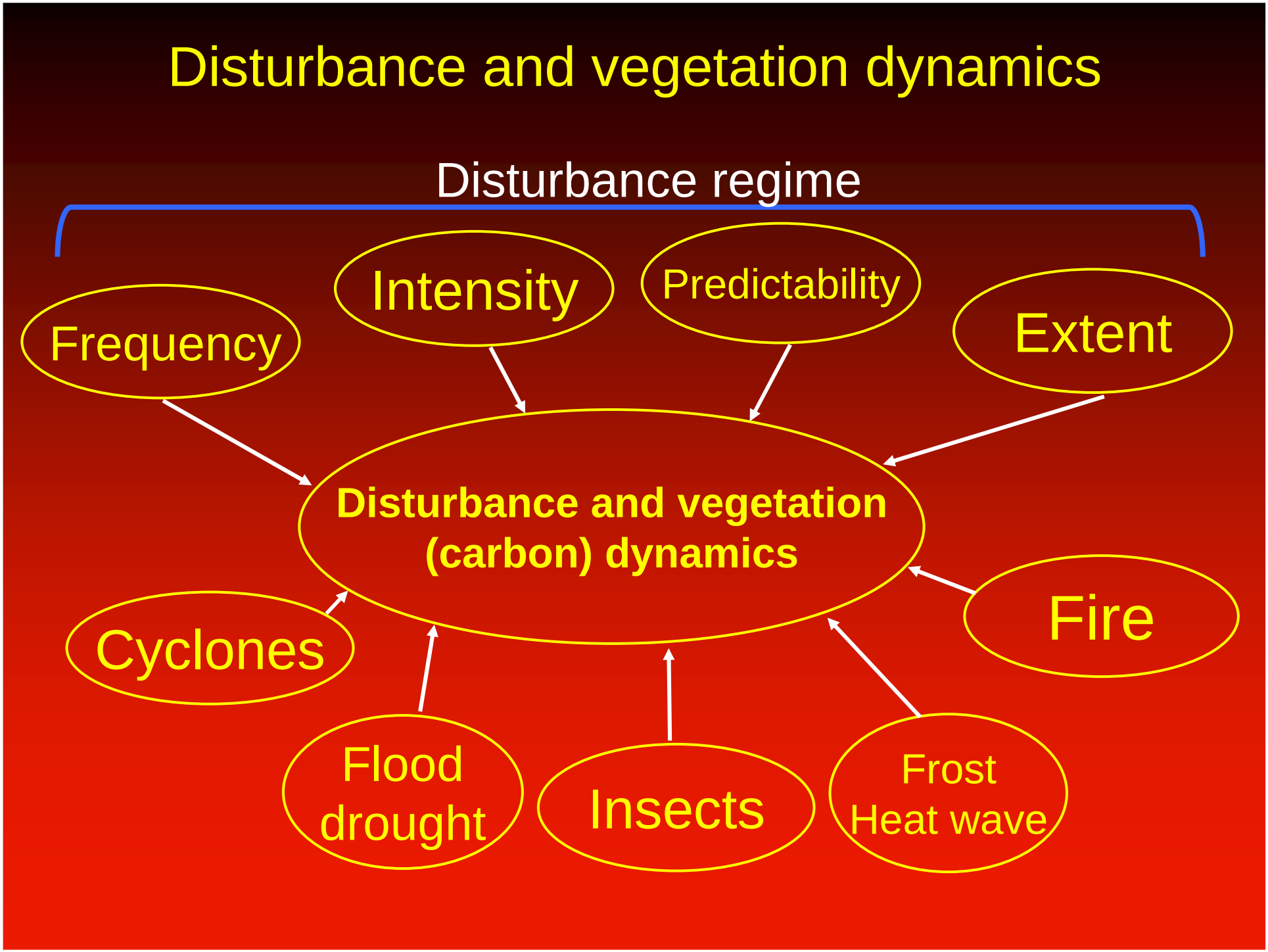


Multi-species woodland

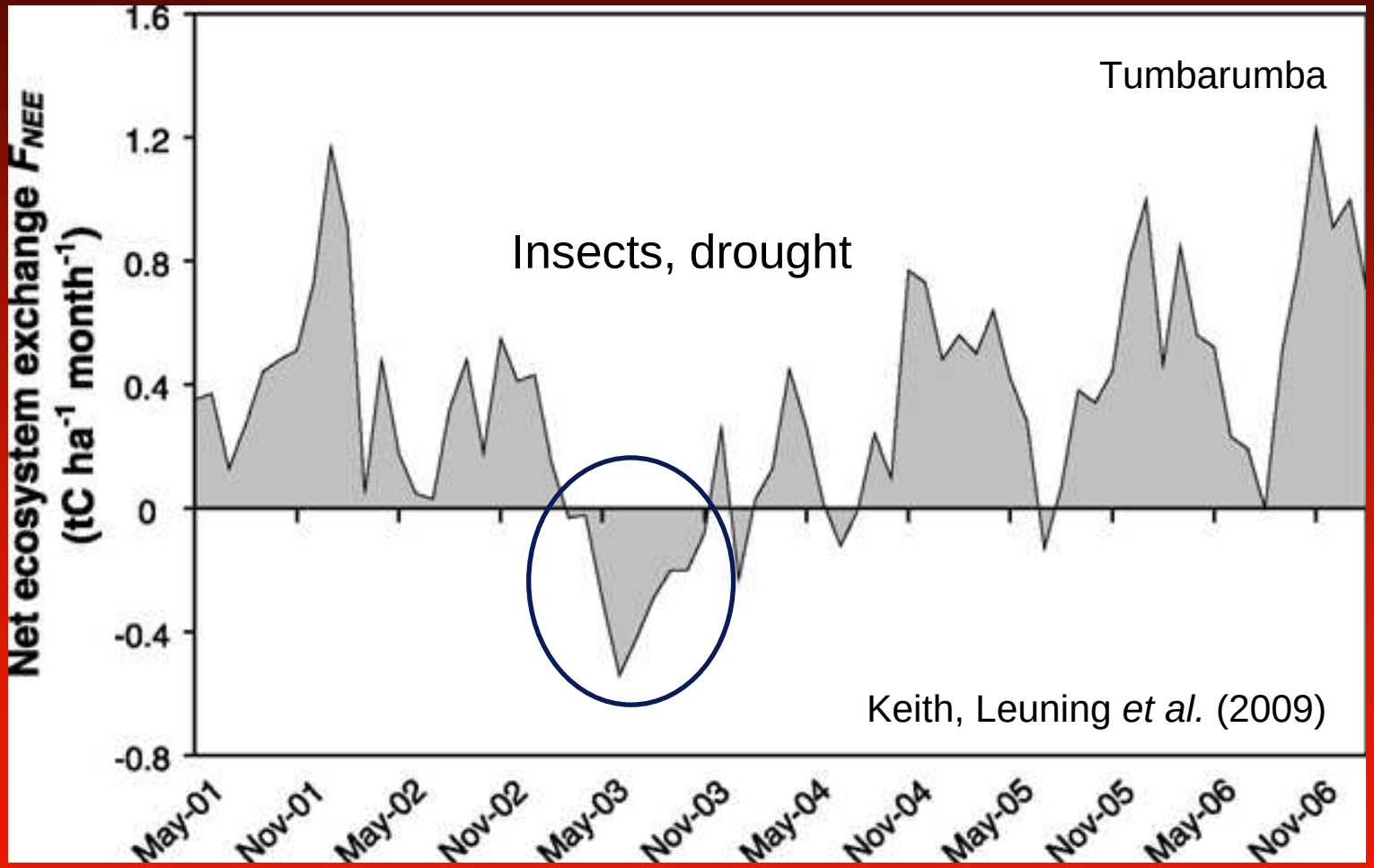
Disturbance and vegetation dynamics

- Disturbance
  - Relatively discrete events that induces widespread mortality of the dominant species within an ecosystem
- Plant and animals adapted to *mean* conditions with a tolerance for a range disturbance types
- Strong selective pressure

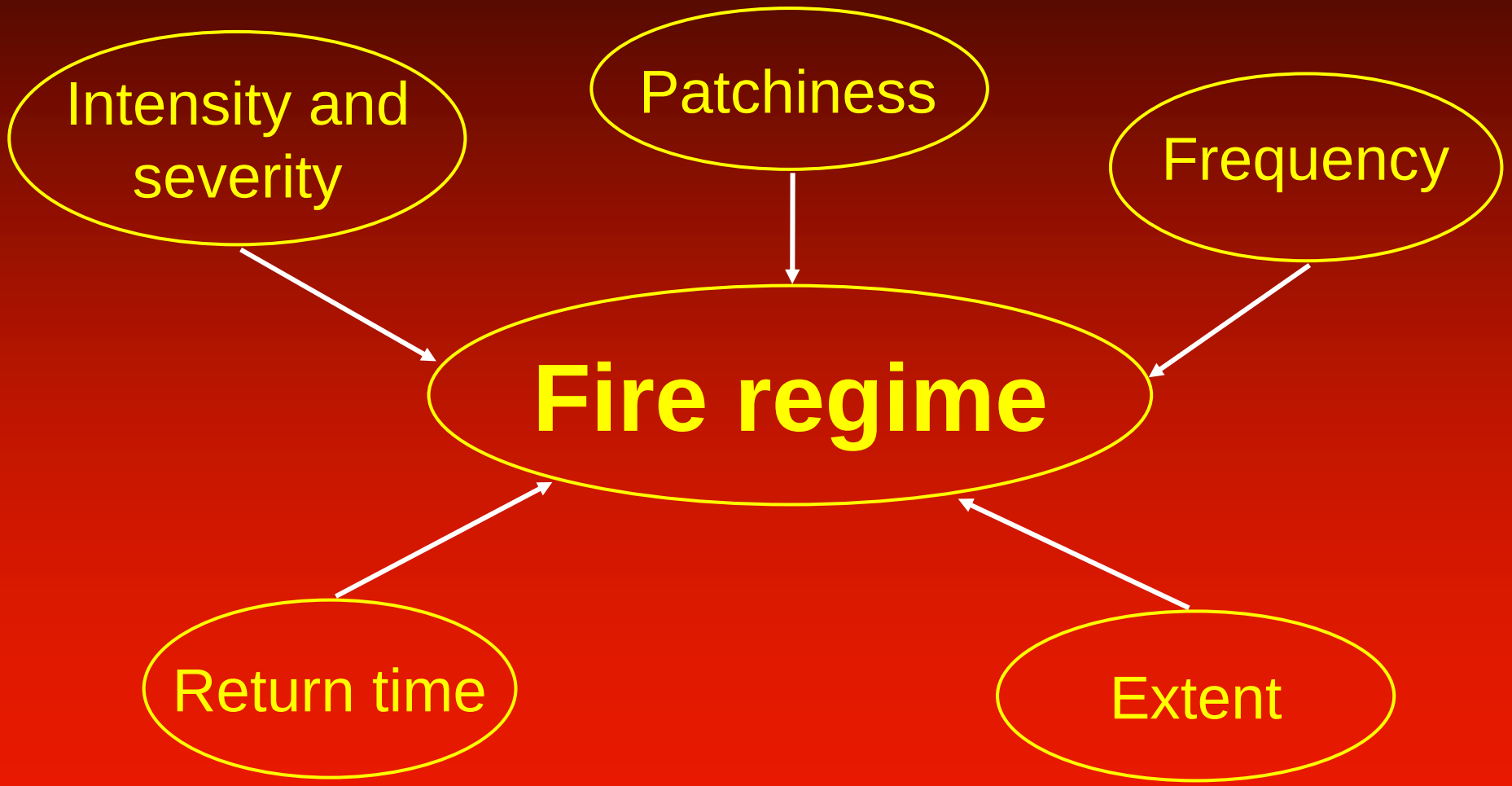
Disturbance and vegetation dynamics



Herbivory and NEP/NEE



Fire – an ecosystem ‘sculptor’



Fire regime – contrasting impacts on vegetation

- Burn ground fuels *and* crown
- High intensity
- Temperate woodlands and forests

Crown fires

Fire impacts

Photos courtesy Darren H, Monash U

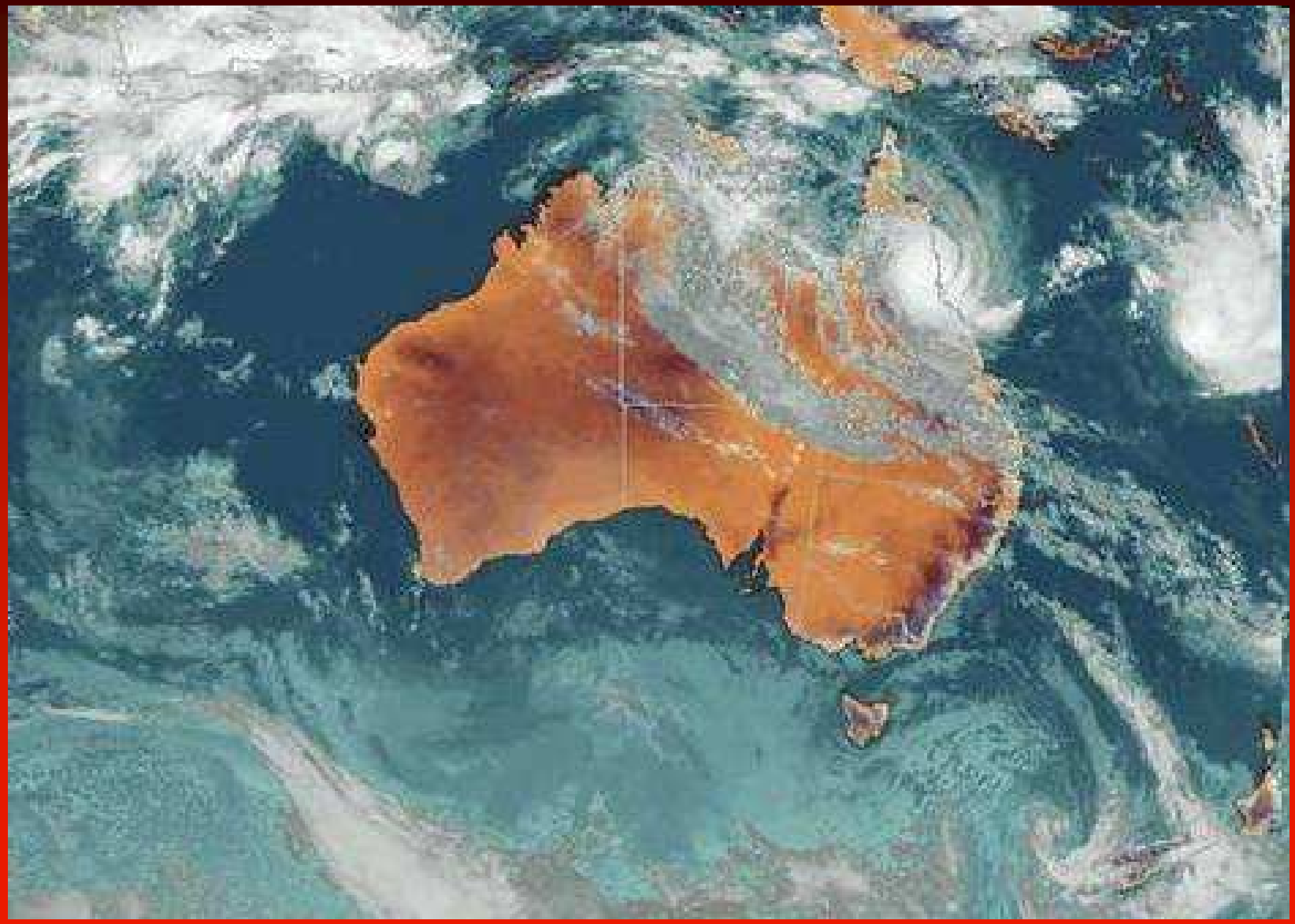
Fire regime – contrasting impacts


Post-fire regeneration
Mountain Ash forest (*E. regnans*)
Kinglake NP, Victoria

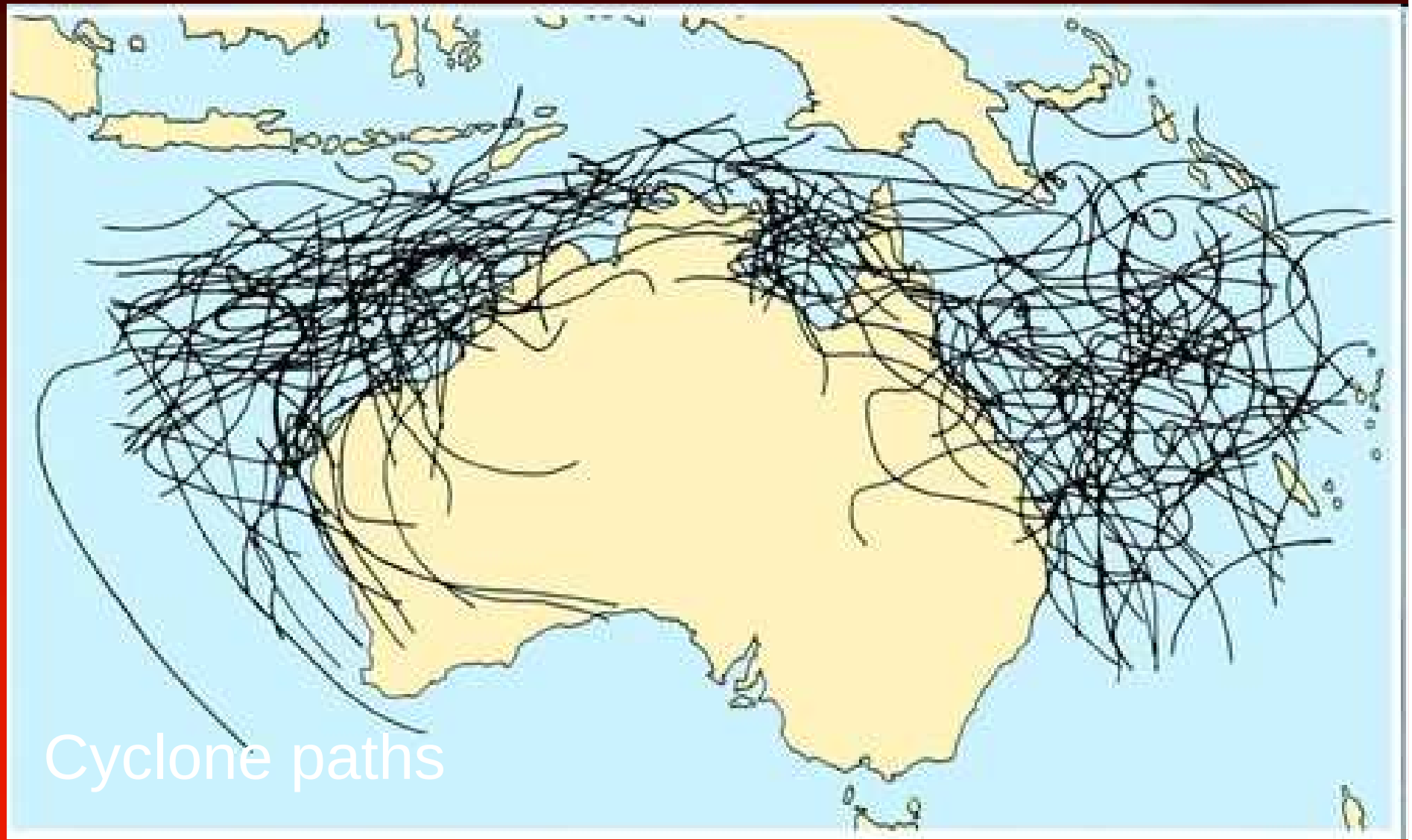
Fire regimes – contrasting impacts on vegetation

Fire regimes – contrasting impacts

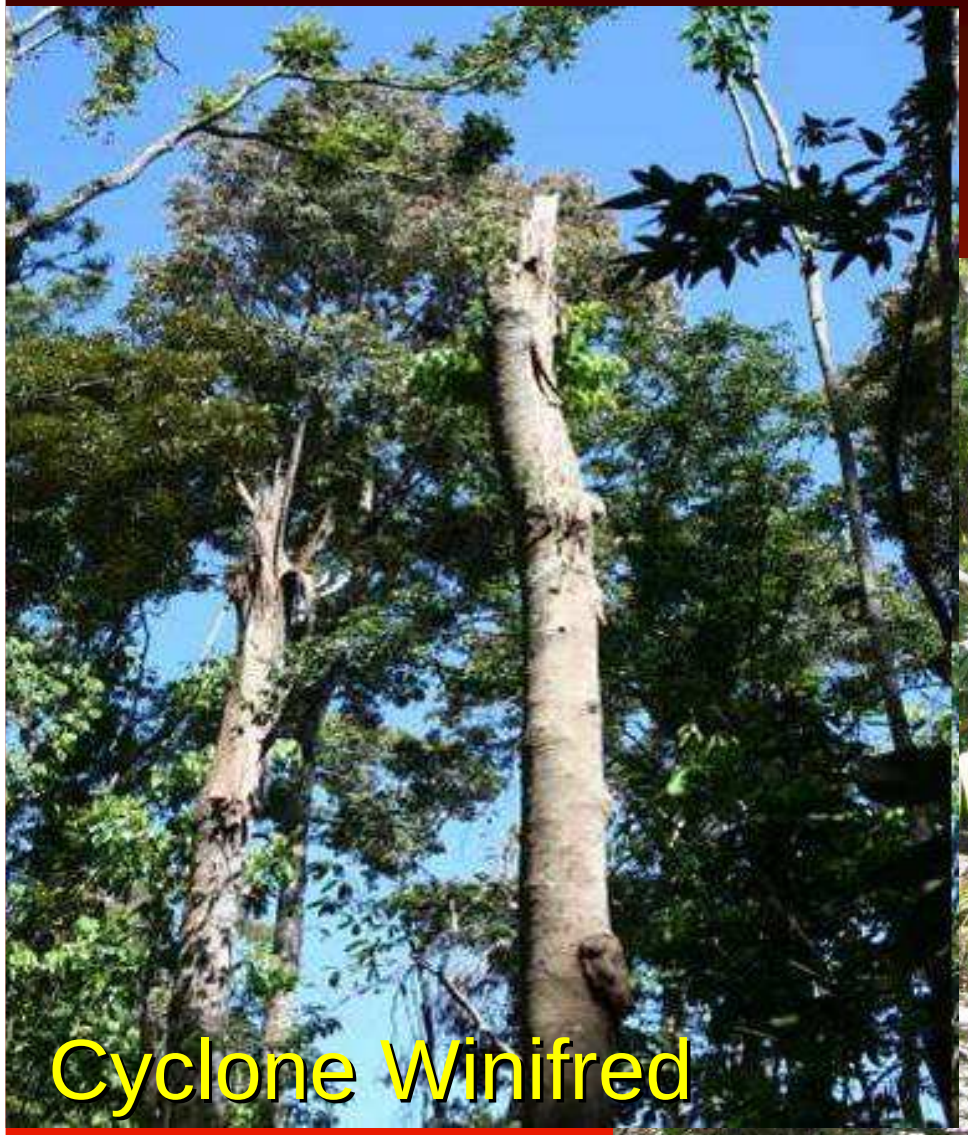
Disturbance agents - cyclones



Tropical disturbance agents - cyclones



Cyclone impacts – rainforests and gap dynamics



Cyclone Winifred

- Impacts
  - Succession event → recruitment
  - Shift in NEP *f*(severity)

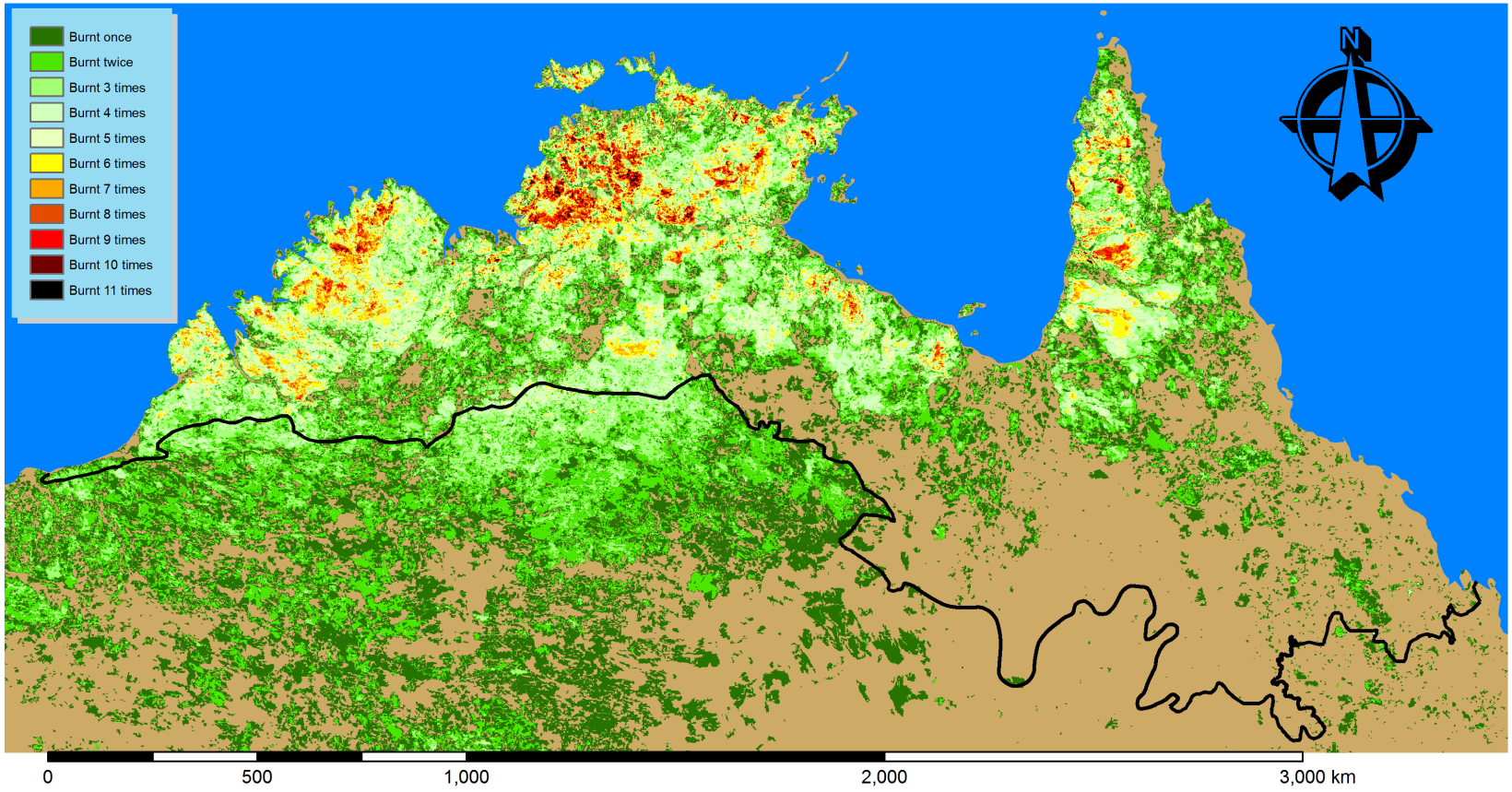
Summary

- Disturbance events have ‘ecological footprint’ over time
- Strong influence on rates of biogeochemical cycling in ecosystem
- Can we observe this footprint ?

2. Case study
Tropical savanna flux program

- Examine savanna land-atmosphere dynamics
  - Highly seasonal climate
- Impact of disturbances on NEP
  - Fire
  - Cyclones impacting coastal savanna

Savanna disturbance - fire

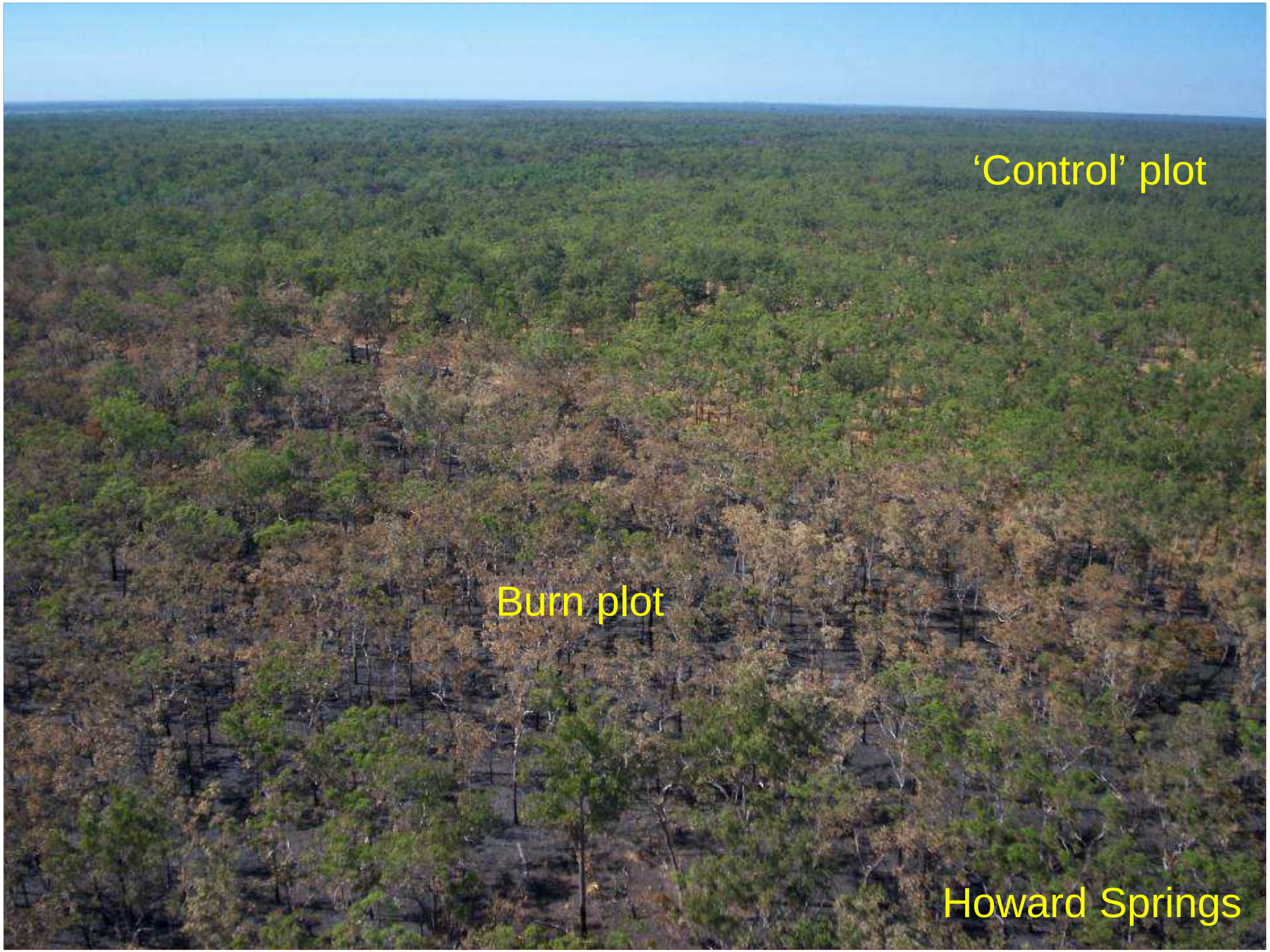


Fire frequency 1997 to 2007
AVHRR satellite imagery

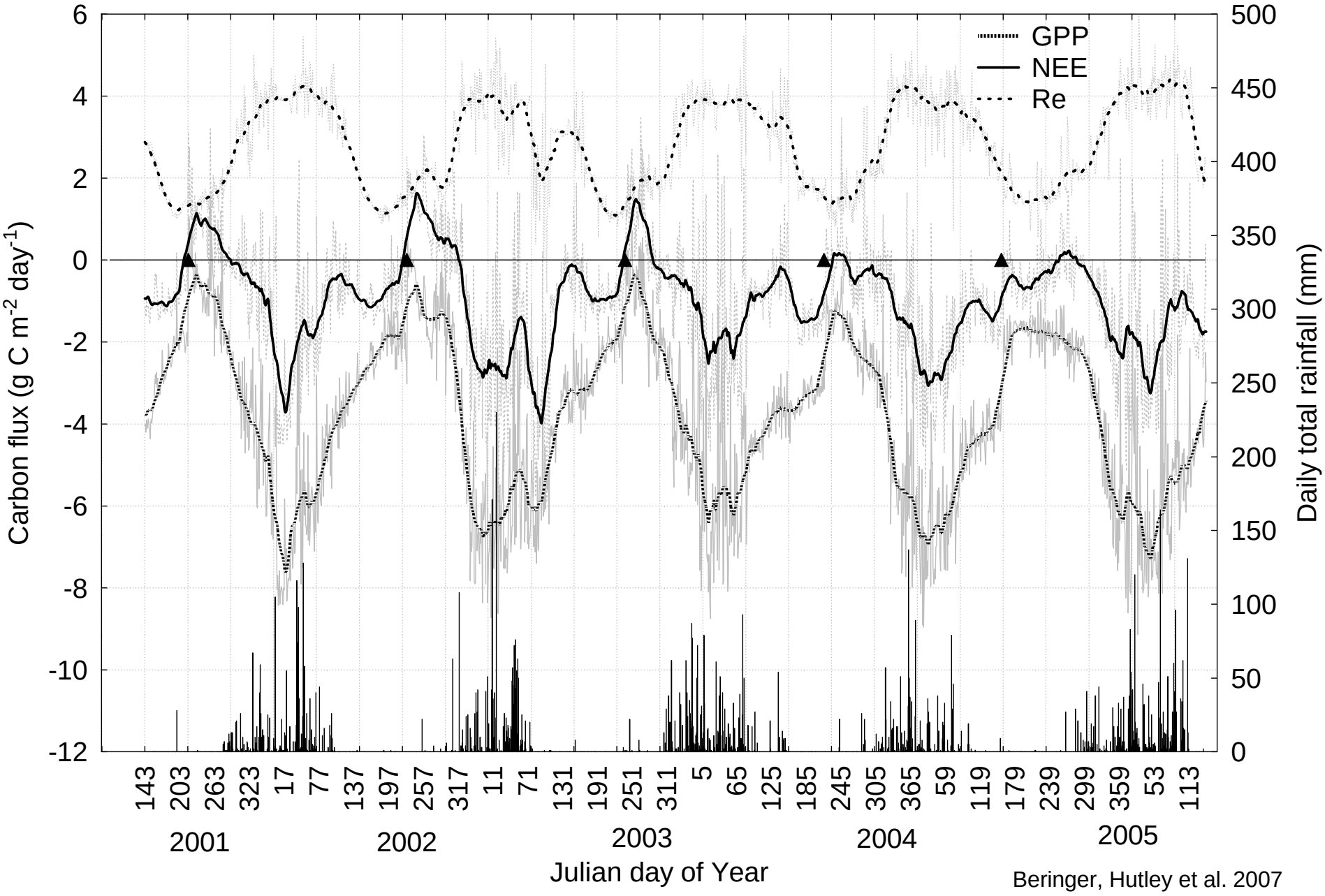
Howard Springs plots

NBP via Eddy covariance

- Carbon → slow in, fast out
  - Need to capture disturbance events
  - NEP over-estimated globally?
- 8 years and counting
- 300 ha plot, fire events ‘embedded’ in flux record


‘Control’ plot
Burn plot
Howard Springs

Interannual carbon dynamics and fire

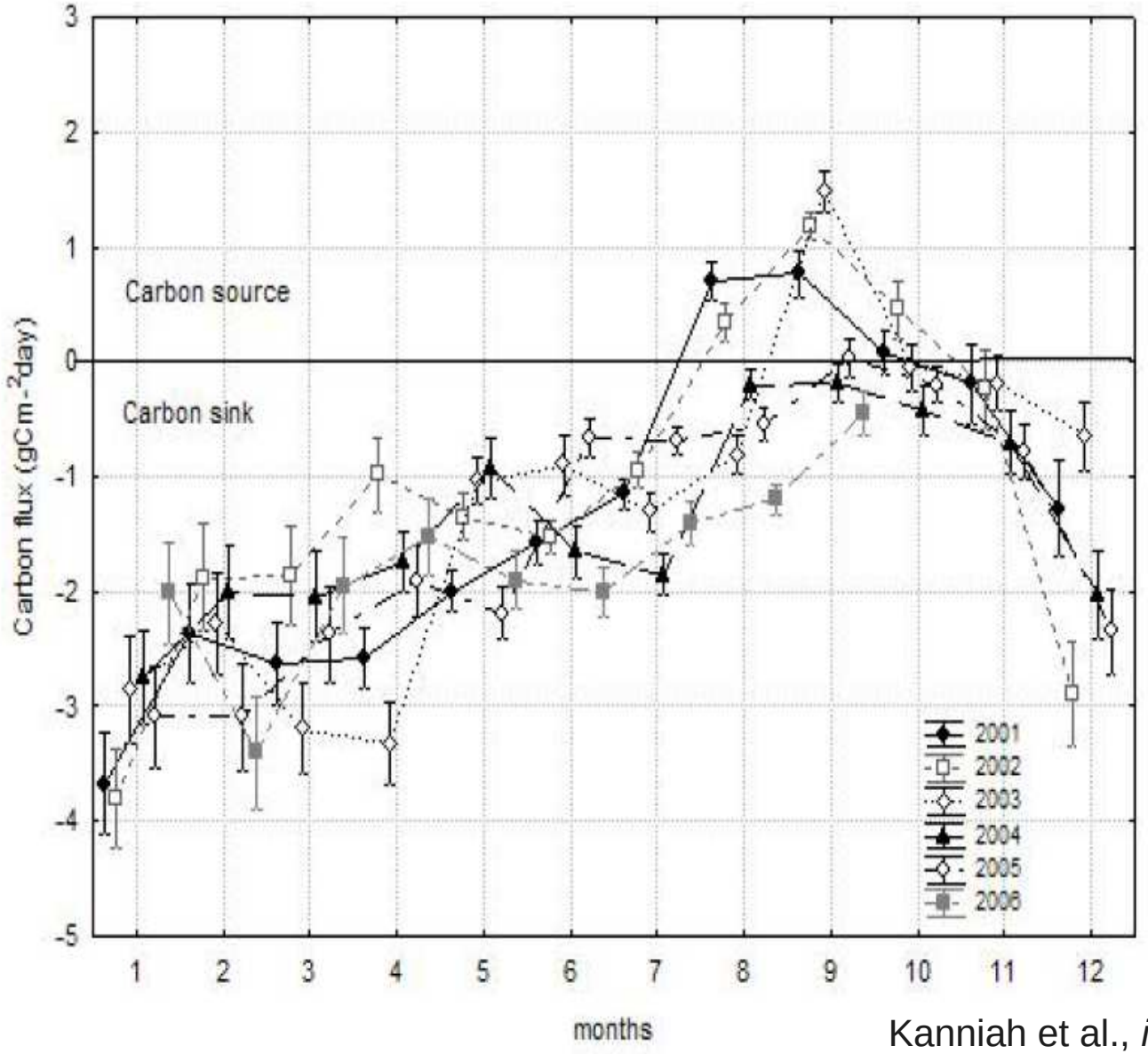


Beringer, Hutley et al. 2007

Data analysis – impact of fire

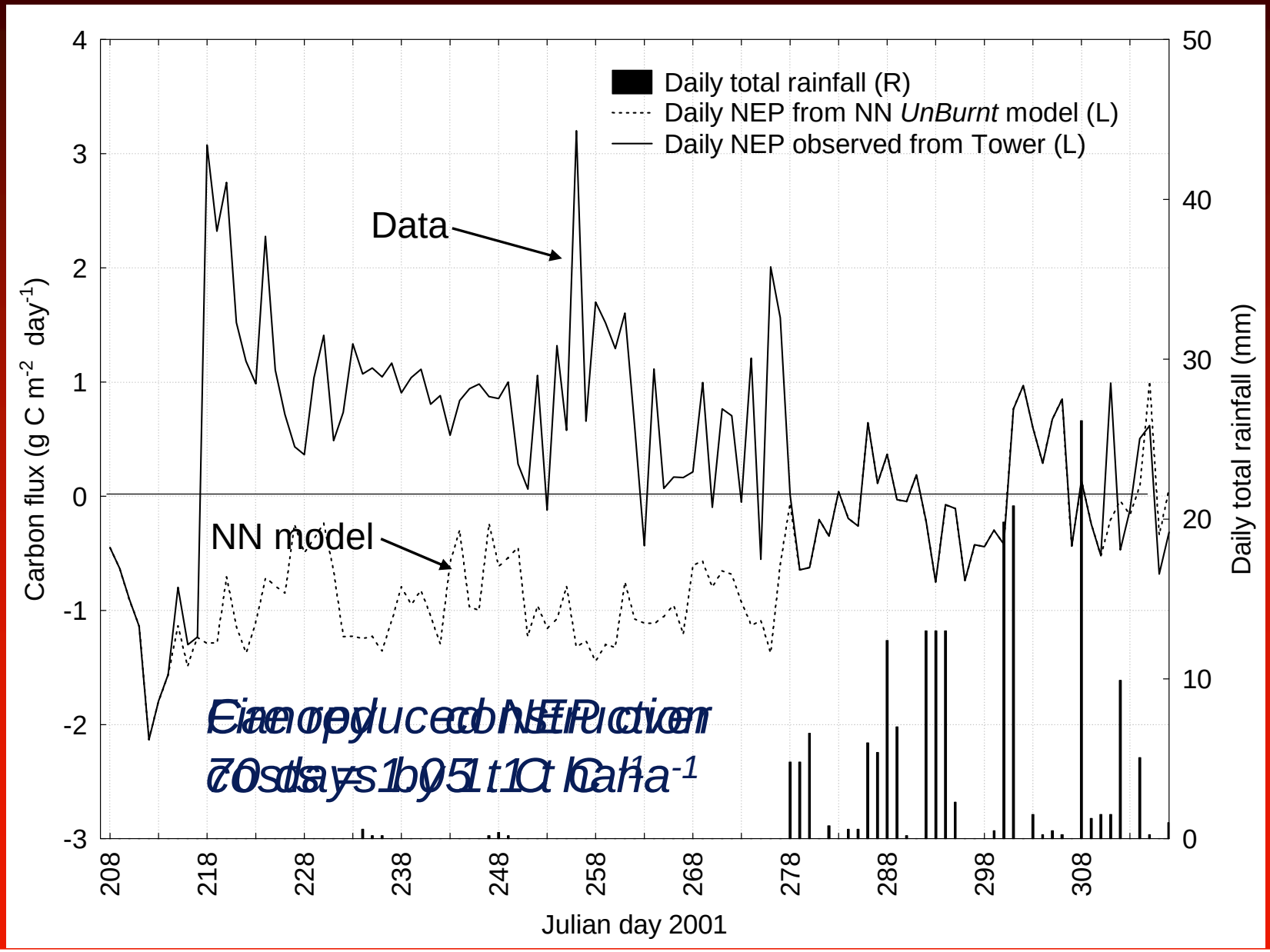
- Gap filling required
  - 30% data loss
  - Neural network models developed
  - Model trained for burnt (B) and unburnt (UB) surface conditions
- Use models and data to estimate impact of fire on NEP

Fire and seasonal source-sink dynamics



Kanniah et al., *in press*

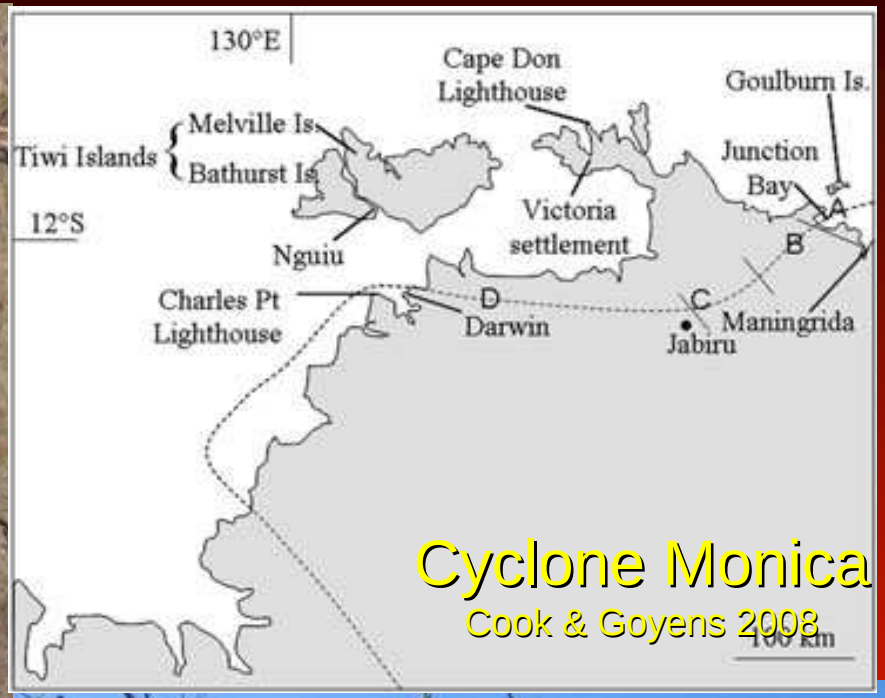
Post fire carbon dynamics



Conclusions

- Flux site Representative of mesic savanna, impacted by frequent fires, storms and cyclones
- Fire reduces NEP by ~50%
- Canopy remained a source of carbon for 70-100 days following fire depending on fire severity
- NBP ~ 2 t C ha^{-1} y^{-1} per^{-haps}
- Despite frequent fire, still a sink?

Disturbance impacts - cyclones

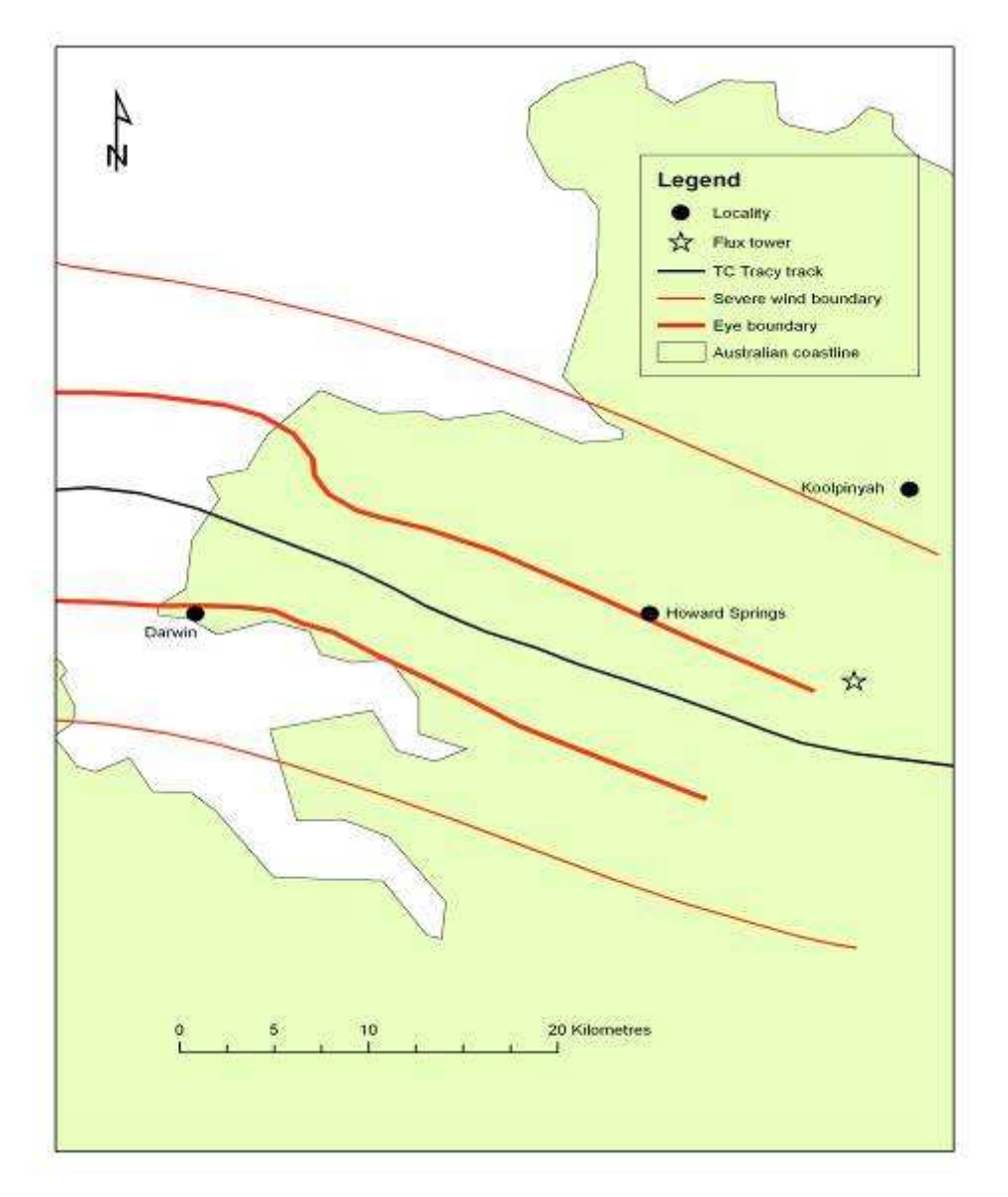


Disturbance impacts - cyclones

- Cyclone Monica impacted 6500 km^2 of savanna across the NT
- Emission via fire / respiration of CWD will be approximately 60 Mt CO_2
  - Equivalent to 10% of Australia's total annual anthropogenesis GHG emission (Cook and Goyens 2008)
- **'Resets' savanna stand structure – recruitment via re-sprouting**

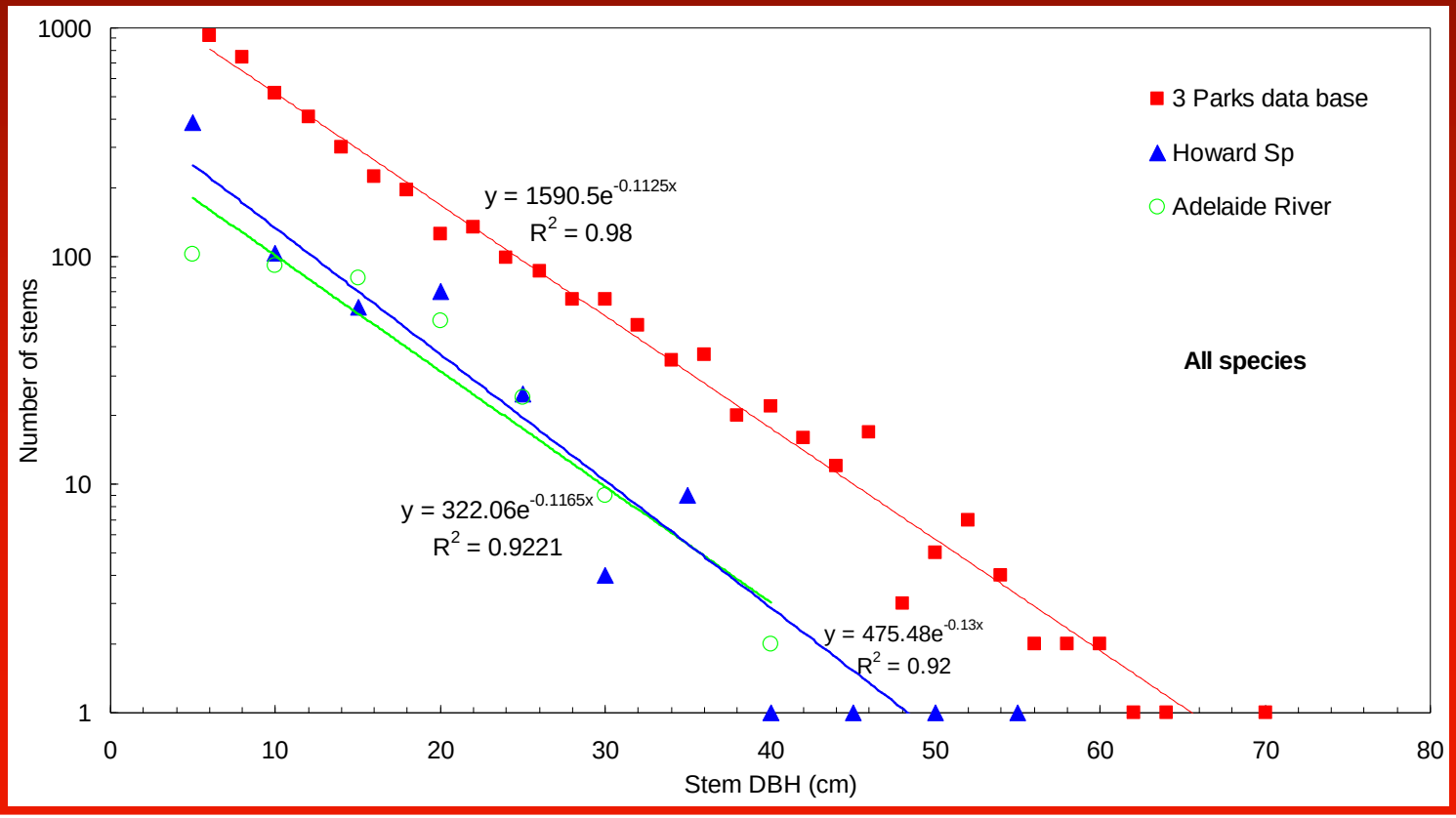
Maningrida coastline, NT - crossing point

Disturbance impacts - Cyclone Tracey

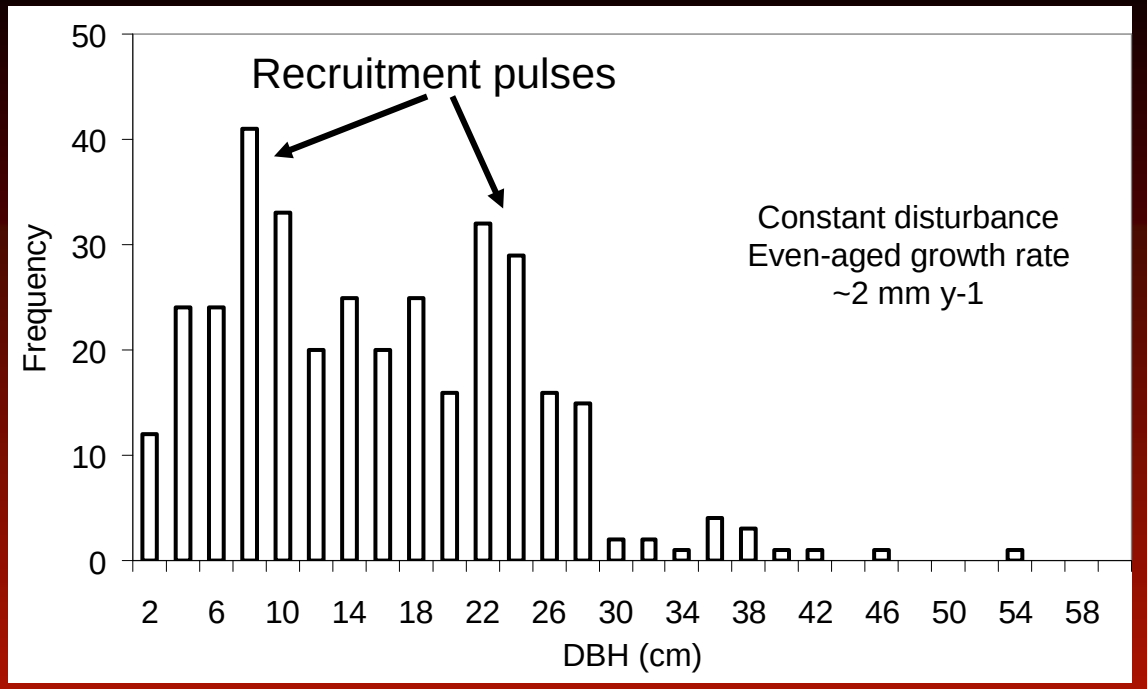


Disturbance impacts - Cyclone Tracey

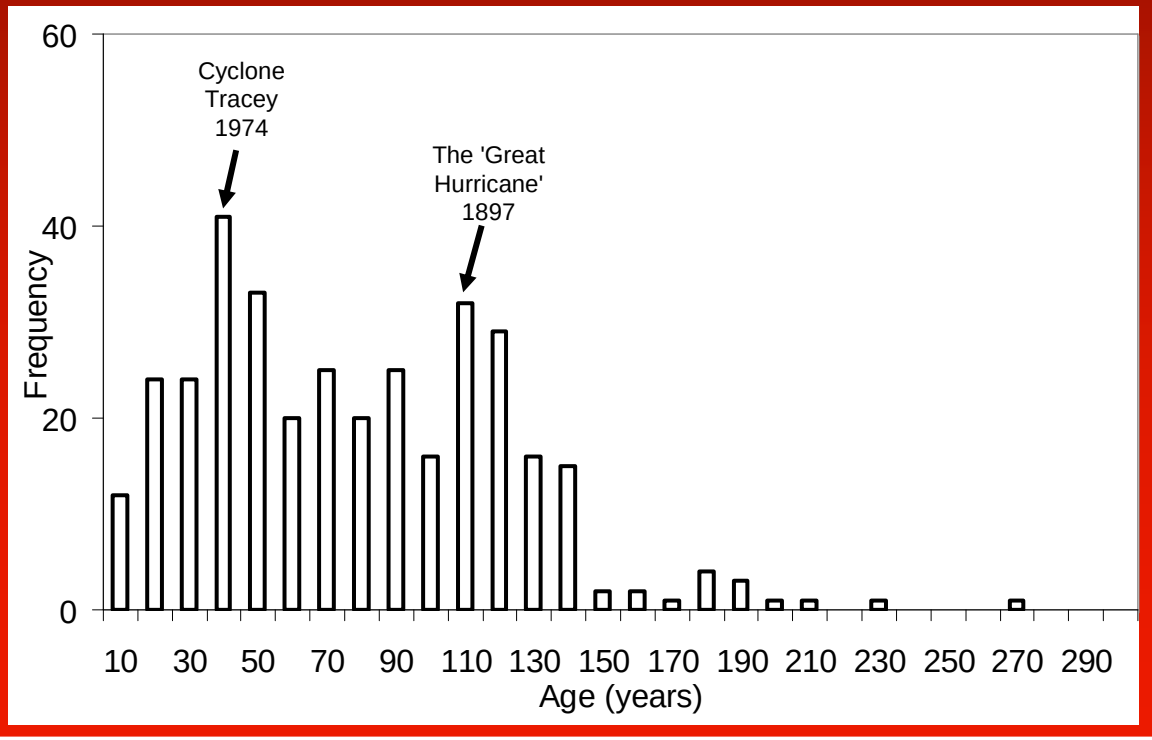
- Influence on flux ?
  - How representative is Howard Springs site ?
  - Look at stand structure



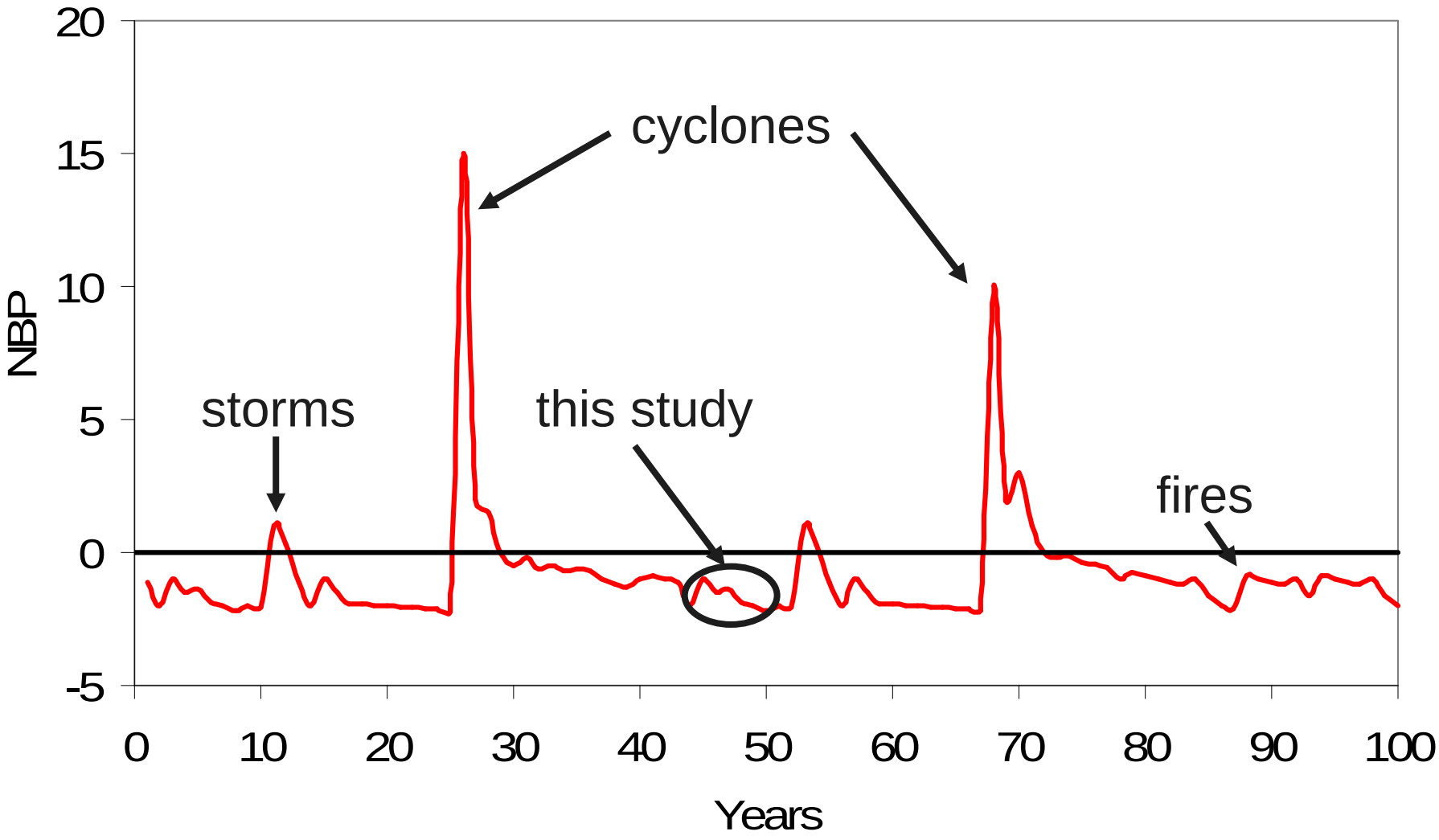
Howard Springs savanna size class distribution



- Assumes growth rate of 2 mm y^{-1} across all size classes
- Convert tree size to age



Sink saturation ?
Constant disturbance cycle




The end