



*Landscape-scale fire research in northern
Australia - from single issue studies to
multiple benefits in a changing world*



Dick Williams

et al.

CSIRO Sustainable Ecosystems, Darwin

Tropical Savannas CRC

Bushfire CRC

Savannas and sequestration – why?

Global savannas:

- 12% land area ($16 \times 10^6 \text{ km}^2$)
- 13% global C stock (66Pg C)

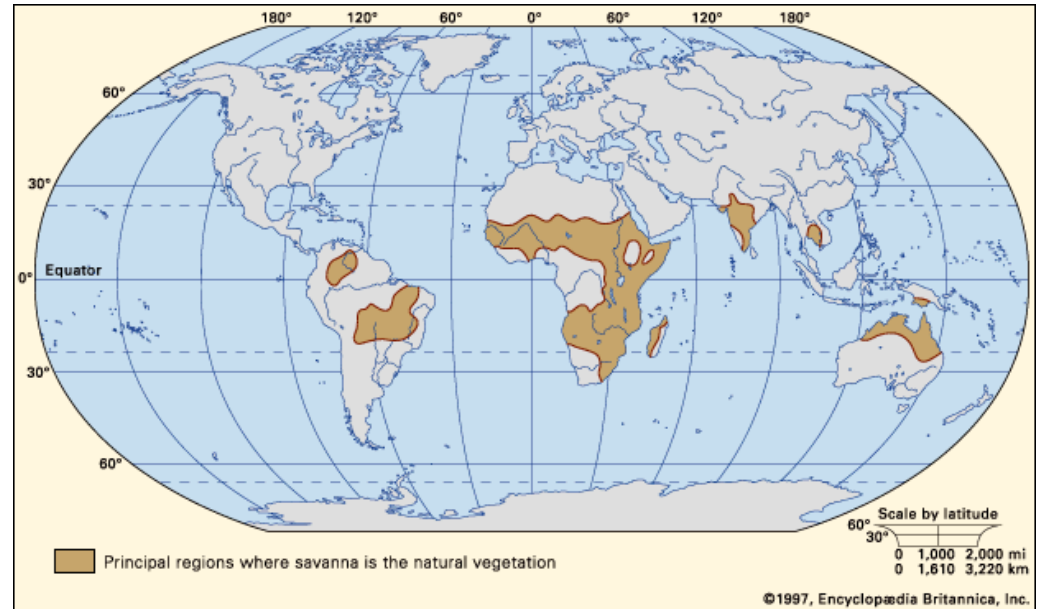
Australian savannas:

- 26% land area ($2 \times 10^6 \text{ km}^2$)
- 33% continental C stock

Oz Sav Emissions, 1991-2005

- Deforestation: 50-130 Mt CO₂-e y⁻¹
- Livestock: 60-66 Mt CO₂-e y⁻¹
- Fire: 5-15 Mt CO₂-e y⁻¹
- Strong influence: climate, land use

Ecosystem sequestration capacity of international interest



We need knowledge about savanna sequestration

Savannas will be increasingly important because:

- GHG abatement is international news
- Savannas a large part of the national and international carbon story
 - Emissions
 - Stocks
 - Sequestration
- Meeting targets will become big business
 - individuals, corporations and governments
- We need to know where we stand as savannas will be part of the deal, BUT
 - Capacity
 - Longevity
 - Commercial and policy constraints

Complexity and confidence in a carbon constrained world



Increasing complexity of systems
Decreasing confidence of regionality of change projections
Increasing opportunity of adaptive changes to nullify effects
Increasing opportunities for extraneous forcing to influence future
Increasing identification of nature/magnitude of impacts
Decreasing confidence in probability of occurrence

Take a few steps back and ask how we got here?

Fire experiments

Carbon and water studies

Many other interactions between NT ecological 'loose group'

- Savanna CRC *et al.*

20 years' worth of Savanna Ecology 101

Wet season



Dry season



Strongly seasonal phenology of growth and disturbance
Extensive, 'intact' landscapes
Multiple values

20 years' worth of fire experiments

5 years ago in a room not far from here:

Fire ecology, management and biodiversity in Australian savannas : Lessons from field experiments

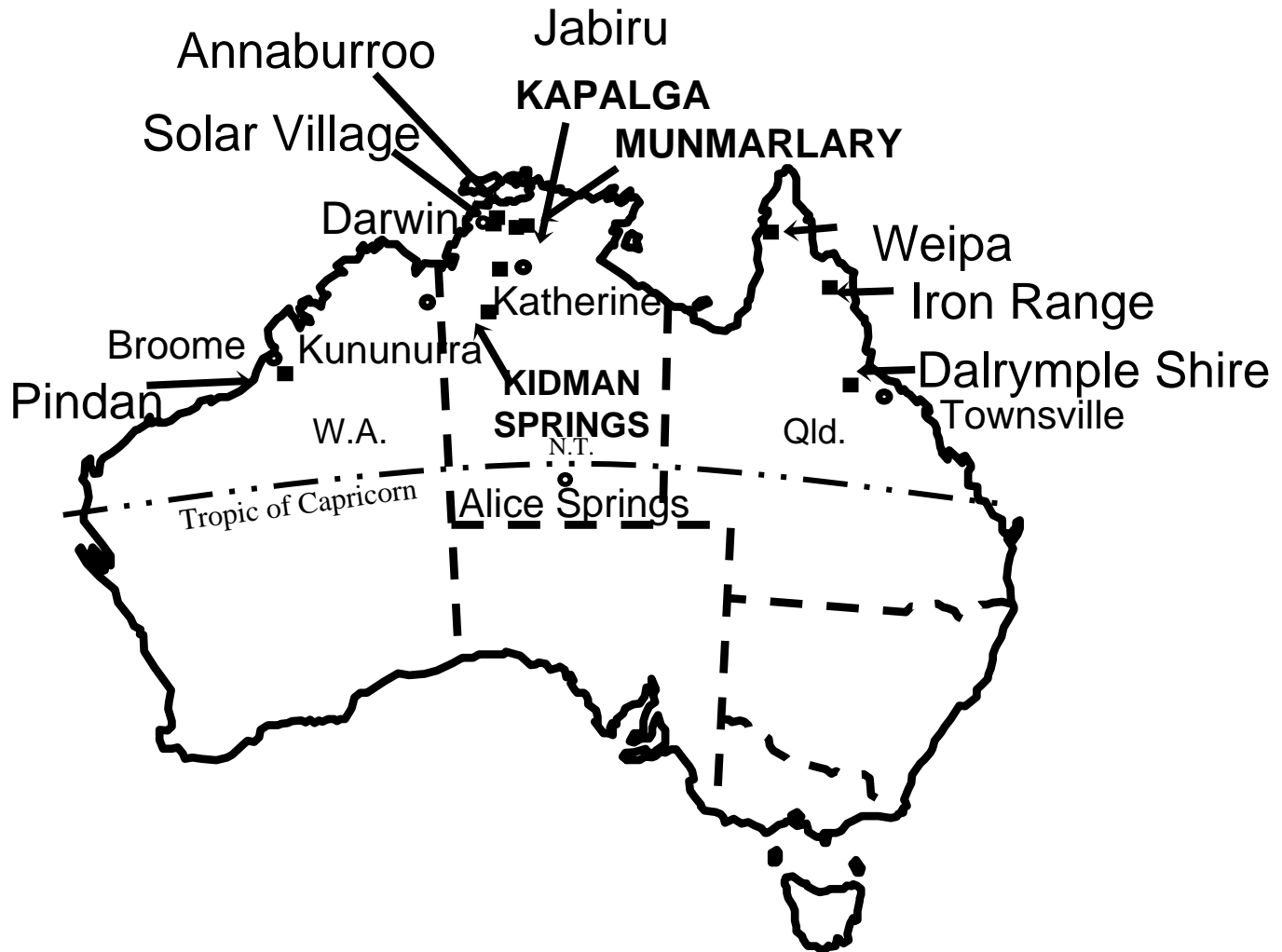
The portfolio of fire experiments

Lessons for doing experiments

Lessons for ecological pattern and process

Lessons for ecosystem management

Fire experiments across northern Australia



What did these experiments teach us?

Fire behaviour

Landscape resilience and sensitivity

Experiments one part of the tool box

The value of monitoring and modelling

Back chat

Experiments yet to be done:

Time since fire

Fine grained patchiness

Barriers to spread

Regimes matter

Parallel stories

In parallel with this research:

- **Remote sensing of quantitative measures of variation in fire regime**
 - Fuels
 - Occurrence
 - Patchiness
 - Monitoring to modify
 - Customary management

- **Landscape grain and biodiversity**

The key has been grappling with the thorny issue of how do deliver the desired variation in fire regime components – intensity, interval, patchiness – at landscape scales with appropriate human capital

Multiple applications, and are widely accessible to researchers and managers alike (e.g. NAFI)

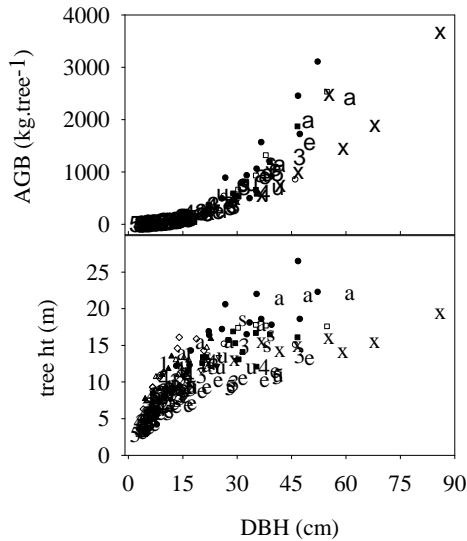
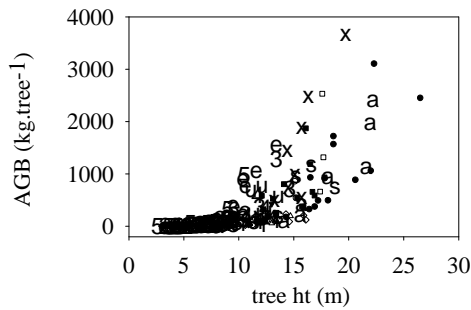
Taylor-made platform for savanna carbon research

Carbon dynamics in Australian savannas

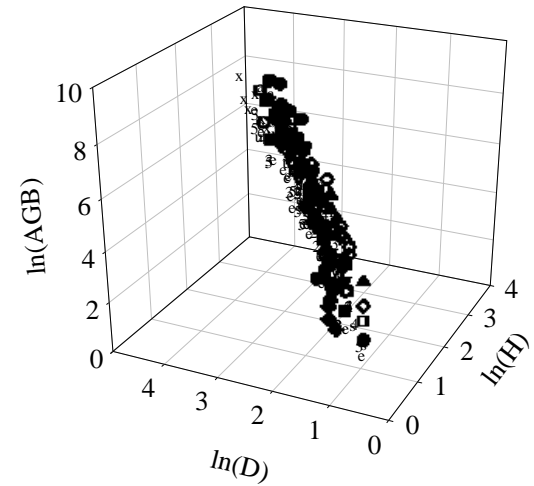
Three foci of carbon project

- Stocks – chopchop, digdig and weighweigh, allometry, RADAR
- Emerging knowledge of strength of sink/source in relation to land use
 - **Net Ecosystem Productivity and Net Biome Productivity**
 - Markets; business prospects etc

Tree biomass allometry



- | | |
|---------------------|--------------------|
| • E. cre -Kro. | ◊ E. min - H.Doo |
| ◦ E. mel - Mit. | ▼ E. min. - Kat. |
| ▪ E. mel - Sum. | ▽ E. por - H.Doo |
| ◻ E. pop - Mit. | ◆ Er. chl - H.Doo |
| ▲ E. ble. H.Doo | ◇ E. tet - H.Doo |
| 1 E. tet - Kat. | u E. tec - Man. |
| 2 T. fer - H.Doo | e E. ter - Kid.Sp. |
| 3 E. fol - Kat. | s E. pop - Inj. |
| 4 E. pat - Kat.R.S. | a E. pop - Roc. |
| 5 E. pru - Kid.Sp. | x E. pop. - Oak. |



A tree is a tree is a tree

Estimation of carbon stocks by RADAR

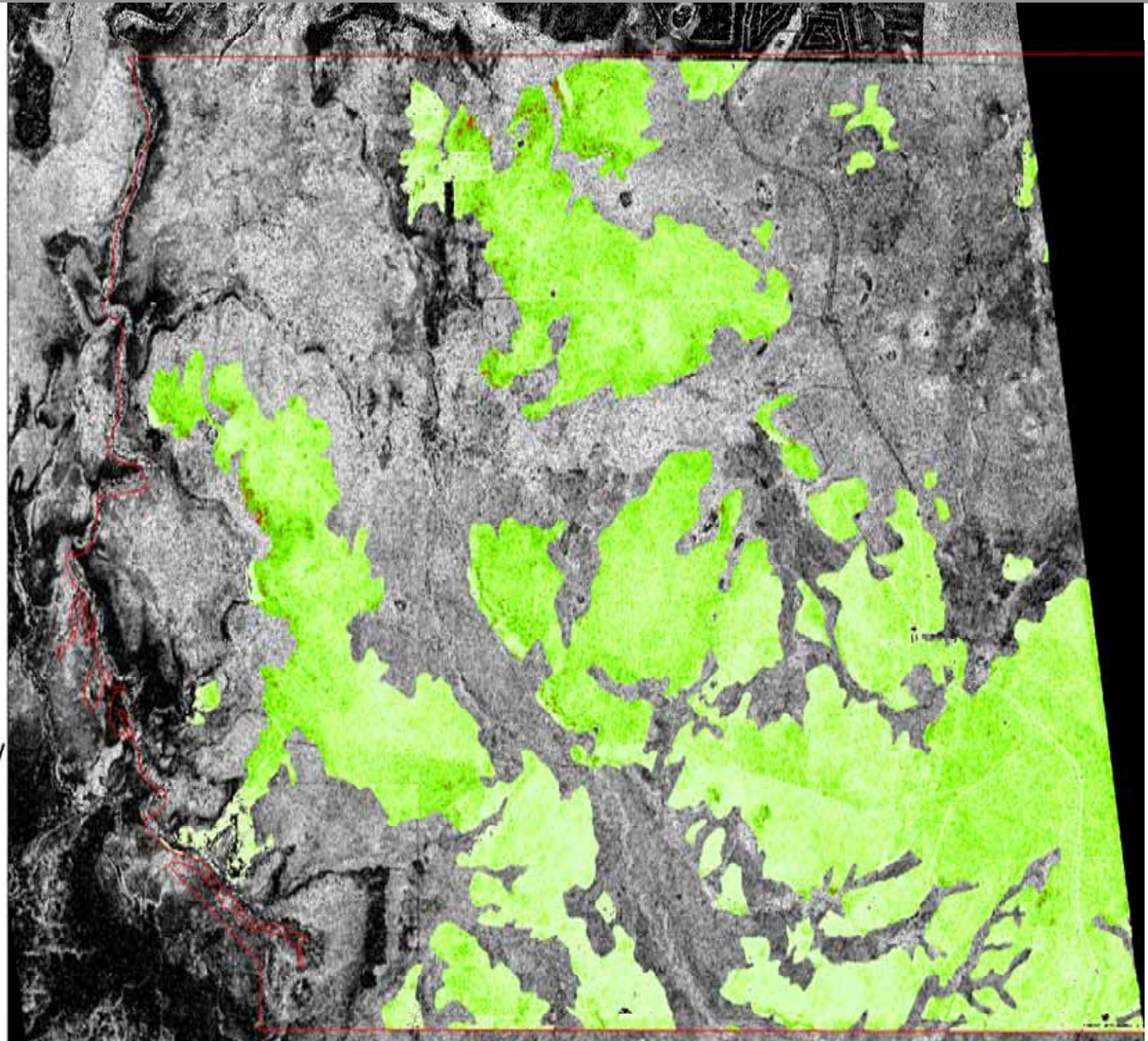
Mary River Catchment *Collins et al. in press*

Total C storage

t C ha⁻¹



0 1.5 3
Kilometers



Savanna carbon sequestration potential

Necessary component of full carbon accounting

Substantial international efforts

Five published approaches to estimating Net Ecosystem Productivity (NEP) and Net Biome Productivity (NBP) in Australian mesic savannas

$$\text{GPP} - \text{respiration} = \text{NPP} - \text{soil respn} = \text{NEP} - \text{disturbance} = \text{NBP}$$

1. Mass-balance and allometry (*Chen et al. 2003*)
2. Apply point source NEP, to landscape-scale area burnt (*Williams et al. 2004*)
3. Eddy covariance before and after fires (*Beringer et al. 2007*)
4. Inventory modelling (*Cook et al. 2005*)
5. VAST coupled carbon-water model (*Barrett et al. 2008*)

Chainsaw Chen et al.

Allometry, respiration chambers, and mass balance – site based

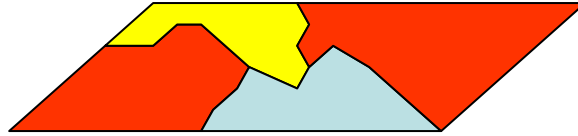


$$\text{NBP} = -1 \text{ t C ha}^{-1} \text{ y}^{-1}$$

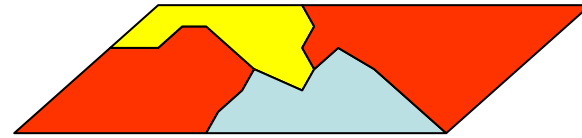
Williams et al. 2004

NBP at landscape scale – NEP minus regional emissions in Arnhemland

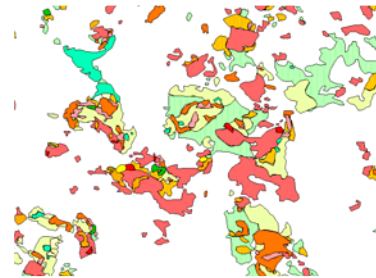
NEP
estimate



Fuel type
map

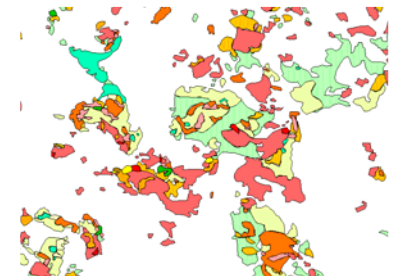


Area burnt



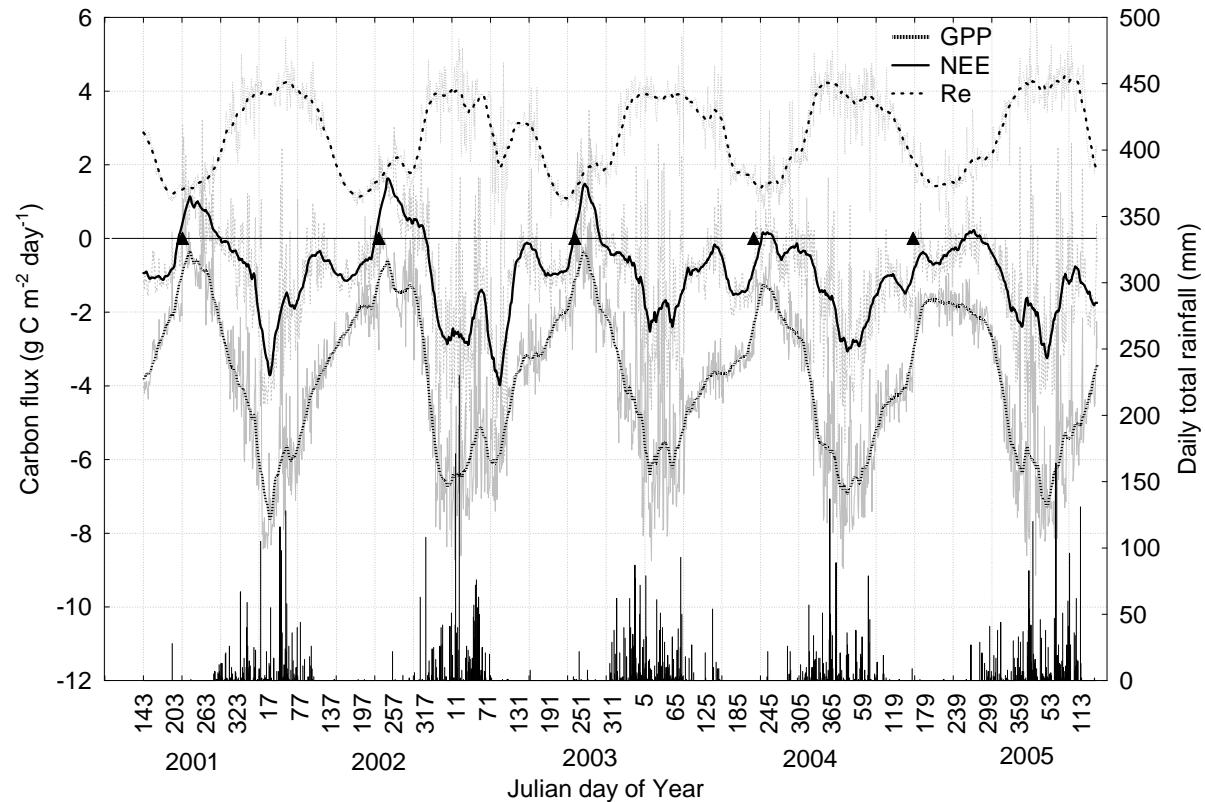
NBP = - 1.1 t C ha⁻¹ y⁻¹

Burning
efficiencies



Burnum Beringer et al. (2006)

Eddy covariance – Darwin site based; 5 years' data



$$\text{NBP} = -2 \text{ t C ha}^{-1} \text{ y}^{-1}$$

Cook et al. (2005)

Tree NBP at multiple sites mesoscale at Kapalga Research Station

30 Long term 0.1 ha plots at
Kapalga, NT

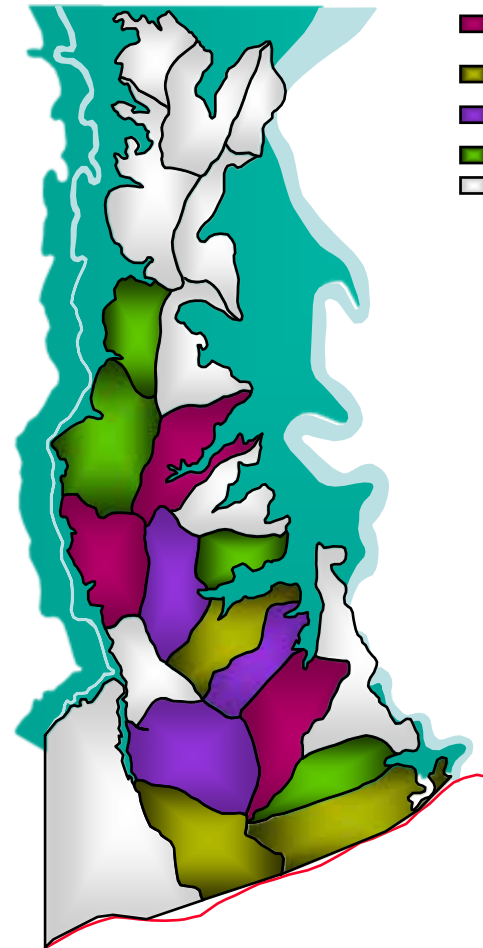
Stand allometry – thousands of
DBHs

Varying fire regimes over 15
years at replicated landscape
scale

– benign to severe

NBP (trees)

**= - 0.5 t C ha⁻¹ y⁻¹ (benign)
+ 4 t C ha⁻¹ y⁻¹ (severe)**



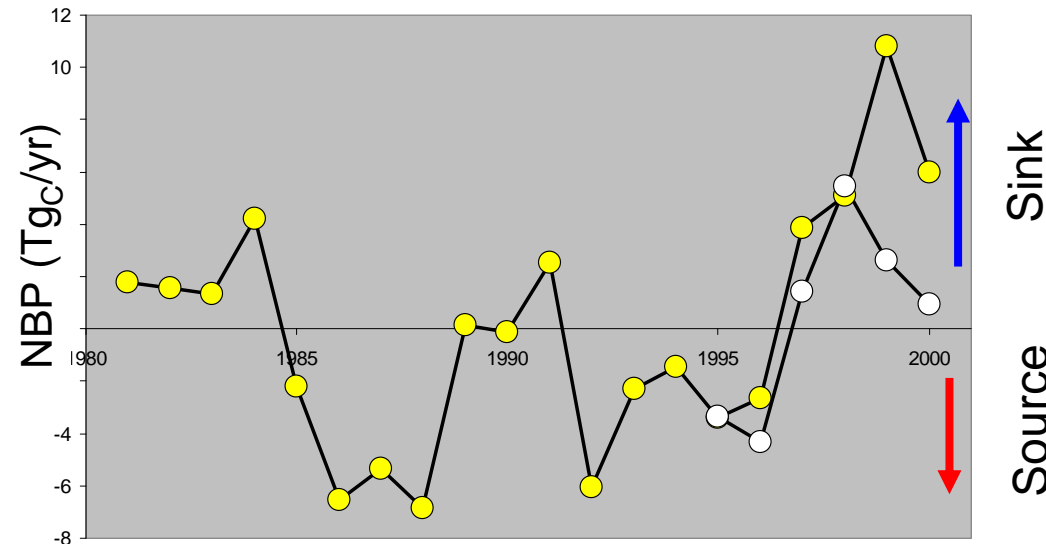
■ Ann. Early
■ Ann. Progressive
■ Ann. Late
□ Unburnt
□ Not used

0 10
Kilometers

-0.5 t C ha⁻¹ y⁻¹ consistent with Berringer: 28% of their 2 tonnes NBP is woody increment

VAST coupled carbon-water model

Barrett *et al.* 2007



Coupled fire into model:

- 15 years: mean fire frequency
- 5 years: AVHRR/ATSR forcing
- Captured feedback: climate → NPP → fuel → emissions

Source or sink on decadal scale

Strong climate feedback on NBP

Average sink over 2M km² ca. - 0.1 t C ha⁻¹ y⁻¹

Savannas a sink....consistent message from multiple studies

NBP: Measured range mesic savannas $-1-2 \text{ t ha}^{-1} \text{ yr}^{-1}$

- In line with most of the world's forests – sinks

Amazon, Siberia, Europe; ca. -1 to $-5 \text{ t C ha}^{-1} \text{ yr}^{-1}$ (Schulze; 2005 Biogeosciences Discussions; Magnani Nature. 2007)

- Global savanna sink - $0.15 \text{ t C ha}^{-1} \text{ yr}^{-1}$ (Grace; GCB 2006)

- Within an Oz order of magnitude variation

- Oz savannas can be a sink even when burnt

- (25 - 50% of landscape)

- NBP sensitive to fire regime

Profound implications for international carbon accounting

OzSavanna sequestration story

The future – a rosy R&D horizon

Quantifying size of capacity –

- Order on magnitude variation – why?

Interacting disturbance regimes

- Long-term variation in NBP – fire x cyclones
- Soil carbon and landuse

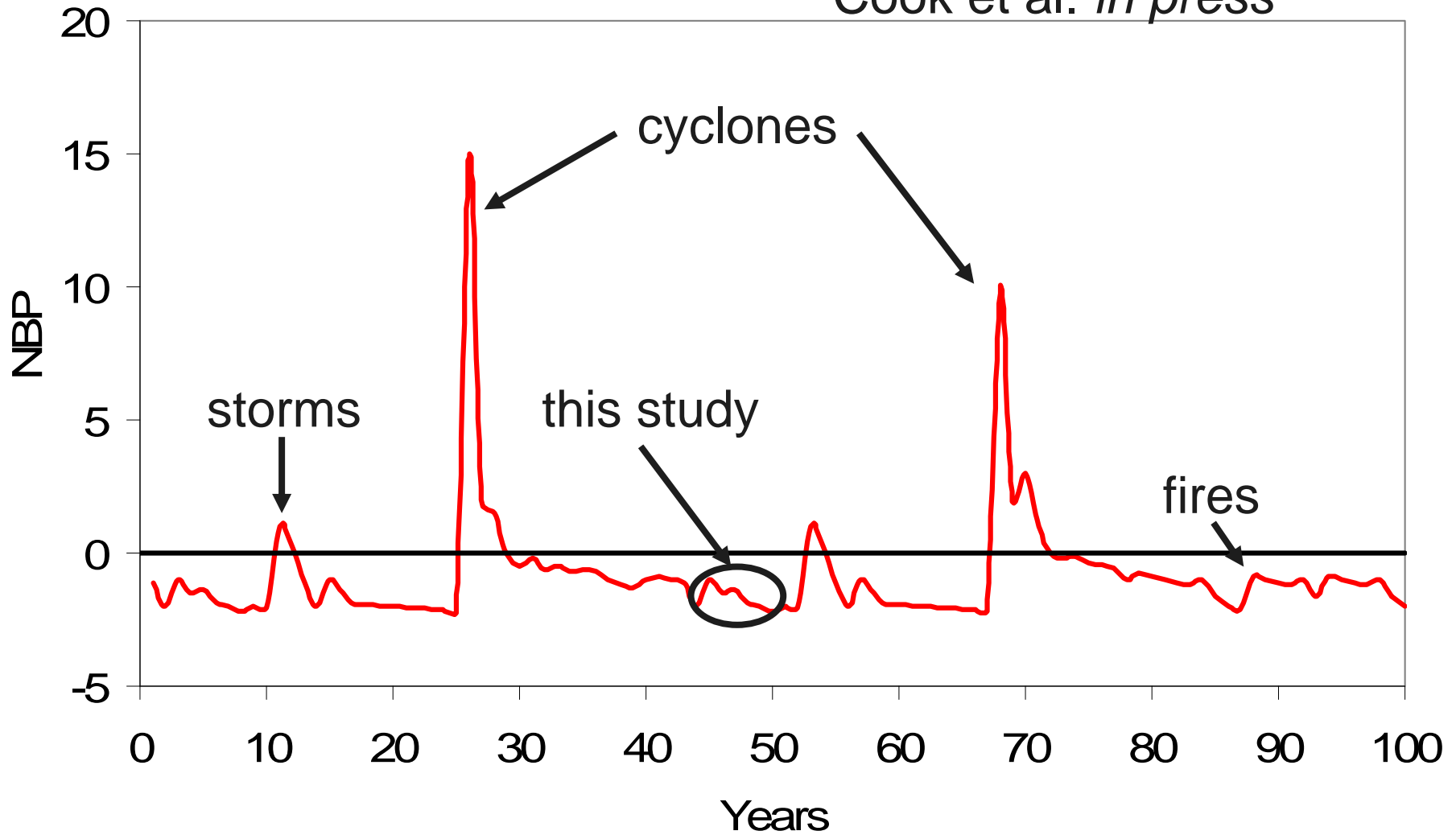
Multiple uncertainties

- Biophysical
- Socio-economic

Uncertainties ?

Constant disturbance cycle

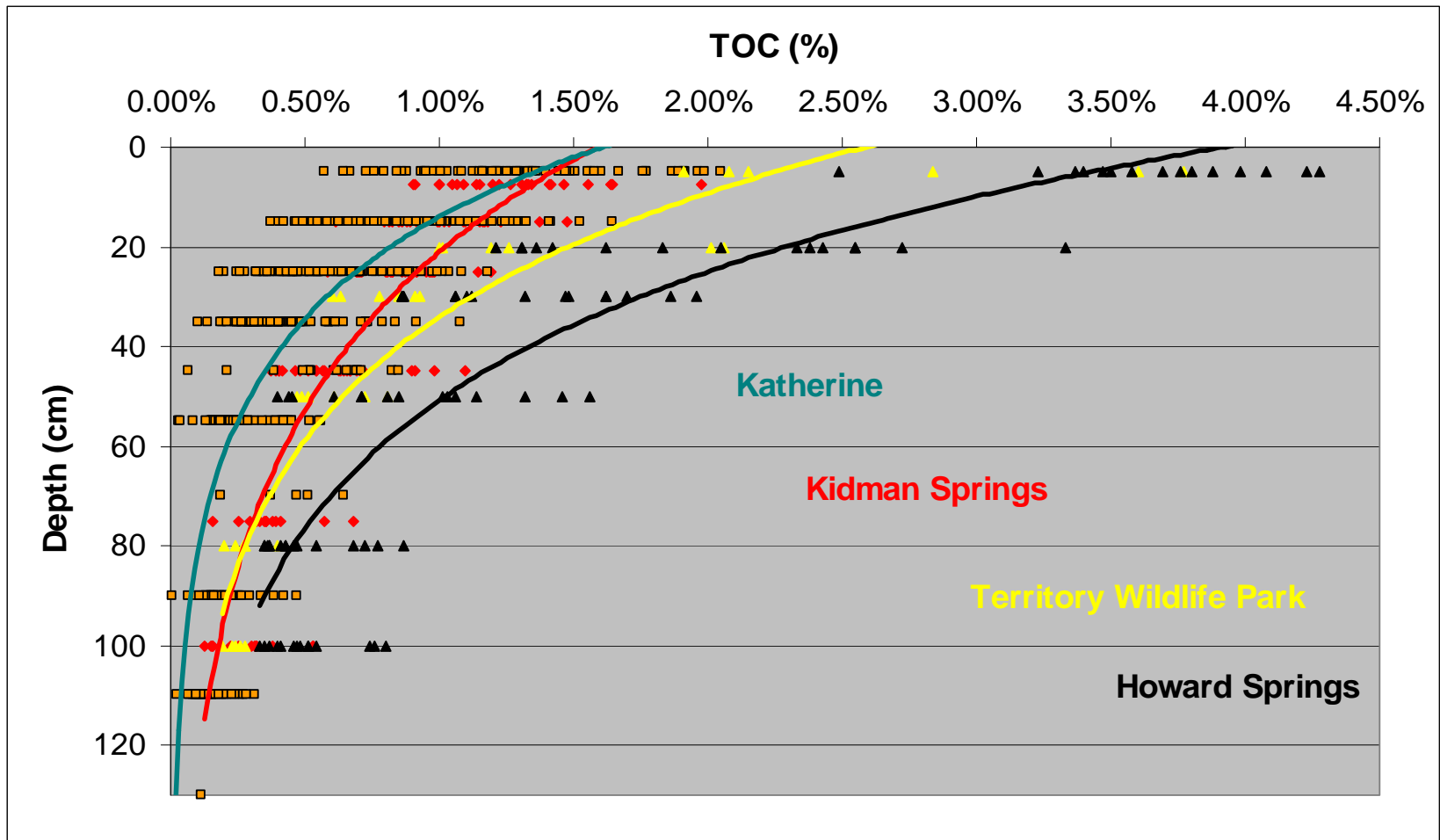
Cook et al. *in press*



Soil Organic Carbon -

where most of the carbon lies; where the action will be

SOC in mesic and semi arid savanna sites



Using National Carbon Accounting System (NCAS) in savanna carbon decision making

Estimating C Stocks in northern Australia

- **Need to determine our current ability to predict C stocks in northern Australian savannas with landuse change (fires, clearing and grazing) using FullCAM/NCAS.**
- **A range of users (NT Govt) require NCAS estimates for policy decisions.**
- **NCAS now being used as Global Carbon stock estimation tool by the Clinton Climate Initiative.**
- **LWA funded project, thru CRC to calibrate for savannas**

Offshore applications

Charles Darwin University

Fire management and livelihoods – NTT

GIS & Remote Sensing applications – NRM & health mapping

Capacity building in regional agencies – training and exchanges

Funded by ACIAR, AusAID, Tropical Savannas CRC and Crawford Fund



Look familiar?



Northern Australia



Nusa Tenggara Timor



Land management research a priority

CDU research in response to priorities of Indonesian partners.



Potential for emissions abatement and sequestration enhancement in Eastern Indonesia



Take home messages: Savannas and Carbon

Look for multiple benefits

- **Nth Australia international leaders in R&D capacity for savanna carbon**
- **Emerging carbon economies in the savannas**
 - Fire abatement demonstrable technology and investment potential
 - Grazing and soil carbon; tree planting on the horizon
 - Grazing management to enhance soil carbon? – potential
 - Gamba grass as carbon offset product? – forget it
- **Multiple Uncertainties**
 - Buyer beware
- **Off-shore applications**
- **Look for multiple benefits**

Multiple benefits

Smoke abatement in WAFA et al.	Landscape Research and Development
Emissions reduction	Fire and biodiversity
Sequestration enhancement	Grazing land management
Indigenous land management	Carbon stocks and flows
Biodiversity benefits	Monitoring and mapping
Regional livelihoods	International carbon economy

All begin and end with investment in detecting and delivering the appropriate temporal and spatial variation in the disturbance *regime*