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

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Savannas and sequestration – why?

Global savannas:
- 12% land area (16 x 10^6 km^2)
- 13% global C stock (66Pg C)

Australian savannas:
- 26% land area (2 x 10^6 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
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

We need knowledge about savanna sequestration
Primary climate-change drivers
- Carbon dioxide
- Temperature
- Rainfall
- Humidity
- Winds

Complex & secondary outcomes affected by magnitude & frequency
- Drought
- Run off
- Soil Moisture
- Soil erosions
- Salination
- Sea level

Ecosystem & human system impacts
- Growth rates: Plants and animals
- Seed quality
- Vernalisation/seed set
- Species competition
- Coastal inundation
- Built environment

Economic & environmental outcomes
- Crop, pasture & agriculture system productivity
- Ecosystem integrity, genetic richness, resilience
- Ecosystem services
- Replacement of built facilities

Societal risks
- Environmental aesthetics, and function, Tourism
- Cultural values, indigenous rights
- Human systems management of vulnerabilities
- Food production, fisheries, crops, pastures, horticulture
- Human Health
- Security, wellbeing
- Intergenerational legacy

Key Vulnerabilities
- Natural systems
- Water security
- Fire and drought
- Coastal communities
- Bio-security
- Critical infrastructure and threats to life
- National security

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.
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
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

A tree is a tree is a tree

- E. cre - Kro.
- E. mel - Mit.
- E. mel - Sum.
- E. pop - Mit.
- E. ble. H.Doo

1. E. tet - Kat.  u  E. tec - Man.
3. E. fol - Kat.  s  E. pop - Inj.
Estimation of carbon stocks by RADAR
Mary River Catchment Collins et al. in press
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

\[ \text{NBP} = -1 \quad \text{t C ha}^{-1} \text{ y}^{-1} \]
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)

-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 $\rightarrow$ NPP $\rightarrow$ fuel $\rightarrow$ 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 \(-1-2\ t \ ha^{-1} \ yr^{-1}\)

- In line with most of the world’s forests – sinks
  
  Amazon, Siberia, Europe; ca. \(-1\) to \(-5\ t \ C \ ha^{-1} \ yr^{-1}\) (Schulze; 2005 Biogeosciences Discussions; Magnani Nature. 2007)

- Global savanna sink - 0.15 \(t \ C \ ha^{-1} \ yr^{-1}\) (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*

- Cyclones
- Storms
- This study
- Fires
Soil Organic Carbon - where most of the carbon lies; where the action will be

SOC in mesic and semi arid savanna sites

TOC (%) vs Depth (cm)

Katherine
Kidman Springs
Territory Wildlife Park
Howard Springs
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.

“Fire management and reforestation programs are required for the economic development of NTT” (Saragih et al. 2000)
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

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