# Fire management for conservation, indigenous benefit, and greenhouse gas emissions abatement: west Arnhem Land, NT.


Dr Andrew Edwards

Research Fellow - Bushfires


BUSHFIRES NT

CSIRO

DCBR Darwin Centre for Bushfire Research, Charles Darwin University

NAILSMA

Balkanu

Northern Land Council

Dilly Bag

Landgate

CHARLES DARWIN UNIVERSITY — Research Institute for the Environment and Livelihoods RIEL

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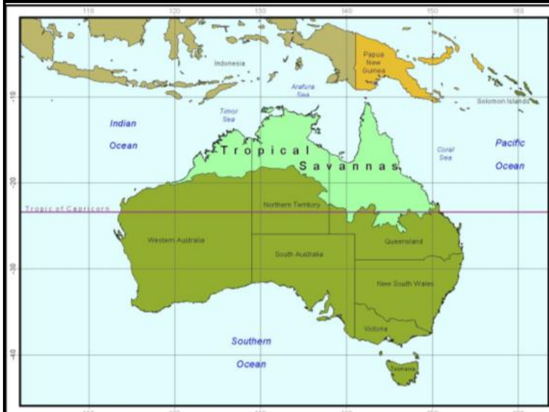
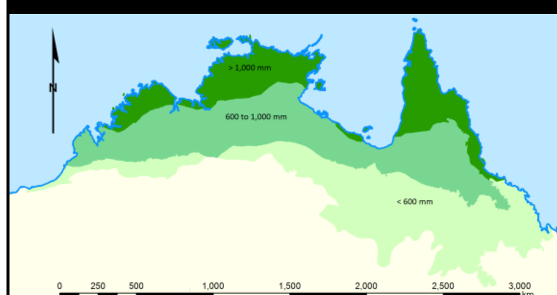
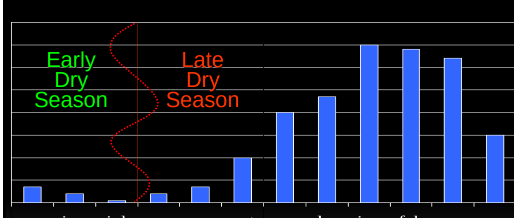
## Outline:

- What's different about where we are?
- What made us start all this research?
- How did we do it and what have we found out?
- What's the link between Indigenous Australians and Carbon?
- Can this lead to other livelihoods for Indigenous Australians?




Savannas are characterised by seasonal water availability, with the majority of rainfall being confined to one season of the year.



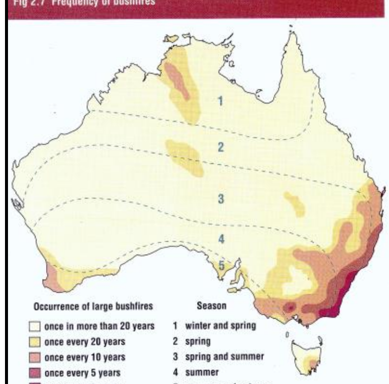

DRY SEASON | WET SEASON

YEKKE (DRY) WURRKENG (LATE DRY) KURRUNG (BUILD UP) KUNUMELENG (FIRST STORMS) KUDJEWK (WET) BANGKERRENG (LATE WET)

Mean Average Monthly Rainfall (mm) for Darwin, Northern Territory (~100 years) (Source: Bureau of Meteorology, Commonwealth of Australia)

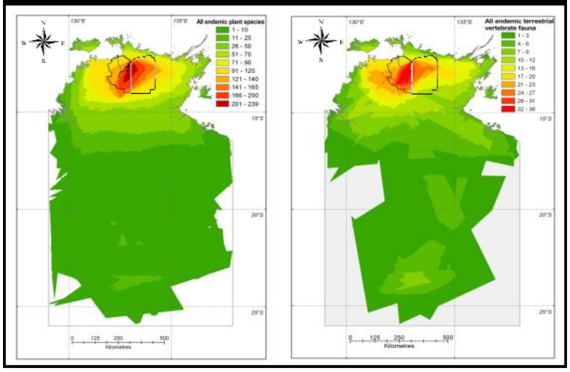
## Fire the Enigma

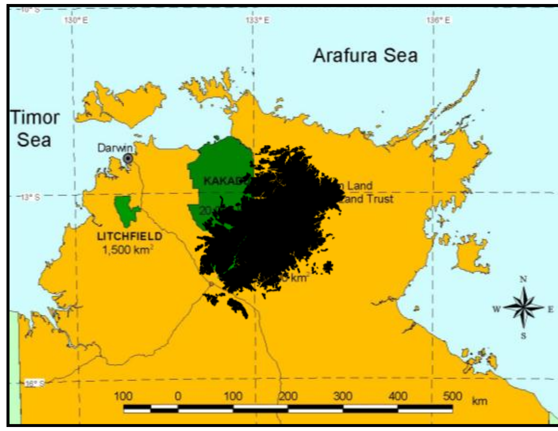
Fig 2.7 Frequency of bushfires

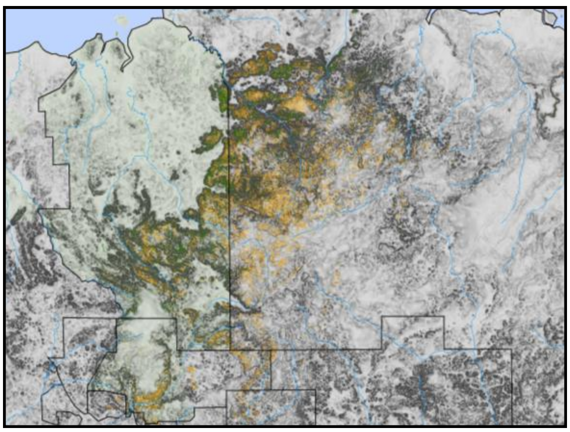


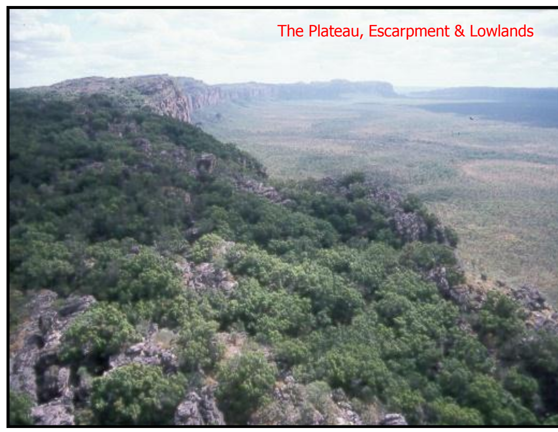

Source : State of Environment 1996

## Hot Spot of Endemicism








Different types of fire:

**- prescribed burning**
**the result is a low intensity, low severity fire that reduces the fuel and does not affect the overstorey**

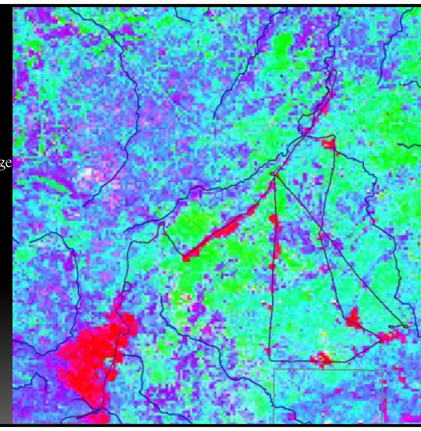
**INITIAL RUN**

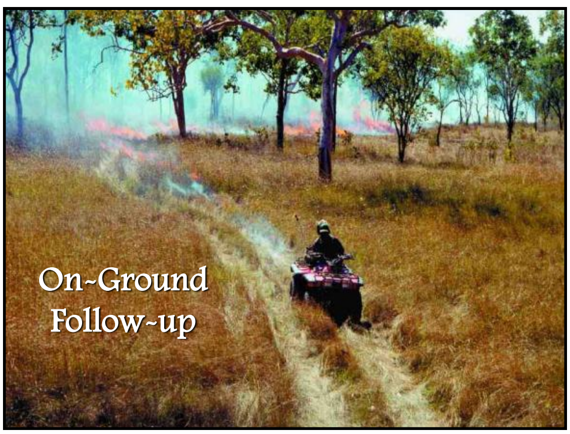
Aerial Prescribed Burning

9th May

MODIS satellite image

12th May





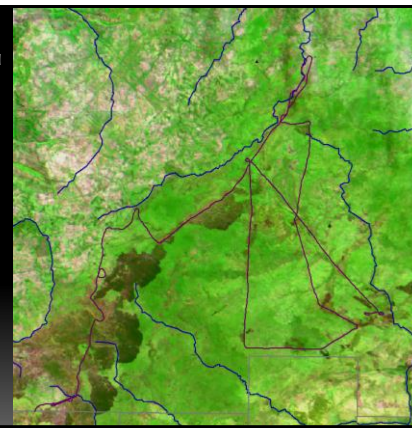

**FOLLOW UP**

**Aerial Prescribed Burning**

**30th May**

**MODIS satellite image**

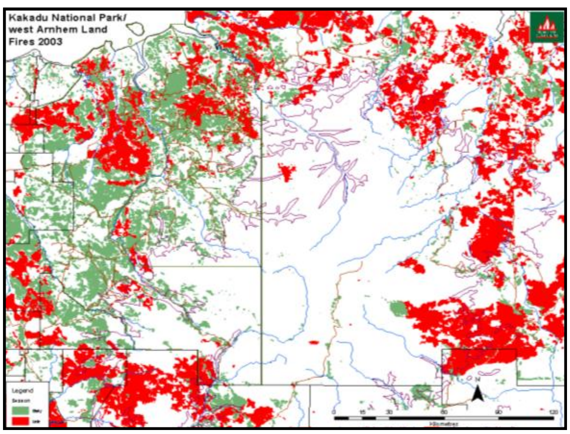
**2nd June**

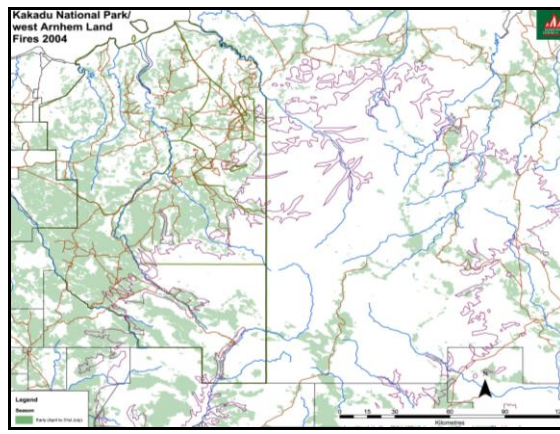


Different types of fire:

- **Wildfires**

**the result is total canopy consumption**
**local extinction of obligate seeders and species with small home ranges**


Kakadu National Park/
west Arnhem Land
Fires 2003
Legend
Season
0 15 30 60 90 120
Kilometres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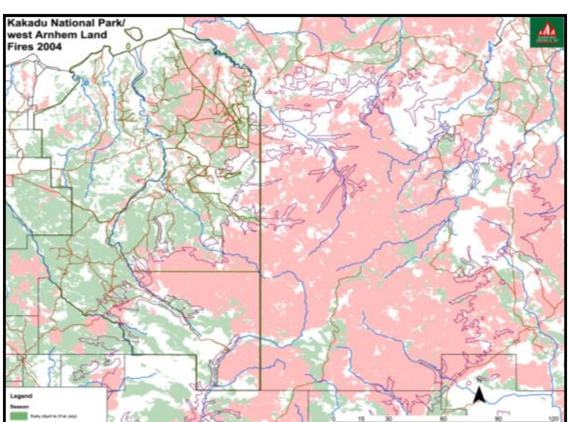
Kakadu National Park/
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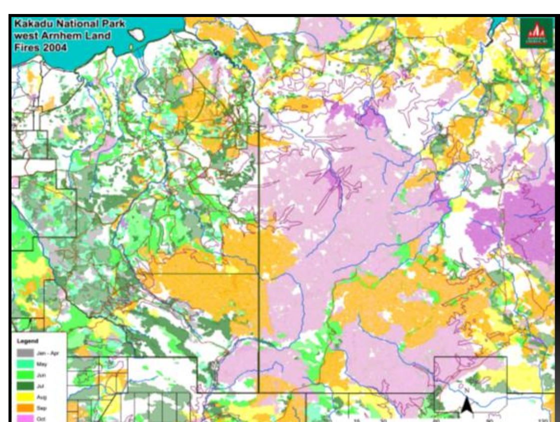
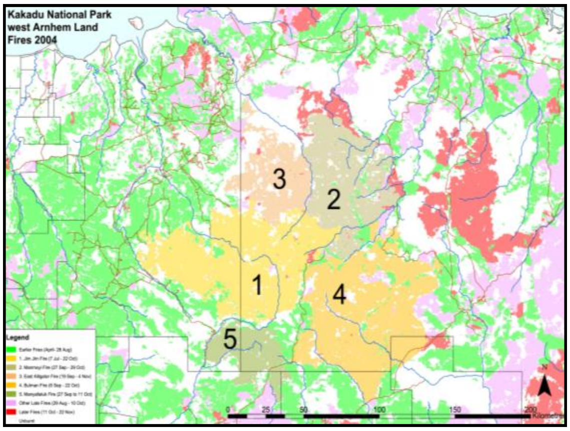
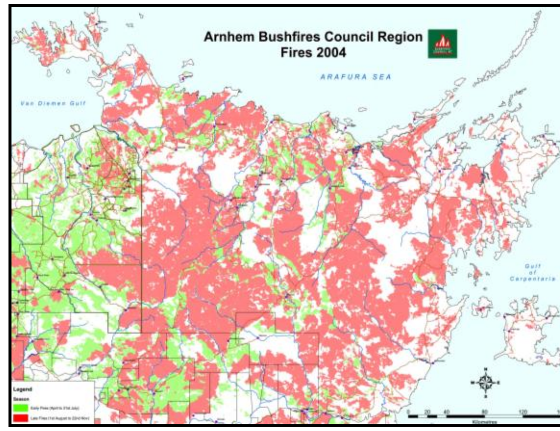
Season
0 15 30 60 90 120
Kilometres


Kakadu National Park
west Arnhem Land
Fires 2004
Legend
Jan - Apr
May
Jun
Jul
Aug
Sep
Oct
Nov - Dec
0 15 30 60 90 120
Kilometres




Rabbit Eared Rat

*(Conilurus penicillatus)*

Home Range < 1 ha

Quoll or Native Cat

*(Dasyurus hallucatus)*

Home Range: ~ 1km²

Black Footed Tree Rat

*(Mesembriomys gouldii)*

Home range: 1 ha to 1 km²

Rock Myrtle

*(Petraeomyrtus punicea)*

Shrub, found in rocky heaths

Time to reseed 6 years

Cypress Pine (*Callitris intratropica)*

Tree found in woodlands

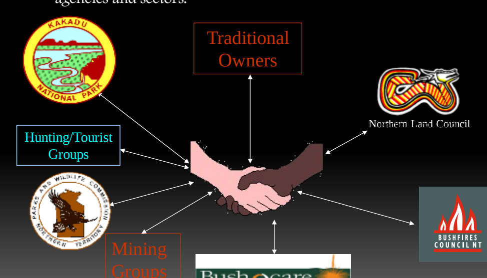
Time to reseed >>10 years

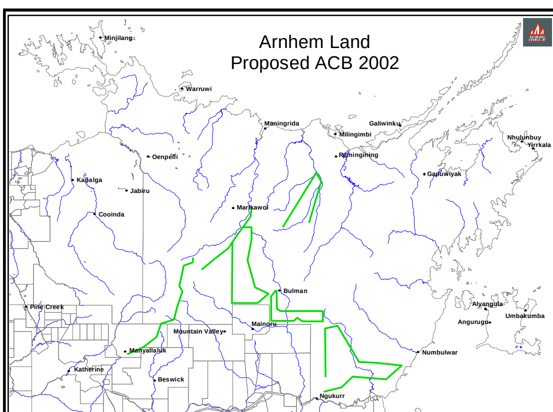

TROPICAL SAVANNAS CRC
Cooperative Research Centre for the Sustainable Development of Tropical Savannas

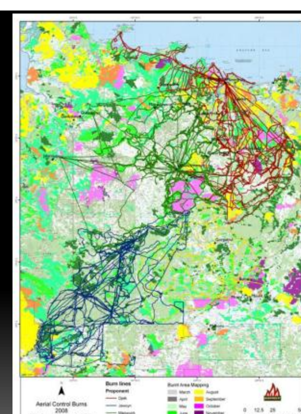
Natural Heritage Trust

## AIMS:

**Network of people** ~ thorough consultation with aboriginal custodians and organisations, and relevant regional agencies and sectors.



## Two toolboxes:

- indigenous knowledge
➔ how, where, why we burn

-western science:
➔ satellite image interpretation
➔ecological analysis

Result:
➔ improved conservation management
➔ calculation of greenhouse gas emissions
➔ **vastly improved resources and employment**



Fully trained and equipped, young Indigenous Rangers prepare for fire suppression

Young Indigenous Rangers creating a fire break against the threat of a wildfire in "Catastrophic" fire weather conditions

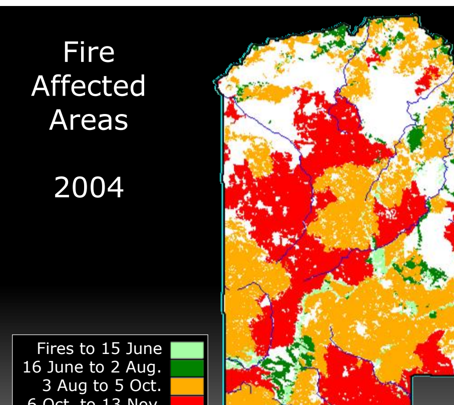
Young Indigenous Ranger using an innovative technique to create a fire break

Indigenous Rangers creating a mineral earth fire break to halt an impending wildfire

## Spatial Analyses

## Fire Affected Areas

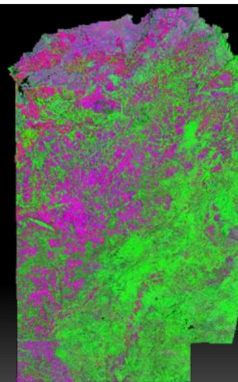
## 2004



## Normalised Difference Vegetation Index

Uses Ratio of Red and Near Infra Red to highlight Vegetation

$$NDVI = \frac{(Red - NIR)}{(Red + NIR)}$$



NDVI is directly related to the photosynthetic capacity and hence energy absorption of plant canopies (Sellers 1985 and Myneni et al. 1995)

## Geomorphological Mapping[1]

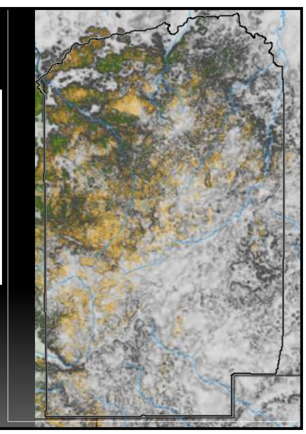
Sandstone
non-Sandstone

[1] derived from Lynch & Wilson **Land Systems of Arnhem Land** Technical Report No R97/1 Palmerston NT Australia

Slope

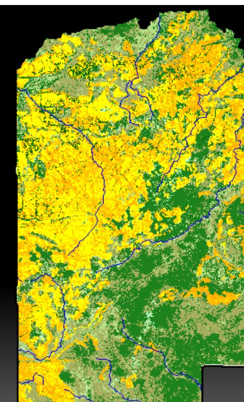
Elevation

Roughness



## Habitat Mapping

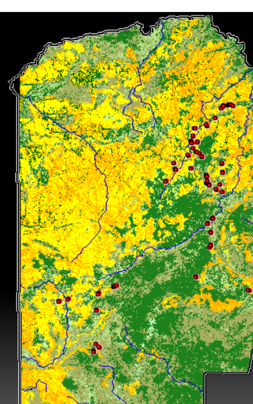
Closed Forest
Open Forest
Woodland
Sandstone Woodland
Sandstone Heath



## Classification refinement

140 sites

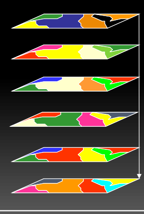
→ 420 x 100m transects



Fuel accumulation
➔
Time since last burnt

Fire Histories

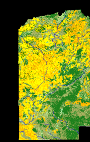
yr 1
+ yr 2
+ yr 3
+ yr 4
+ yr 5
.....
+ yr n



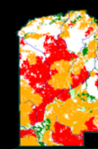
**Analysis:**

**COMBINE**

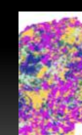
**Fuels Mapping**

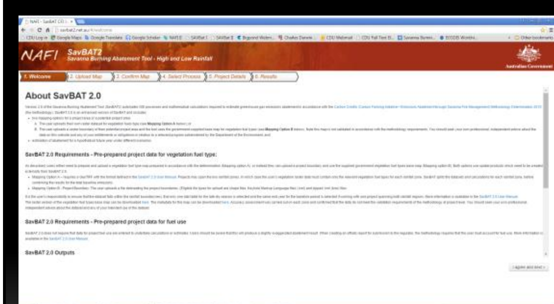


**Fire Mapping**



**Time Since Last Burnt Map**






# Savanna wide Risk Analyses

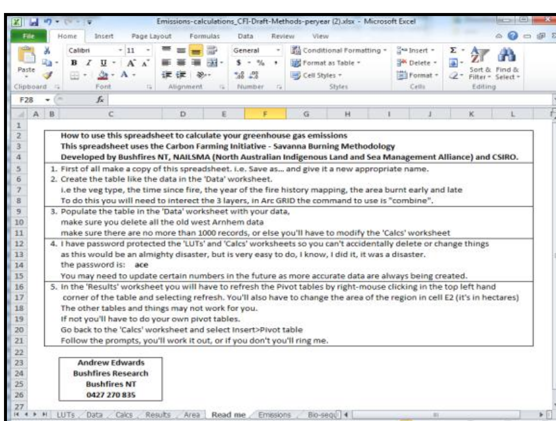
## Key risk attribute models

**(a) Greenhouse gas emissions abatement**

Applying the nationally accepted Australian model savanna burning emissions (E) are calculated as the product of the mass of fuel pyrolised (FP) and the emission factor (EF) of respective accountable GHG (g) species:

**E = FP * EF(g)**

where FP is the product of the area exposed to fire (A) taking into account spatial patchiness, the fuel load (FL) in respective fuel classes, and the burning efficiency (BEF) defined as the mass of fuel exposed to fire that is pyrolised. EF(g) is defined relative to the fuel elemental content where, for carbon species, EF(g) is expressed relative to fuel carbon, and nitrogen species are expressed relative to fuel nitrogen. Fuel carbon mass is determined from fuel mass by the fuel carbon content, while fuel nitrogen is derived from the fuel mass by the product of carbon content and the fuel nitrogen to carbon ratio. Units of emissions (E) are given as Mt $CO_2$-e, taking into account the enhanced respective warming potential of accountable gases ($CH_4$, $N_2O$) relative to $CO_2$.



Emissions-calculations_CFI-Draft-Methods-peryear (2).xlsx - Microsoft Excel

**How to use this spreadsheet to calculate your greenhouse gas emissions**
**This spreadsheet uses the Carbon Farming Initiative - Savanna Burning Methodology**
**Developed by Bushfires NT, NAILSMA (North Australian Indigenous Land and Sea Management Alliance) and CSIRO.**

1. First of all make a copy of this spreadsheet. i.e. Save as... and give it a new appropriate name.
2. Create the table like the data in the 'Data' worksheet.
   i.e the veg type, the time since fire, the year of the fire history mapping, the area burnt early and late
   To do this you will need to interect the 3 layers, in Arc GRID the command to use is "combine".
3. Populate the table in the 'Data' worksheet with your data,
   make sure you delete all the old west Arnhem data
   make sure there are no more than 1000 records, or else you'll have to modify the 'Calcs' worksheet
4. I have password protected the 'LUTs' and 'Calcs' worksheets so you can't accidentally delete or change things
   as this would be an almighty disaster, but is very easy to do, I know, I did it, it was a disaster.
   the password is: ace
   You may need to update certain numbers in the future as more accurate data are always being created.
5. In the 'Results' worksheet you will have to refresh the Pivot tables by right-mouse clicking in the top left hand corner of the table and selecting refresh. You'll also have to change the area of the region in cell E2 (it's in hectares)
   The other tables and things may not work for you.
   If not you'll have to do your own pivot tables.
   Go back to the 'Calcs' worksheet and select Insert>Pivot table
   Follow the prompts, you'll work it out, or if you don't you'll ring me.

**Andrew Edwards**
**Bushfires Research**
**Bushfires NT**
**0427 270 835**

LUTs / Data / Calcs / Results / Area / Read me / Emissions / Bio-sequ

## Key risk attribute models

### (b) Savanna burning bio-sequestration

Based on assessment of 10 years of long-term monitoring data for 135 plots, the annual proportional change in tree biomass carbon stocks for both lowland and upland woodland savannas can be given as:

**New C Biomass (t.ha$^{-1}$) = C biomass * ((1.45 - 0.11 * ln(C biomass) + b)^(1/6))**

Where (1) if fire severity = mild, moderate, severe, then b = -0.1, -0.15, -0.53 respectively, and (2) assuming an initial tree carbon biomass of 25.8 t.ha$^{-1}$

### (c) Fire-sensitive obligate seeder plants

#### (i) Callitris intratropica

Based on assessment of 15 years fire regime observations at 18 long-term monitoring plots, change in stem ($\geq$ 5 cm DBH) density in topographically variable terrain can be given as:

Stem density = 1.33 – 1.15 * frq_sev

where (1) frq_sev = the frequency of moderately severe and severe fires over the assessment period, and (2) assuming an initial stem density of 99.8 stems.km-²

#### (ii) Longer-maturing (LOS) shrub taxa

Based on assessment of 15 years fire regime observations at 34 long-term monitoring plots, change in numbers of longer-maturing ($\geq$3 yr) obligate seeder shrub taxa in topographically variable terrain can be given as:

Number of LOS taxa = 0.89 – 0.26 * fire frq

where (1) fire frq = frequency of fires over the assessment period, and (2) assuming an initial complement of 2.27 LOS taxa.0.01 ha$^{-1}$

## Key risk attribute models

### (d) Erosion effects

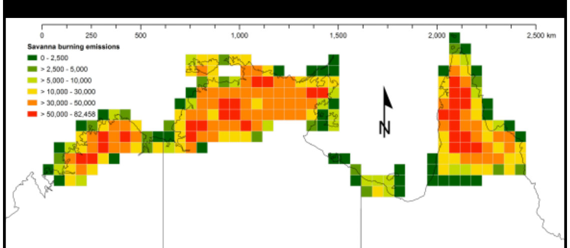
Based on replicated assessment of the effects of Late Dry Season burning on soil movement at two hill-slope sites, the effects of Late Dry Season fires on soil movement in topographically variable terrain can be given as:

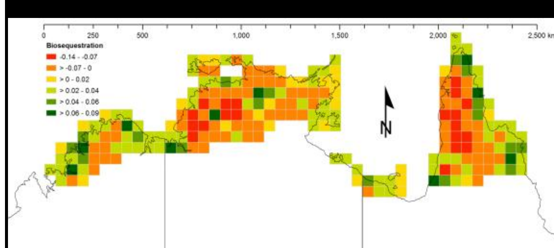
**Soil movement (t.ha$^{-1}$) = (2.0 * frq_nonLDS + 4.21 * frq_LDS) * 22.8**

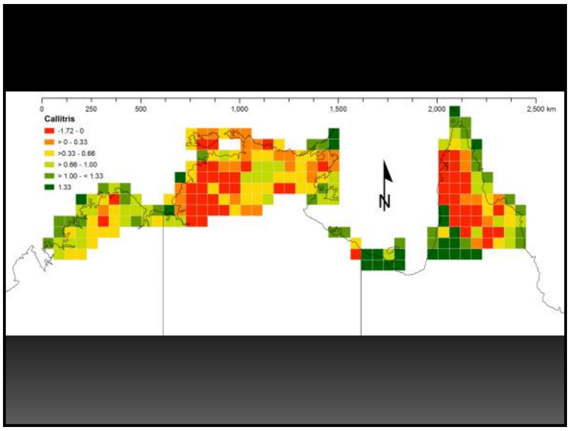
where (1) frq_non-LDS is the mean frequency of Unburnt and Early Dry Season fires combined, frq_LDS is the mean frequency of Late Dry Season fires, and (2) assuming each 1 mm of soil movement results in movement of 22.8 t.ha$^{-1}$ of fine earth and coarse fragments

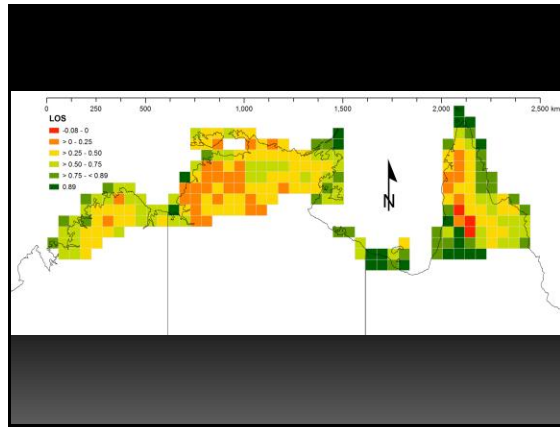
Scenarios: BAU = Business as Usual  CCI = Climate Change Impacts  IFM = Improved Fire Managem

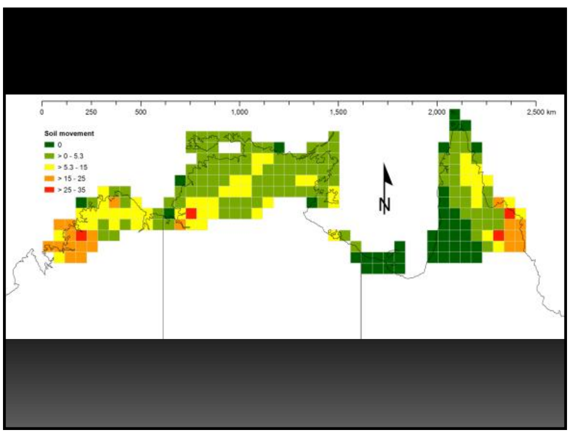
| 2008-2012 | BAU benchmark | BAU+CCI | IFM | IFM+CCI |
|---|---|---|---|---|
| Fire seasonality | EDS = 0.19; LDS = 0.34 | EDS = 0.19; LDS = 0.44 | EDS = 0.29; LDS = 0.17 | EDS = 0.29; LDS = 0.22 |
| Fire severity | mild = 0.25<br>moderate = 0.17<br>severe = 0.11 | mild = 0.28<br>moderate = 0.21<br>severe = 0.14 | mild = 0.28<br>moderate = 0.12<br>severe = 0.06 | mild = 0.30<br>moderate = 0.14<br>severe = 0.07 |
| **Effects on key risk attributes** | | | | |
| Bio-sequestration (Mt C.y-¹) | -0.641 ± 0.002 | -6.86 ± 0.02 (-1078%) | 5.51 ± 0.01 (+959%) | 2.75 ± 0.006 (+538%) |
| Obligate seeders<br>- Callitris (Increase in Stems.km-²) | 100.25 ± 0.04 | 99.93 ± 0.05 (-0.32%) | 100.44 ± 0.03 (+0.19%) | 100.28 ± 0.04 (+0.03%) |
| Obligate seeders<br>- Longer-maturing shrubs<br>(Species.0.1 ha$^{-1}$) | 2.75 ± 0.02 | 2.66 ± 0.02 (-3.3%) | 3.08 ± 0.02 (+12%) | 2.77 ± 0.02 (+0.7%) |
| Erosion effects<br>- soil movement (t.ha$^{-1}$)* | 50 | 63 (+26%) | 28 (-44%) | 34 (-32%) |






where does this all lead?

➔ ➔ ➔

Payment for Ecosystem Services (PES)