Greenhouse gas fluxes and land use in savanna ecosystems

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Outline

• Project details
• Results
  – seasonality, fire and conversion to pasture
  – environmental drivers: soil temperature, soil water content, soil nitrate and ammonia
• Average values and conclusions
• Acknowledgements: Hizbullah Jamali, Bianca Baldiserra, other authors
GHG dynamics and nutrient cycling in north Australian savannas

Spatial and temporal variability
Land use change
Mechanisms controlling emissions
Physical, chemical and biological soil properties
Effect of Fire
Contribution of termites

Eddy-covariance towers
Automated trace gas system
Manual trace gas chambers
Soil nutrients and moisture
Modelling (NCAS, DNDC)

ARC LP0774812
Seasonality; Fire

Howard Springs

- CO₂ (mgC m⁻² h⁻¹)
- N₂O (ugN₂O-N m⁻² h⁻¹)
- CH₄ (ugCH₄-C m⁻² h⁻¹)
Seasonality; Conversion to pasture

Douglas Daly

Graphs showing CO2 emissions (mg CO2-C m^{-2} h^{-1}) over time from September 2007 to December 2008 for different pasture types:

- **savanna**
- **5 year pasture**
- **25 year pasture**
Seasonality;

Conversion to pasture

Douglas Daly
Seasonality; Conversion to pasture

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CH4 (ug CH4-C m^2 h^-1)

savanna

5 year pasture

25 year pasture
Environmental drivers: soil temperature

- Burnt vs. unburnt savanna
- 5 year pasture
- 25 year pasture
Environmental drivers: soil temperature

- Soil temperature (°C) vs. N2O (µg N2O-N m⁻² h⁻¹)
  - Burnt vs. unburnt
  - Savanna
  - 5 year pasture
  - 25 year pasture
Environmental drivers: soil temperature

CH$_4$(ugCH$_4$-C m$^{-2}$h$^{-1}$)

Soil T (°C)

burnt unburnt

5 year pasture

savanna

25 year pasture

CH$_4$(ugCH$_4$-C m$^{-2}$h$^{-1}$)

Soil T (°C)
Environmental drivers: soil water content

- Burnt
- Unburnt
- 5 year pasture
- 25 year pasture
- Savanna
Environmental drivers: soil water content

- **Burnt vs. Unburnt**
  - 5 year pasture
  - 25 year pasture

θᵥ (cm³ cm⁻³) vs. N₂O (μg N₂O-N m⁻² h⁻¹)
Environmental drivers: soil water content

5 year pasture

25 year pasture

θv (cm³ cm⁻³)

CH₄(ugCH₄-C m⁻² h⁻¹)

burnt unburnt
Environmental drivers: soil nitrogen

![Graphs showing relationship between \( \text{NO}_3^- \) and \( \text{N}_2\text{O} \) emissions across different environments and years.](image)
Environmental drivers: soil nitrogen

- **NH₄⁺ (mgN kg⁻¹)** vs. **N₂O (ug N₂O-N m⁻² h⁻¹)**
  - Burnt vs. Unburnt savanna
  - 5 year pasture
  - 25 year pasture
### Seasonal Averages

*Howard Springs: no effect of fire*

<table>
<thead>
<tr>
<th></th>
<th>CO\textsubscript{2} (mgCm\textsuperscript{-2}h\textsuperscript{-1})</th>
<th>N\textsubscript{2}O (µg N\textsubscript{2}O-N m\textsuperscript{-2}h\textsuperscript{-1})</th>
<th>CH\textsubscript{4} (µg CH\textsubscript{4}-C m\textsuperscript{-2}h\textsuperscript{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Build up</td>
<td>172</td>
<td>0</td>
<td>-21</td>
</tr>
<tr>
<td>Wet</td>
<td>422</td>
<td>0.4</td>
<td>-18</td>
</tr>
<tr>
<td>Dry</td>
<td>219</td>
<td>0</td>
<td>-21</td>
</tr>
</tbody>
</table>
## Seasonal Averages

**Douglas Daly: land use change**

<table>
<thead>
<tr>
<th></th>
<th><strong>CO₂</strong> (mgCm⁻²h⁻¹)</th>
<th><strong>N₂O</strong> (µg N₂O-N m⁻²h⁻¹)</th>
<th><strong>CH₄</strong> (µg CH₄-C m⁻²h⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>savanna 5 year pasture</td>
<td>savanna 25 year pasture</td>
<td>savanna 5 year pasture</td>
</tr>
<tr>
<td><strong>Build up</strong></td>
<td>254 334 426</td>
<td>0.1 0.8 3.9</td>
<td>-32 -19 7</td>
</tr>
<tr>
<td><strong>Wet</strong></td>
<td>659 894 633</td>
<td>2.6 2.3 2.4</td>
<td>-12 -8 182</td>
</tr>
<tr>
<td><strong>Dry</strong></td>
<td>103 117 125</td>
<td>0 0 0</td>
<td>-38 -28 -4</td>
</tr>
</tbody>
</table>
Conclusions

• Fire appears to have little effect on ghg emissions from savanna soils
• Conversion to pasture affects ghg emissions from savanna soils, increasing sources of CO$_2$ and N$_2$O, and decreasing sinks of CH$_4$
• Seasonal variation evident in fluxes
• CO$_2$ fluxes driven by soil temperature and water content
• N$_2$O and CH$_4$ fluxes driven primarily by soil water content
Conversion to pasture

Seasonality:

Douglas Daly

Figure: Seasonality of 
N2O (ugN2O-N m^-2 h^-1) emissions for 5 year and 25 year pastures.
Environmental drivers: soil temperature

- Soil T (°C) vs. N2O(ugN2O-N m^{-2}h^{-1}) for burnt and unburnt savanna (top left).
- Soil T (°C) vs. N2O(ugN2O-N m^{-2}h^{-1}) for 5 year pasture (top right).
- Soil T (°C) vs. N2O(ugN2O-N m^{-2}h^{-1}) for savanna (bottom left).
- Soil T (°C) vs. N2O(ugN2O-N m^{-2}h^{-1}) for 25 year pasture (bottom right).
Environmental drivers: soil temperature

Soil T (°C)

CH₄(ugCH₄-C m⁻²h⁻¹)

burnt
unburnt

5 year pasture

savanna

25 year pasture

Soil T (°C)
Environmental drivers: soil water content

- 5 year pasture
- 25 year pasture
- burnt
- unburnt
- savanna

\[ \theta_v \text{ (cm}^3\text{cm}^{-3}) \]

\[ N_2O (\text{ugN}_2\text{O-N m}^{-2}\text{h}^{-1}) \]

\[ \theta_v \text{ (cm}^3\text{cm}^{-3}) \]
Environmental drivers: soil nitrogen
Environmental drivers: soil nitrogen

\[ \text{N}_2\text{O} \text{ (ug N}_2\text{O-N m}^{-2}\text{ h}^{-1}) \]

\[ \text{NH}_4^+ \text{ (mg N kg}^{-1}\text{)} \]

5 year pasture

\[ \text{N}_2\text{O} \text{ (ug N}_2\text{O-N m}^{-2}\text{ h}^{-1}) \]

\[ \text{NH}_4^+ \text{ (mg N kg}^{-1}\text{)} \]

25 year pasture

\[ \text{N}_2\text{O} \text{ (ug N}_2\text{O-N m}^{-2}\text{ h}^{-1}) \]

\[ \text{NH}_4^+ \text{ (mg N kg}^{-1}\text{)} \]

savanna