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Stand age related differences in non-CO_2 soil atmosphere GHG-exchange in wet temperate Eucalyptus forests of SE Australia

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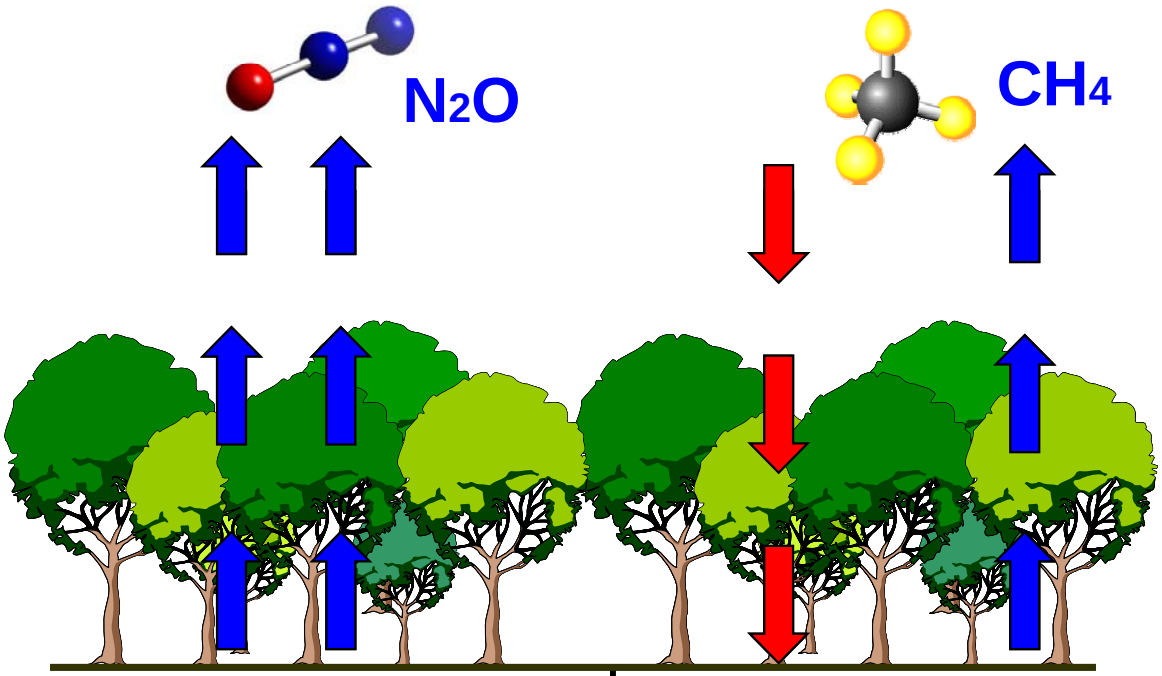
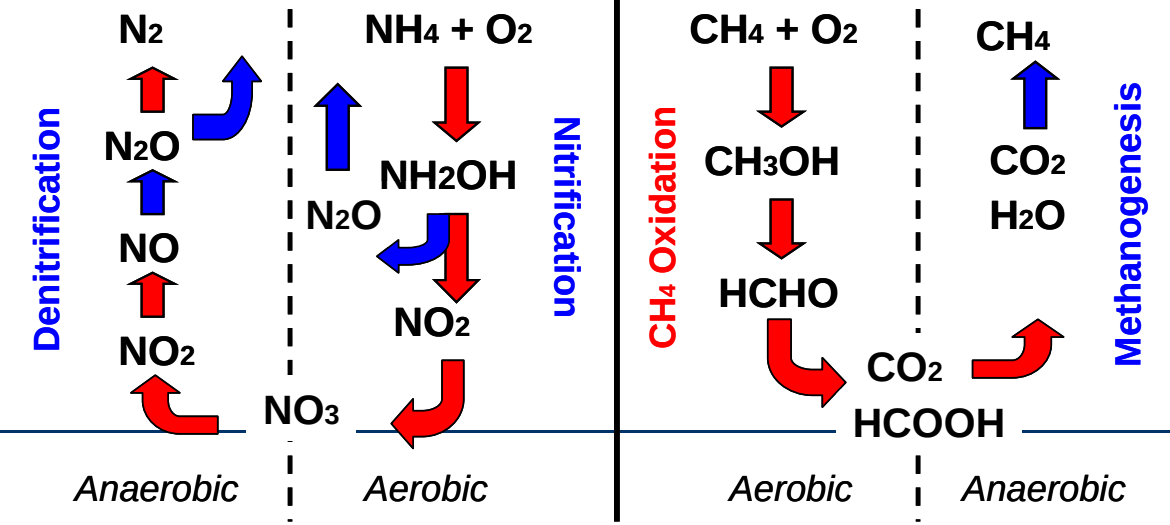
Processes behind non-CO_2 soil GHG-flux





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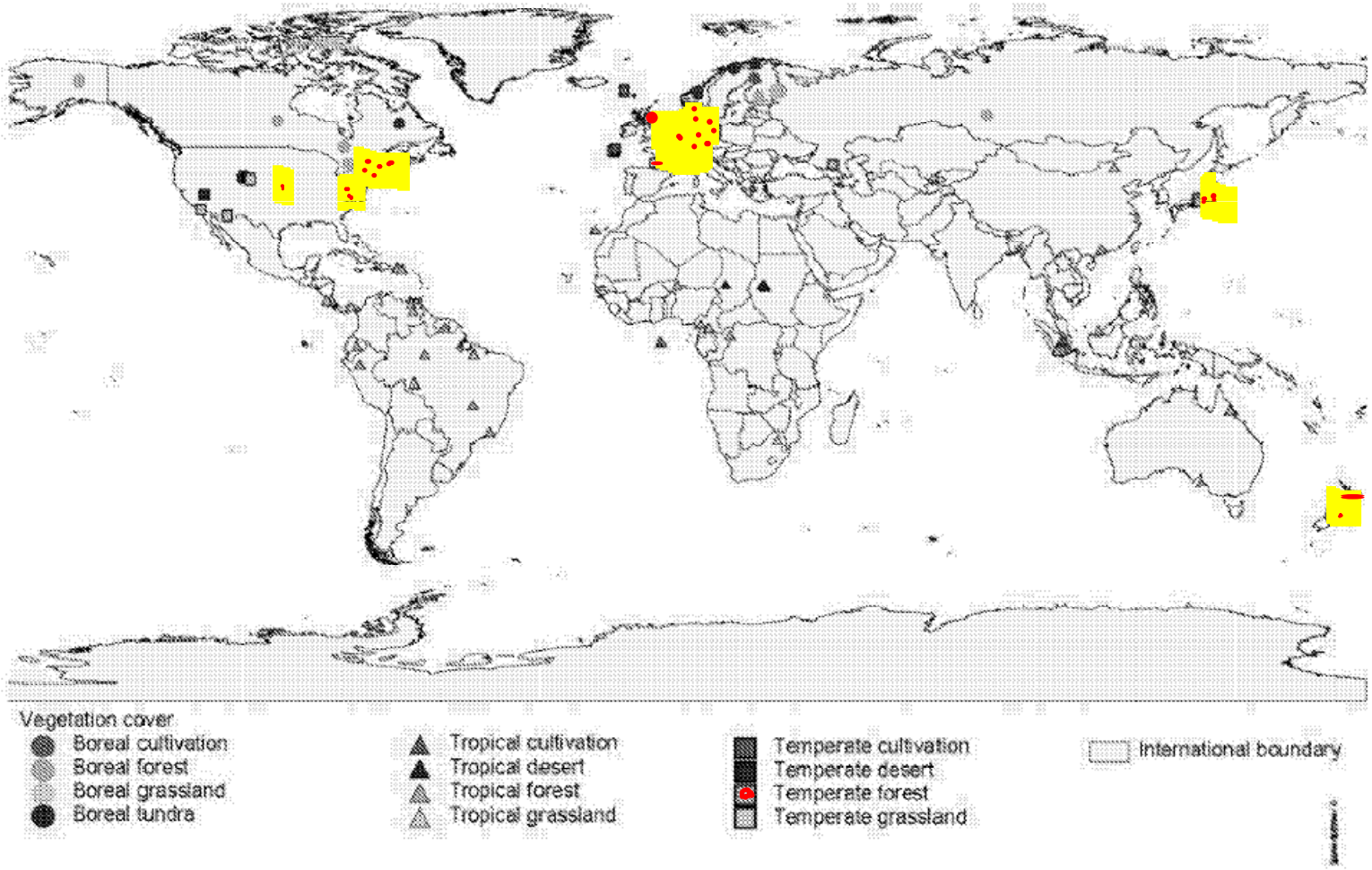
Research rationale



after Dataur and Verchot 2007

Research rationale

Uniqueness of Australian forest systems

- Old, weathered soils with a low nutrient status (especially nitrogen and phosphorous)
- Repeated changes to soil properties due to wildfire
  - Direct fire effects:
    - Physical:
      - Increase in Bulk Density after fire
      - Decrease in soil porosity
      - Decrease in soil permeability
      - Change in pH and EC
    - Chemical:
      - Quantity of organic matter decreases, quality changes
      - Nutrient availability increases sometimes remarkably (NH_4+)
    - Biological:
      - Composition of microbial community changes
      - Microbial biomass decreases

after *Certini et al. 2005*

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Research objective

Investigating the influence of the disturbance history (time since last disturbance) on soil CH_4 and N_2O flux in wet temperate eucalypt forests of SE Australia

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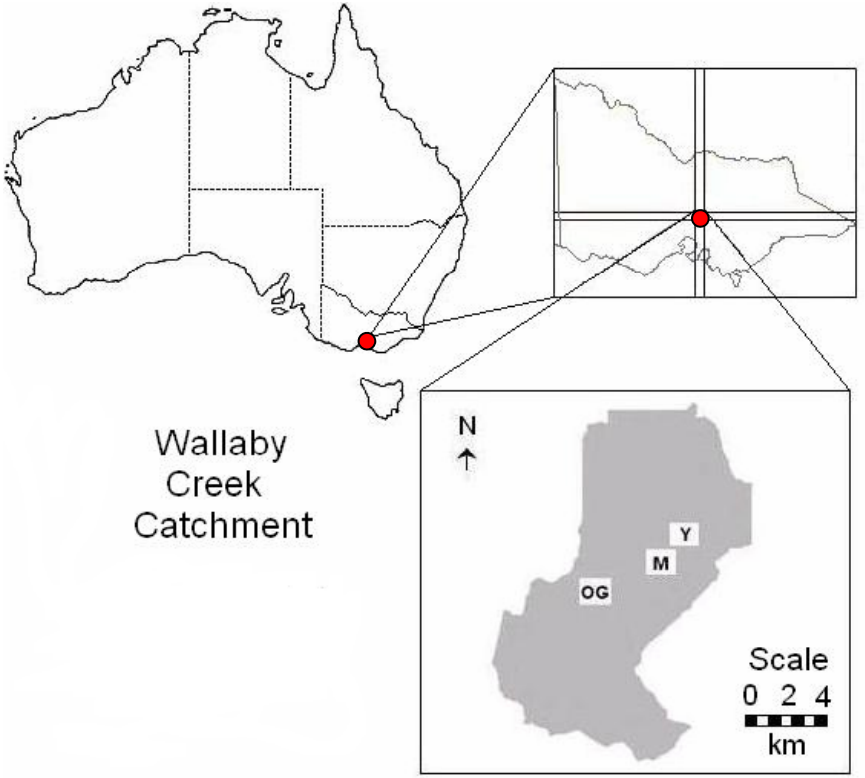
Case Study A King Lake NP

Wallaby Creek, King Lake NP (ca. 1200 mm precipitation y^{-1})

- 'Chrono-sequence' of 3 *Eucalyptus regnans* dominated forest stands that regenerated after stand replacing wildfires



Young (30 years old)

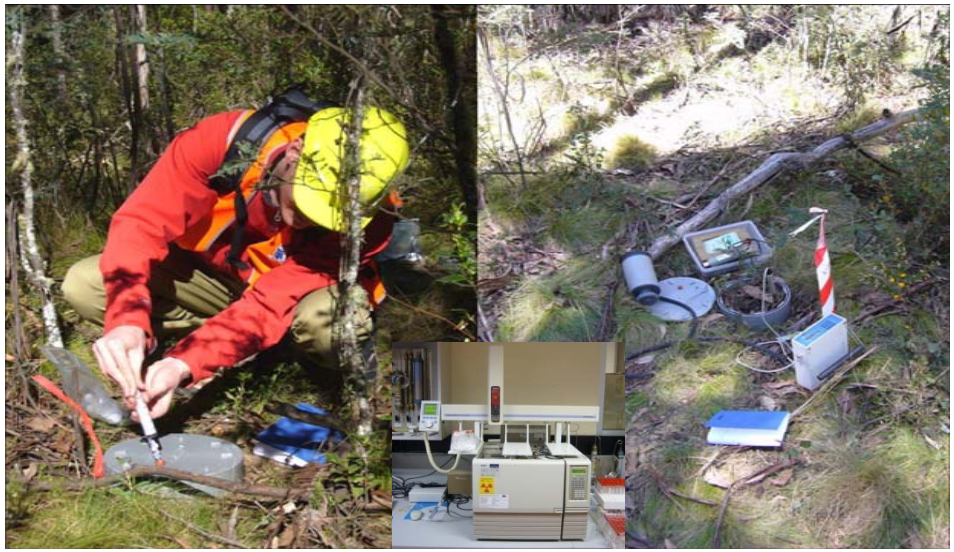
Mature (90 years old)

Old growth (around 300+ years old)

Sampling approach

Manual chamber incubations; to investigate **seasonal** variation of soil GHG exchange **within** forest stands and **spatial** variation **between** different aged forest stands

- King Lake NP:
  - 2x10 chambers along two 50 m transects per forest stand (Project started in 2006 and seasonal measurements were taken in 2008 up to the bushfire in February 2009)



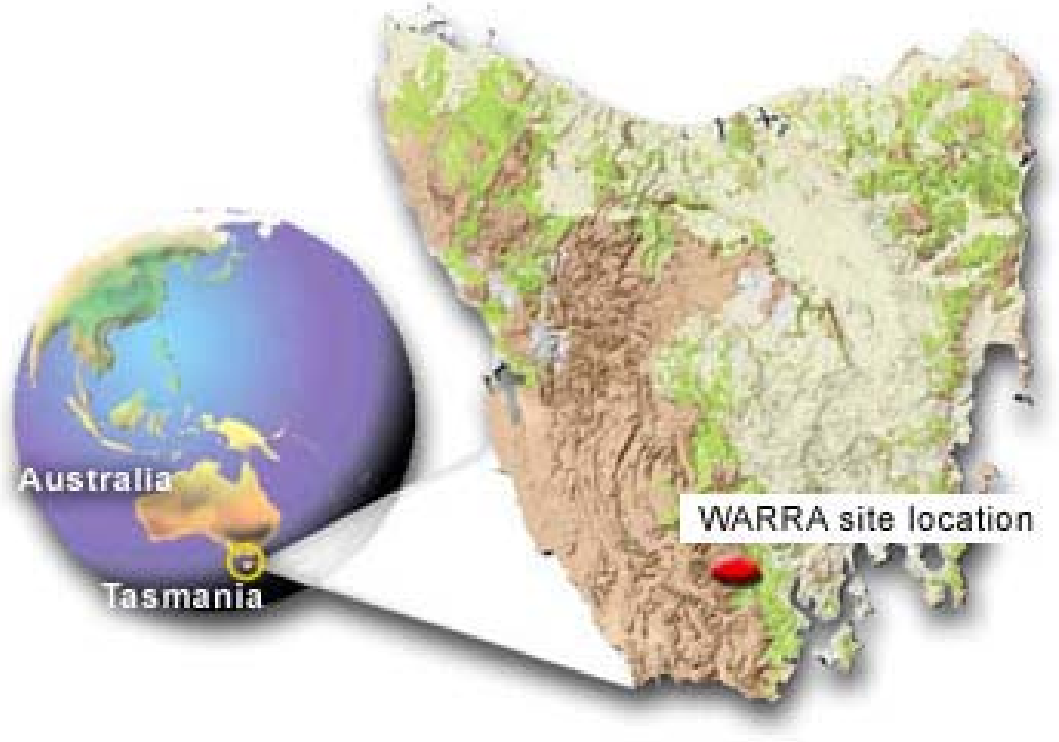
Additional measurements

- Established methods were used to determine:
  - soil bulk density
  - soil gravimetric, volumetric water content
  - soil temperature
  - soil pH and EC
  - particle size analyses
  - soil inorganic N status
  - soil total N, C, litter quantity
  - litter quality (N, C)

Case Study B Warra LTER

Warra LTER (ca. 1500 mm precipitation y^{-1})

- Chrono/disturbance –sequence' of 6 mixed *Eucalyptus obliqua* and *Eucalyptus regnans* forest stands



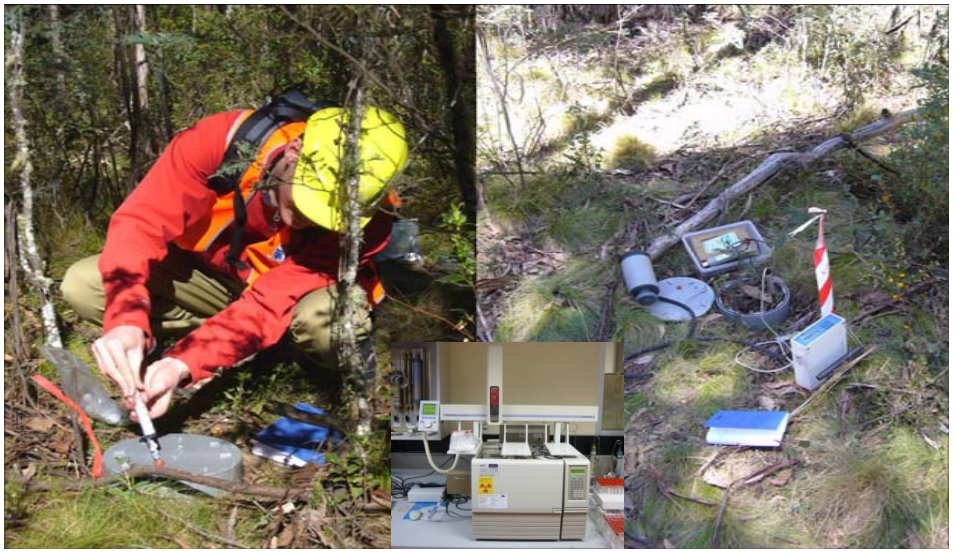
ID	History
01CS	2001 clear fell slash burn
66 CS	1966 clear fell slash burn
66S	1966 wildfire
34S	1934 wildfire
34/98S	Mix of 1934 and 1898 wildfire
OG	Over 200 years old

Sampling approach

Manual chamber incubations; to investigate **seasonal** variation of soil GHG exchange **within** forest stands and **spatial** variation **between** different aged forest stands

- Warra LTER
  - 3 plots a 5 chambers per forest stand, seasonal

    (Project started in 2009, seasonal measurements were taken until 03.2011)



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  - soil bulk density
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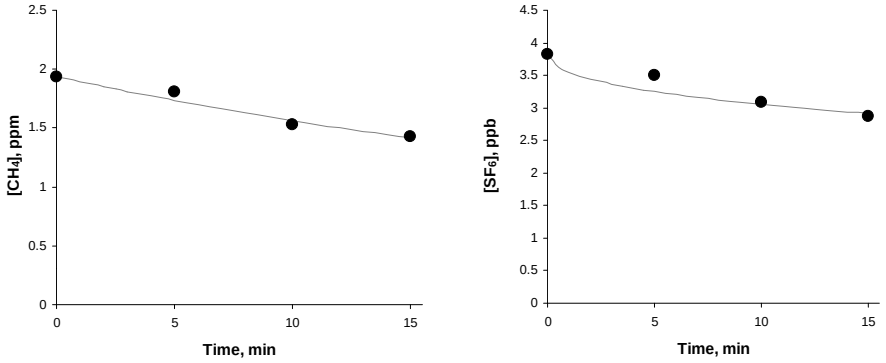
Reaction/diffusion model (von Fischer et al. in press)



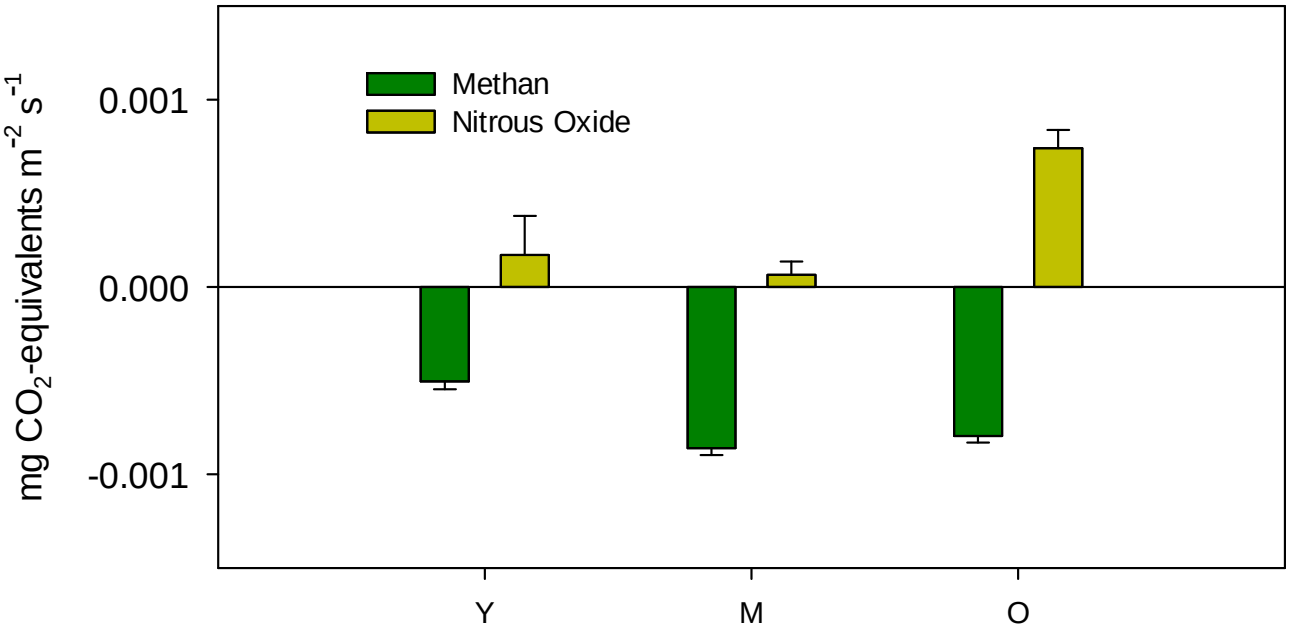
Reactive gas

Non-reactive gas

- A novel approach was used to determine soil diffusivity and methanotrophic activity at the Warra LTER (von Fischer et. al. 2009)
- Soil DNA extraction

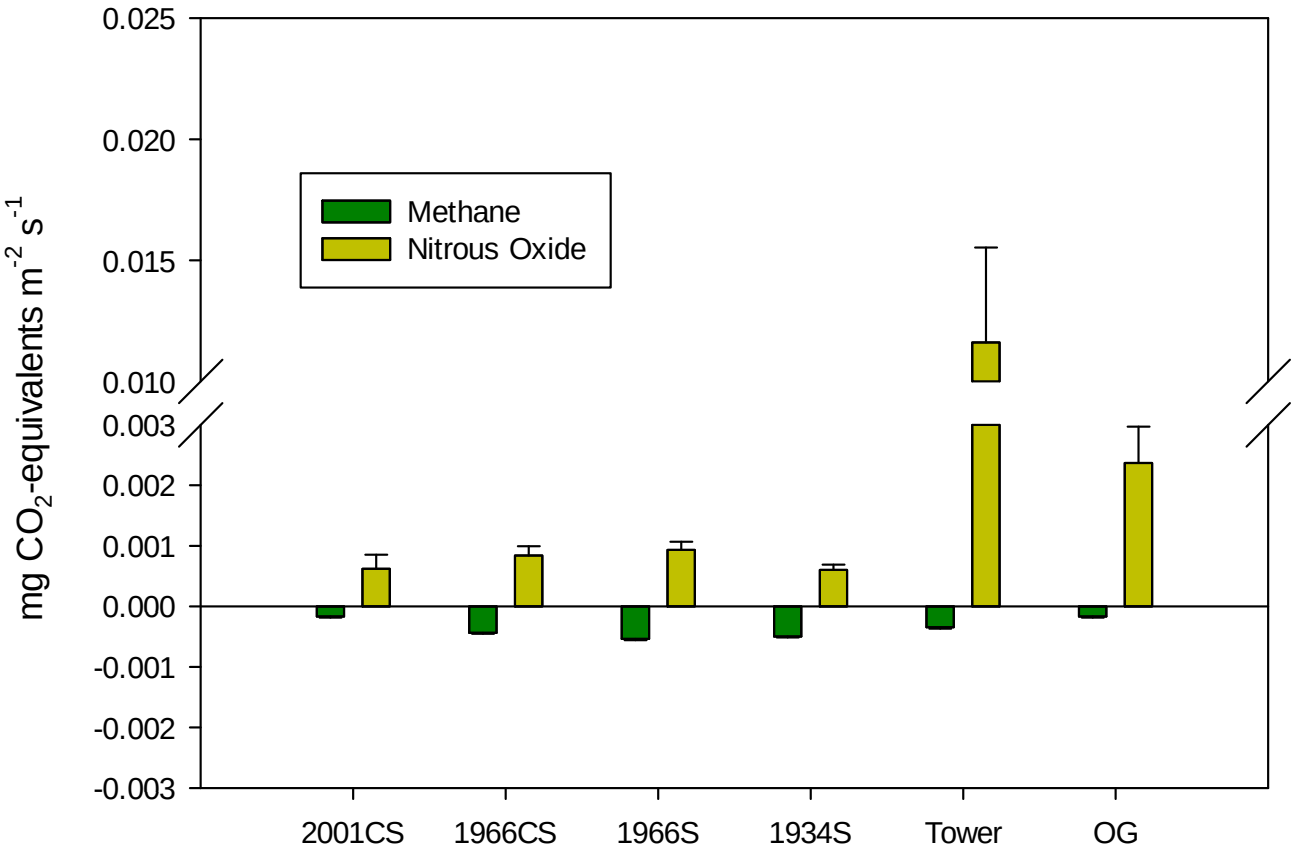
Soil atmosphere non-CO_2 GHG exchange between different age classes

King Lake NP



Soil atmosphere non-CO_2 GHG exchange between different age classes

Warra LTER



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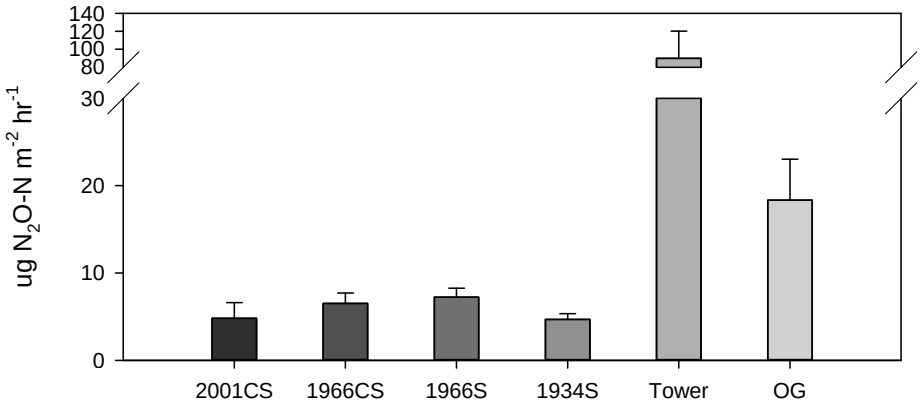
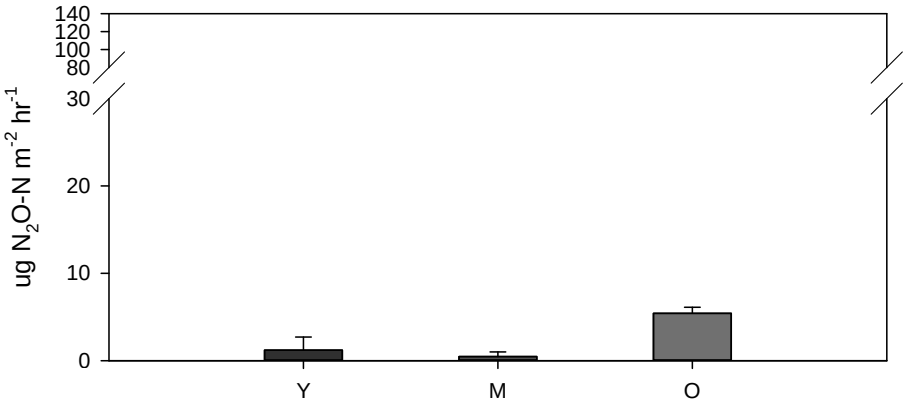
Difference in soil-atmosphere nitrous oxide exchange between stands of different age/disturbance history



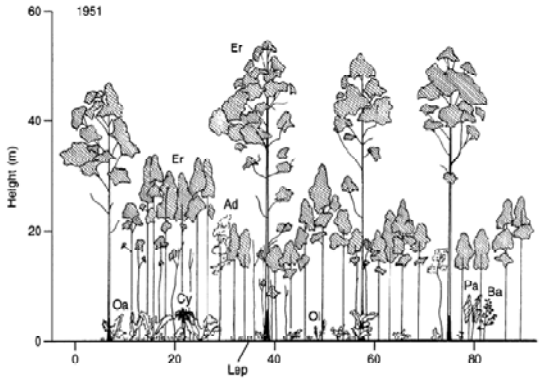
Warra LTER

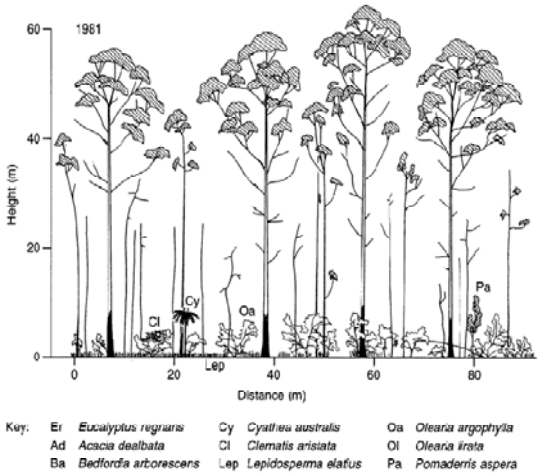


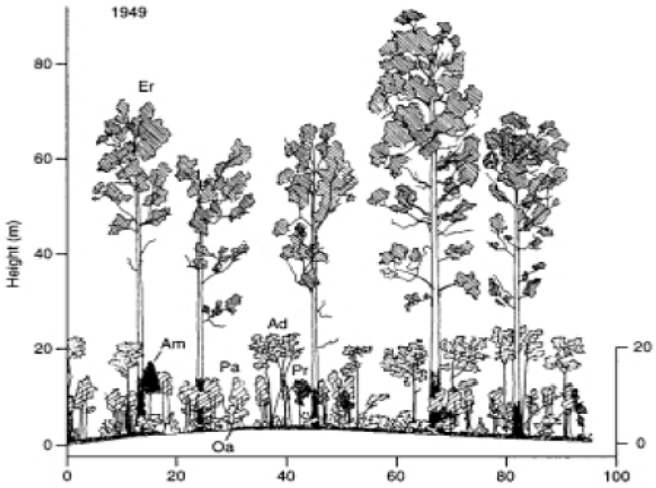
King Lake NP

Stand development

after Ashton, 2000, Aust. J. Bot.



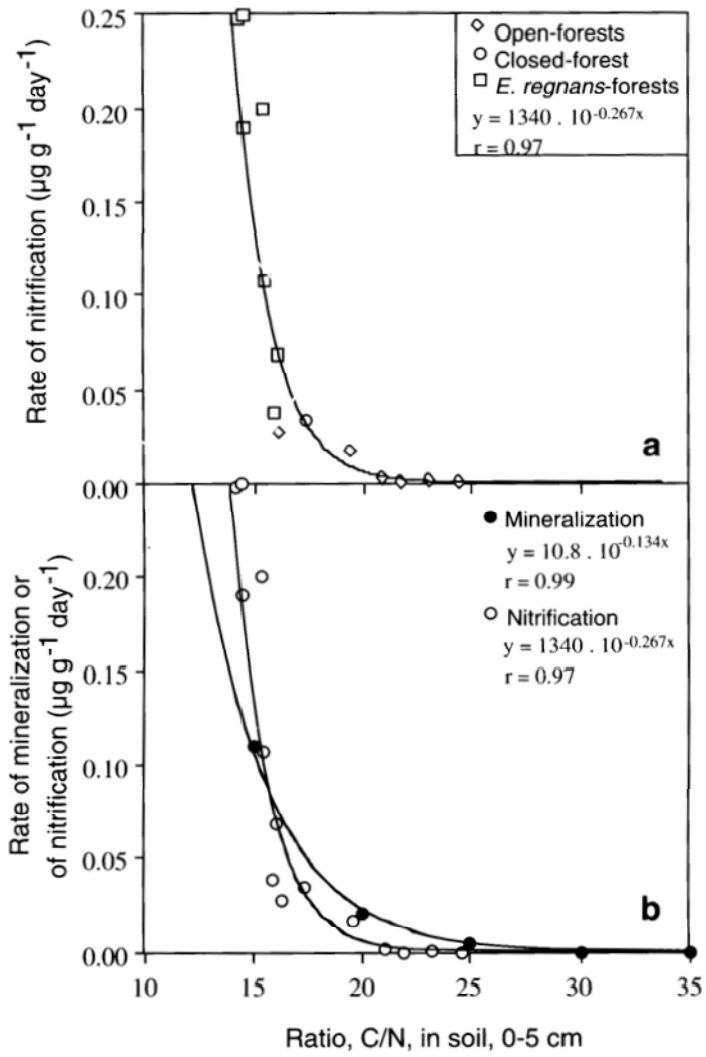




C/N ratio can determine nitrification and mineralisation processes

- Soil C/N ratio has been shown to determine the rate of nitrification and mineralization in eucalypt forest soils

- This might indirectly influence soil microbial activity



After Attiwill & May 2001, Mar.Freshwater Res.

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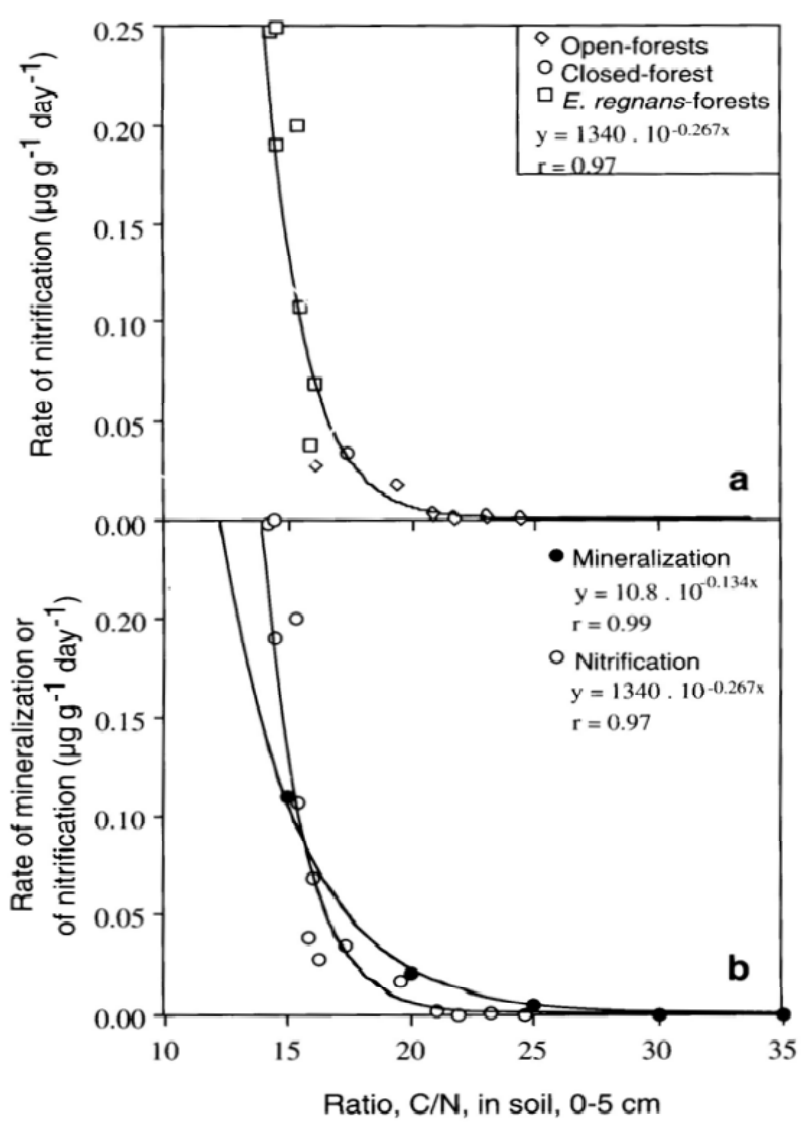
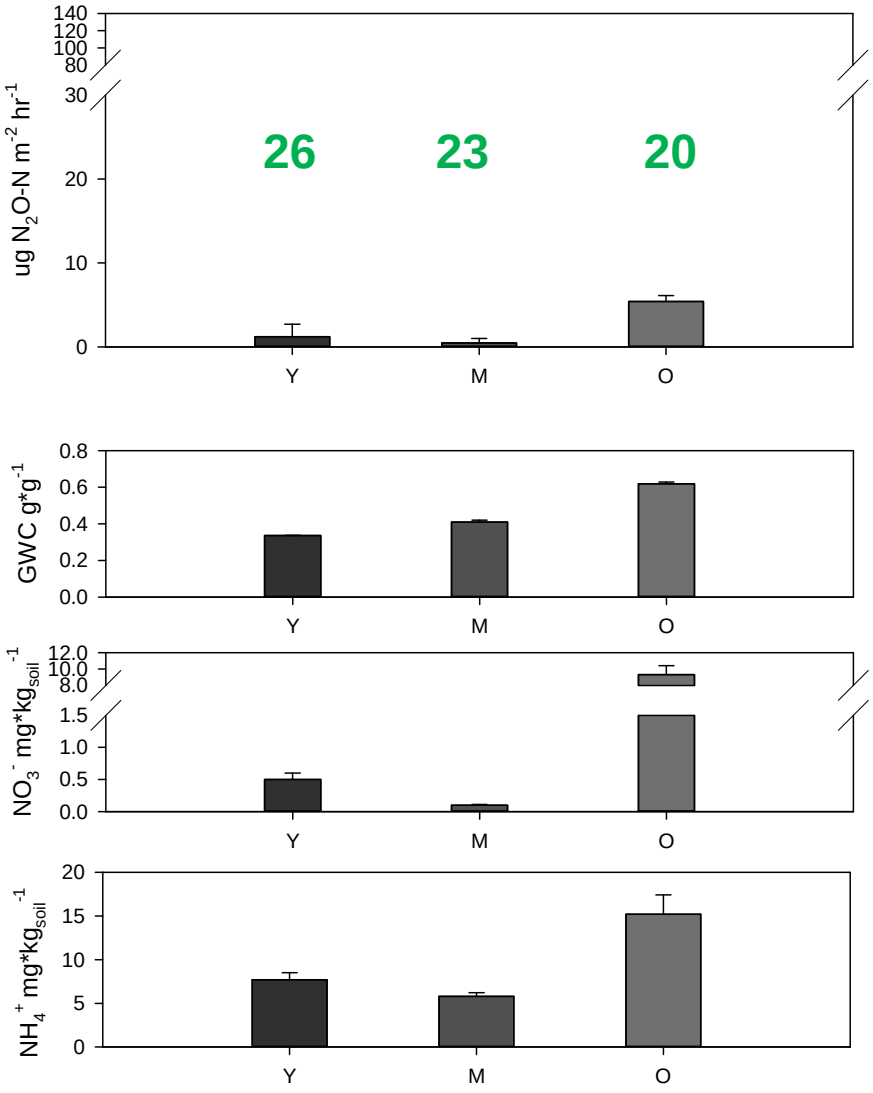
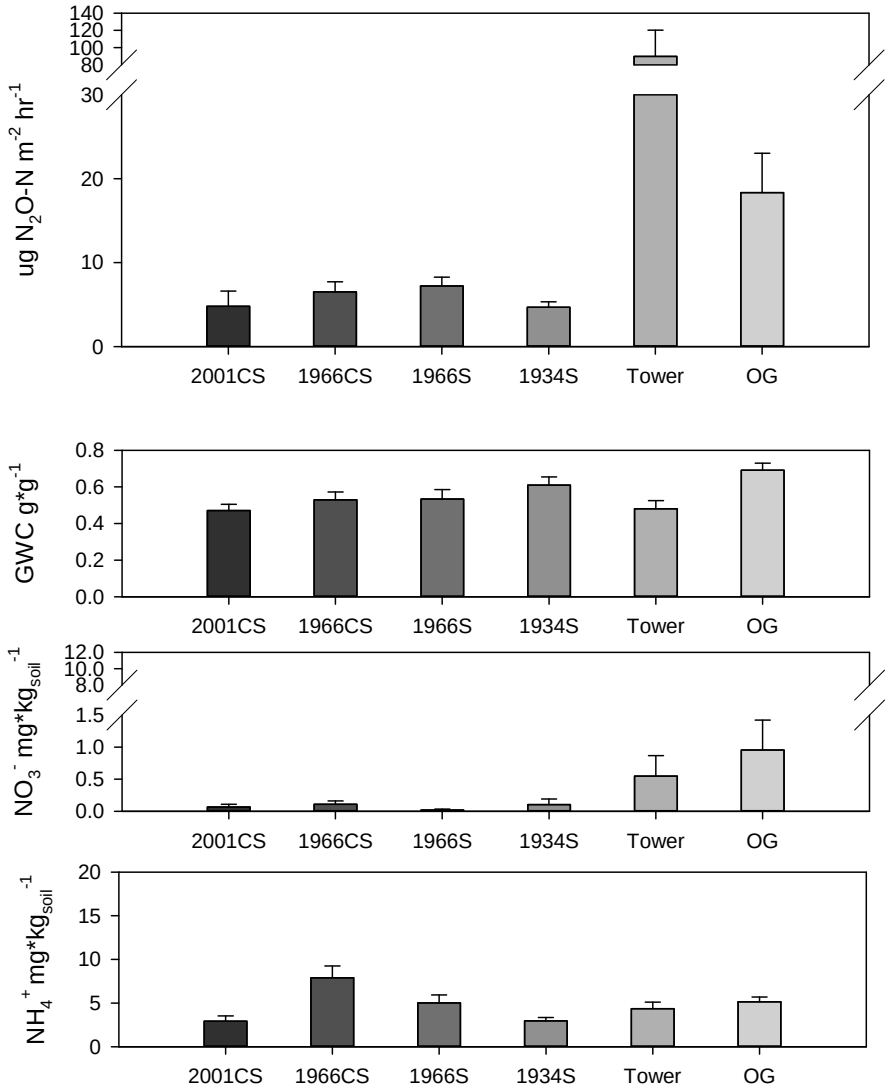
Difference in soil-atmosphere nitrous oxide exchange between stands of different age/disturbance history



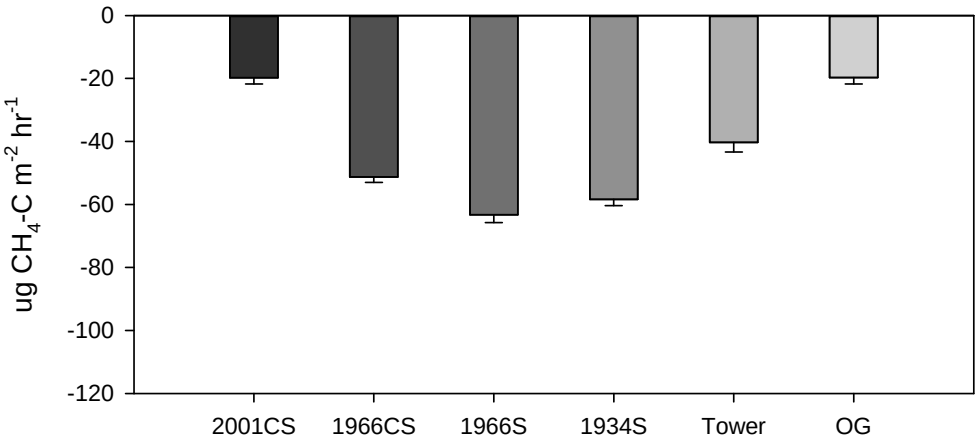


Difference in soil-atmosphere nitrous oxide exchange between stands of different age/disturbance history

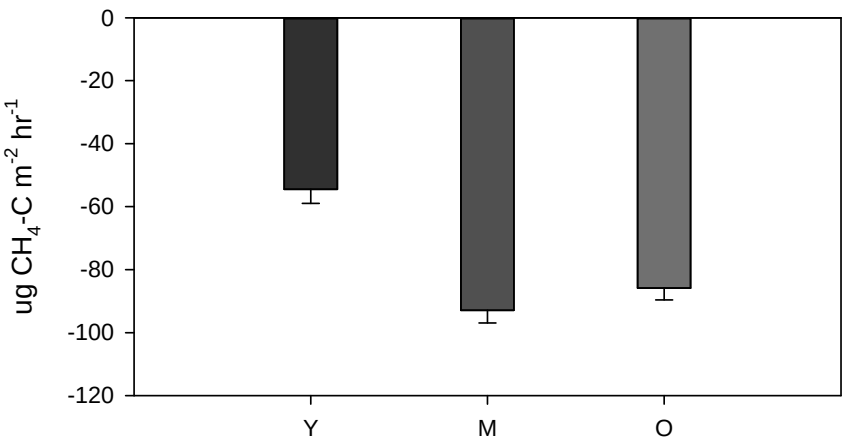


Model	Adjusted R^2
N_2O flux = 8.745 + 18.308*NO_3^-	0.17

Differences in soil-atmosphere methane exchange between stands of different age/disturbance history



Warra LTER



King Lake NP

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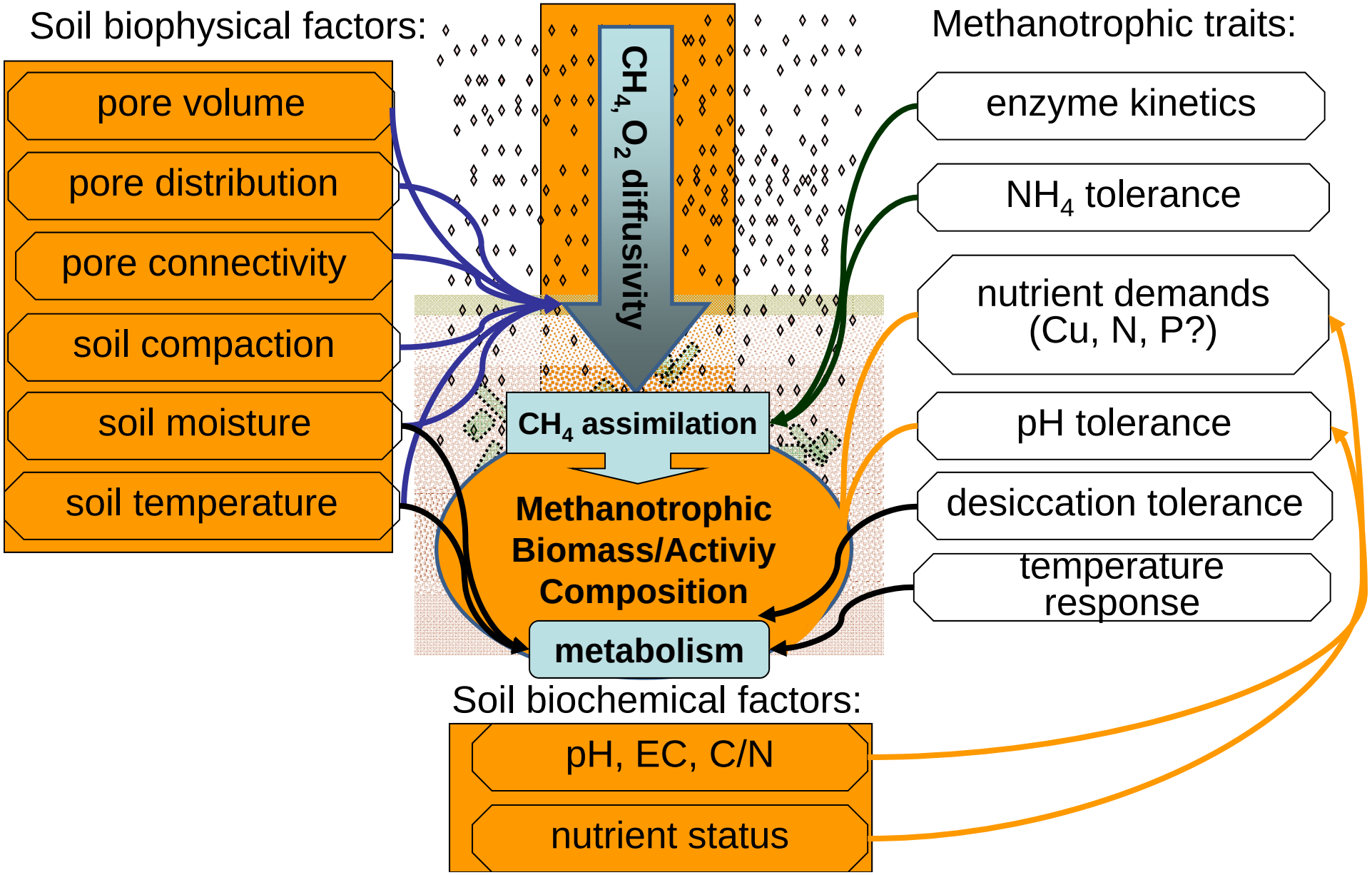
Impact of fire on CH_4 oxidation



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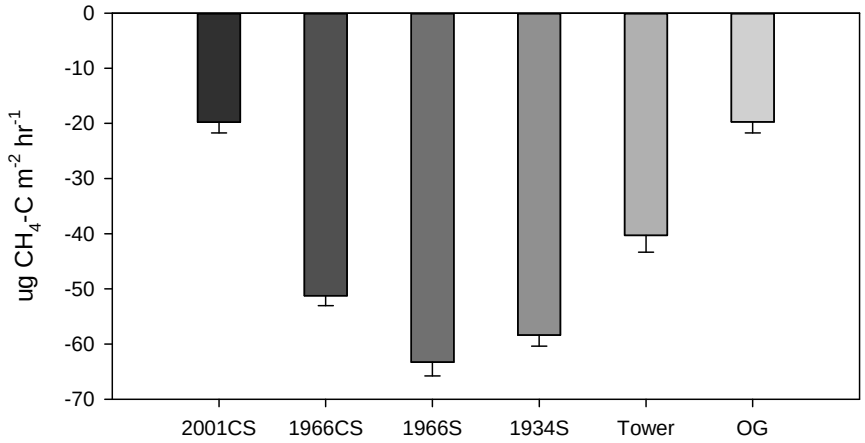
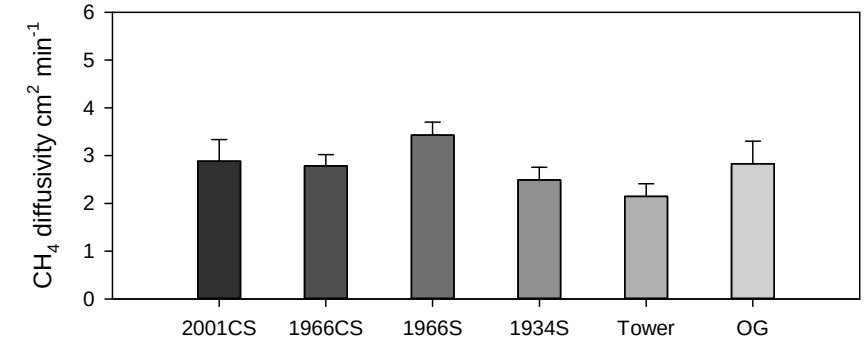
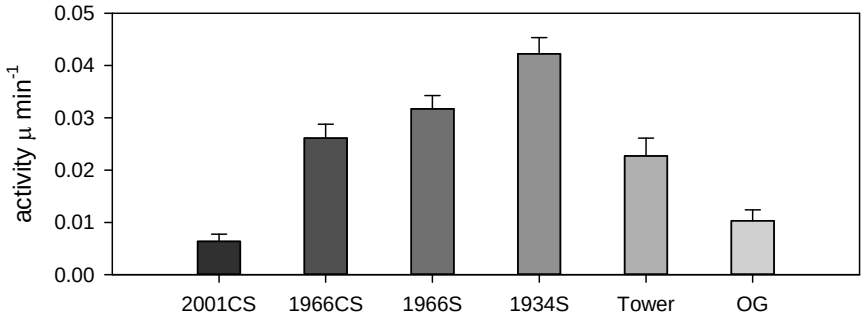
Differences in soil atmosphere methane exchange between stands at Warra LTER



Model	Adjusted R^2
CH_4 flux = -23.169 – 853.3*μ	0.554
CH_4 flux = -12.069 – 816.8*μ – 3.76*D_{CH4}	0.636



Model	Adjusted R^2
D_{CH4} = 4.386-0.165*$Soil_{Temperature}$	0.09
D_{CH4} = 8.057 – 0.268*$Soil_{Temperature}$ – 6.866*VWC	0.212



Model	Adjusted R^2
μ = 0.001 + 0.06*Air filled porosity	0.132
μ = -0.151 +0.24*Air filled porosity + 0.22*VWC	0.233

Summary

- Non-CO_2 soil atmosphere GHG fluxes are different in stands of different disturbance history for the same forest community in the same geographic area

- The differences can partly be attributed to stand development related changes in the soil structure and soil nutrient status

- For CH_4 differences in microbial activity between stands explains most of the observed differences in flux magnitude

- Differences in N_2O flux magnitude between stands can be attributed to with stand development increasing soil NH_4 and NO_3 status probably due to lower soil C/N ratios. This with increased soil moisture probably leads to higher levels of denitrification

Concluding Comments

- Non-CO_2 soil atmosphere GHG fluxes are difficult to upscale due to their spatial variability
- Better mechanistic understanding is needed to model these fluxes
- approaches needed to characterize the soil status/and type for a given stand at one point in time that allows up scaling and modeling of Non-CO_2 GHG (this might be possible for CH_4)

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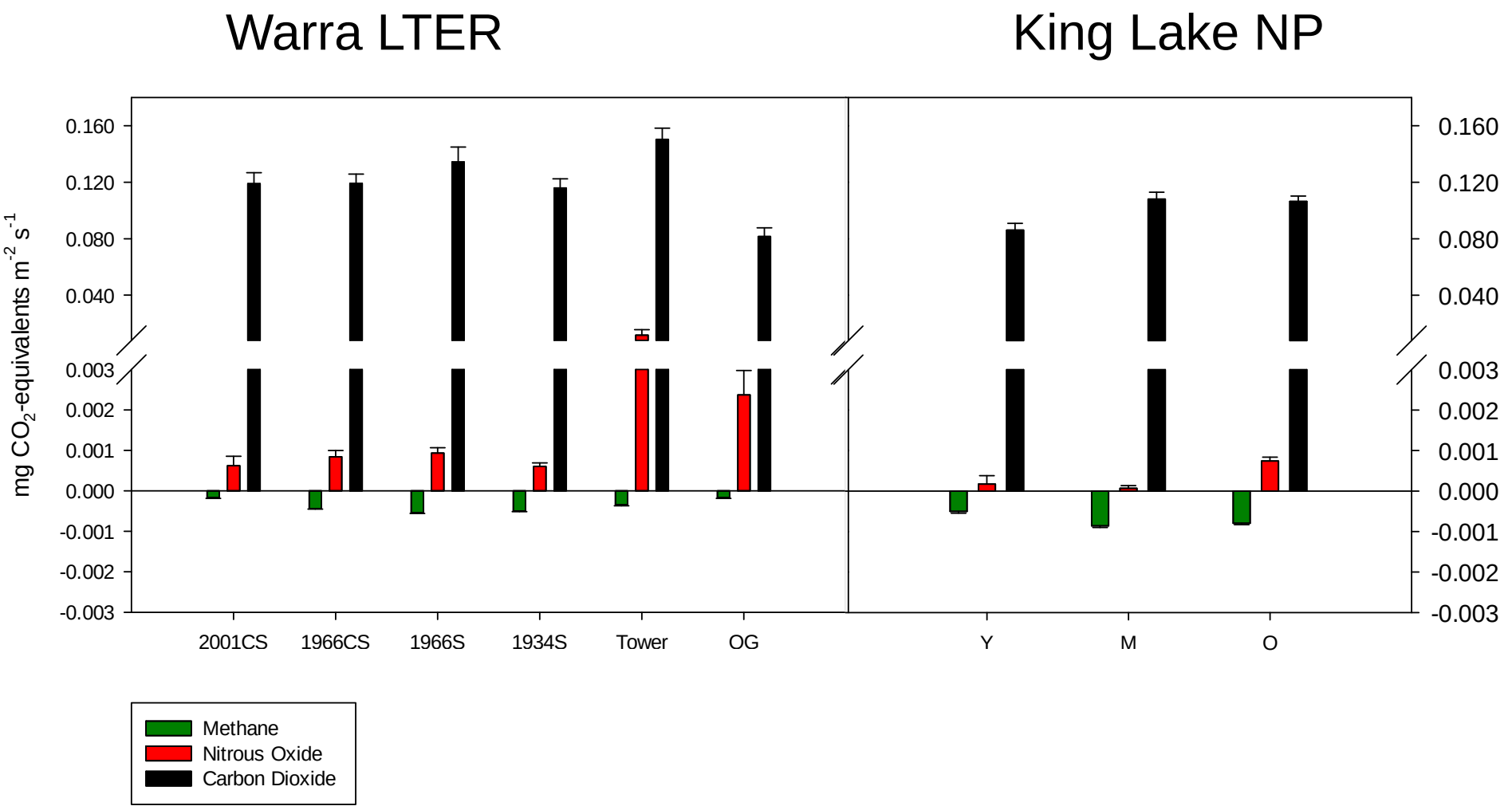
Soil GHG exchange in CO_2 equivalents



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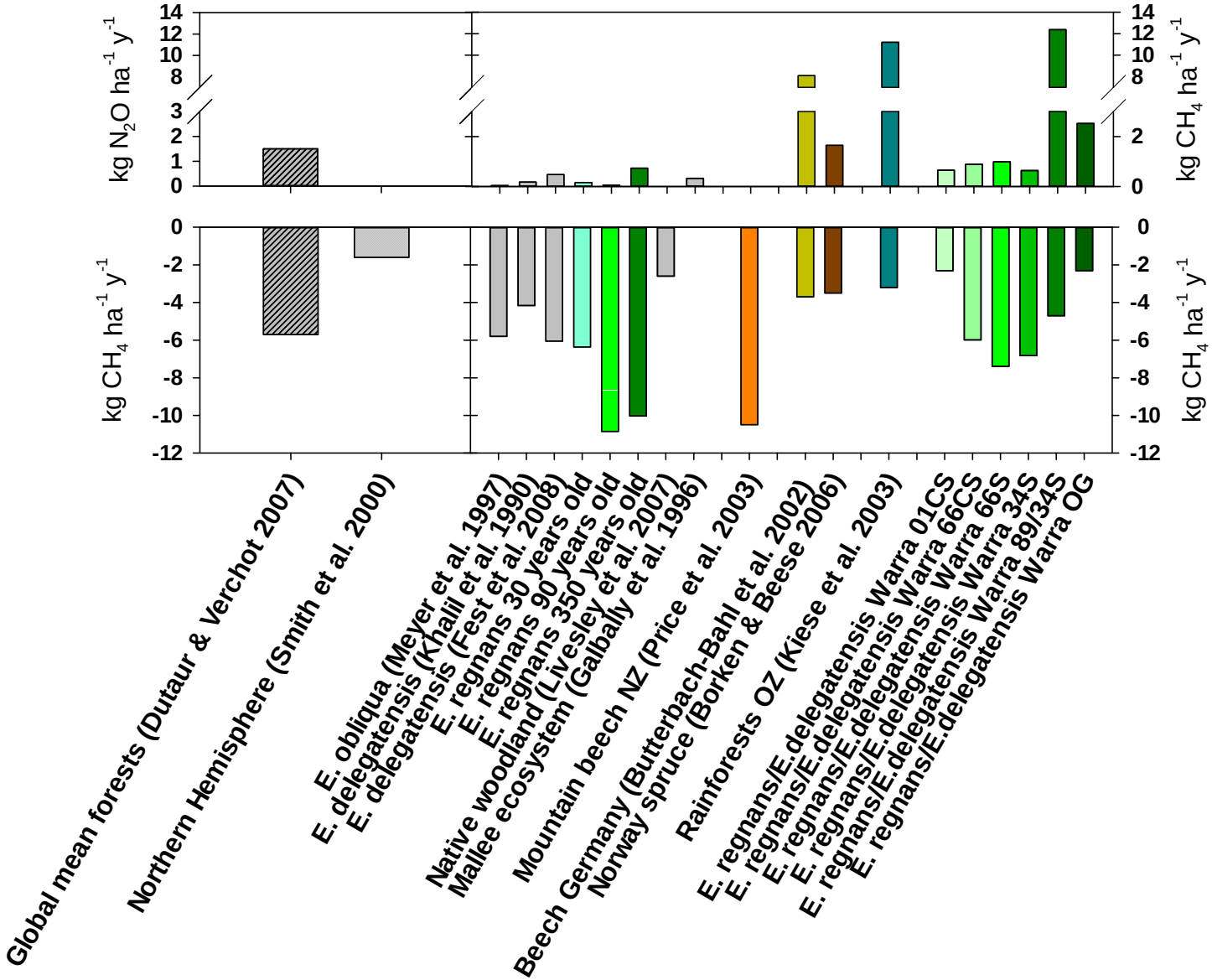
Comparison with other forest systems



Thank you!

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Australian Research Council

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Department of Sustainability and Environment

Parks VICTORIA