Functional ecology of the methanotroph community

An adaptive response to afforestation of pasture in New Zealand

by Loïc Nazaries

Contents

Background

- Methane (CH_4)
  - Potent green-house gas
  - Removed from atmosphere by methanotrophs (type I and type II)
  - Increased oxidation in temperate forests
- Afforestation improves C sequestration in soils
  - Photosynthesis activity from trees
  - CH_4 sink from methanotroph activity
  - Slow process

Effect of afforestation in New Zealand

- Stronger CH_4 sinks in NZ
- Afforestation of pastures with pine trees [1, 2, 3]

- Increased CH_4 sink è C sequestration in soils
  - Combination of changes in abiotic (soil properties) and biotic (methanotrophs) factors
    - Methanotroph community structure
      - type I *vs.* type II

[1] Singh *et al*., 2007. Appl.Environ.Microbiol. 73, 5153-5161; [2] Singh *et al*., 2009. Soil Biology & Biochemistry 41, 2196-2205; [3] Tate *et al*., 2007. Soil Biology & Biochemistry 39, 1437-1449.

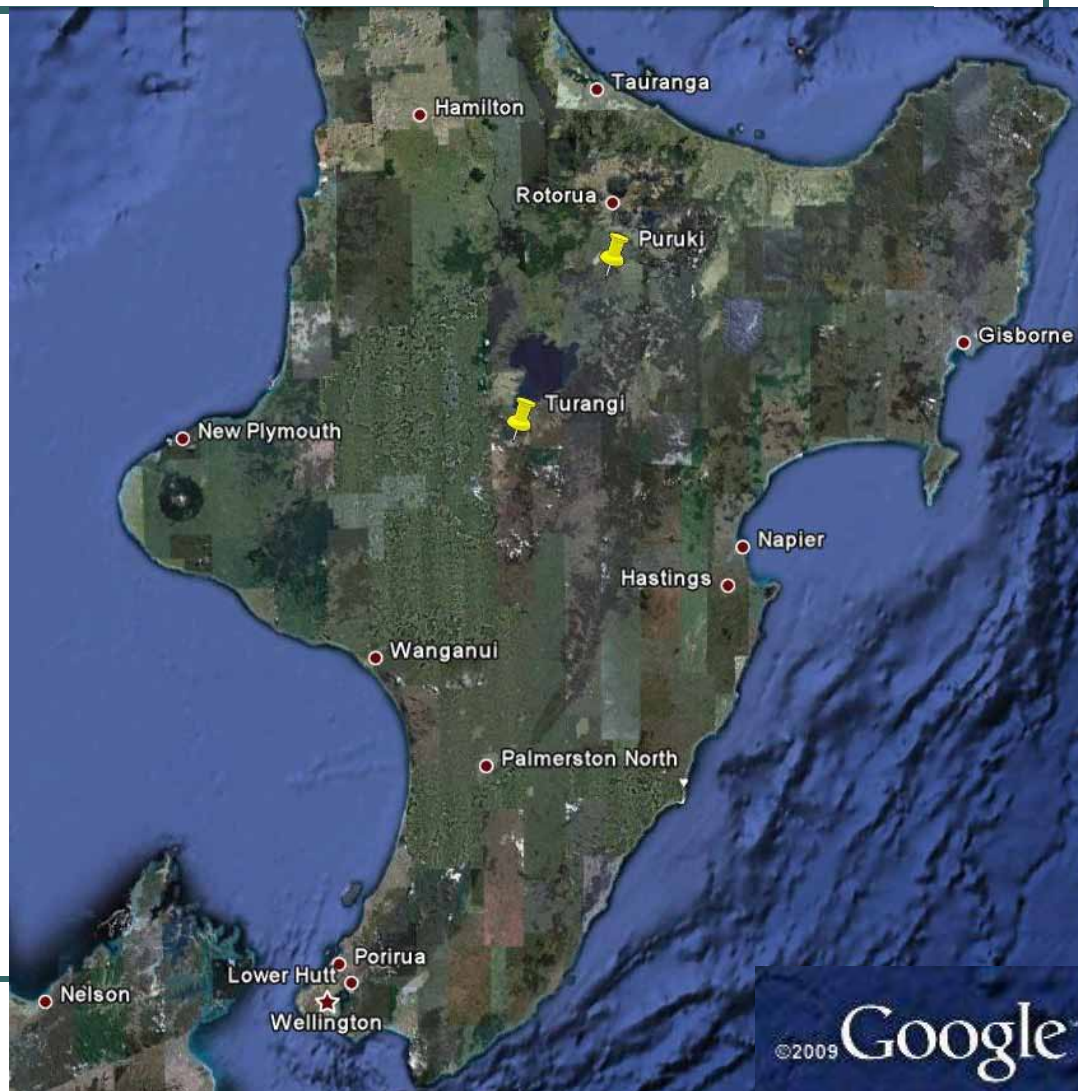
Aims of this study

- Meta-analysis
  - Compare sites with similar vegetation and response to afforestation
- Impact of long-term afforestation on:
  - Methane fluxes
  - Diversity and structure of methanotroph community
- Observe evolution of changes in structure of methanotroph population
  - Pastures *vs*. afforested pastures *vs.* long-established forests

Materials and methods

Description of sites

- Turangi
  - Tongariro National Park
  - Manuka-Kanuka tree forest
  - Stands aged 35 and 55 years
- Puruki
  - Near Rotorua
  - Indigenous forest (mixed vegetation)



Methane flux measurements

- Intact cores (10x10 cm) in a closed PVC chamber
- Measurement of variations in CH_4 concentration in the headspace over time, using gas chromatography (GC)

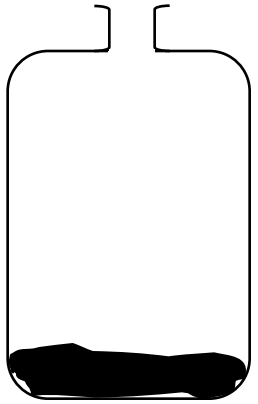
- **Indication on whether a soil is a source or a sink of methane**

Microcosm experiment (PLFA-SIP)

- Injection of 50 ppm of isotopic methane ($^{13}CH_4$)
- Incubation in dark for 14 days

- Extraction of phospholipid fatty acids (PLFAs)

- **Identification of active methanotroph population**



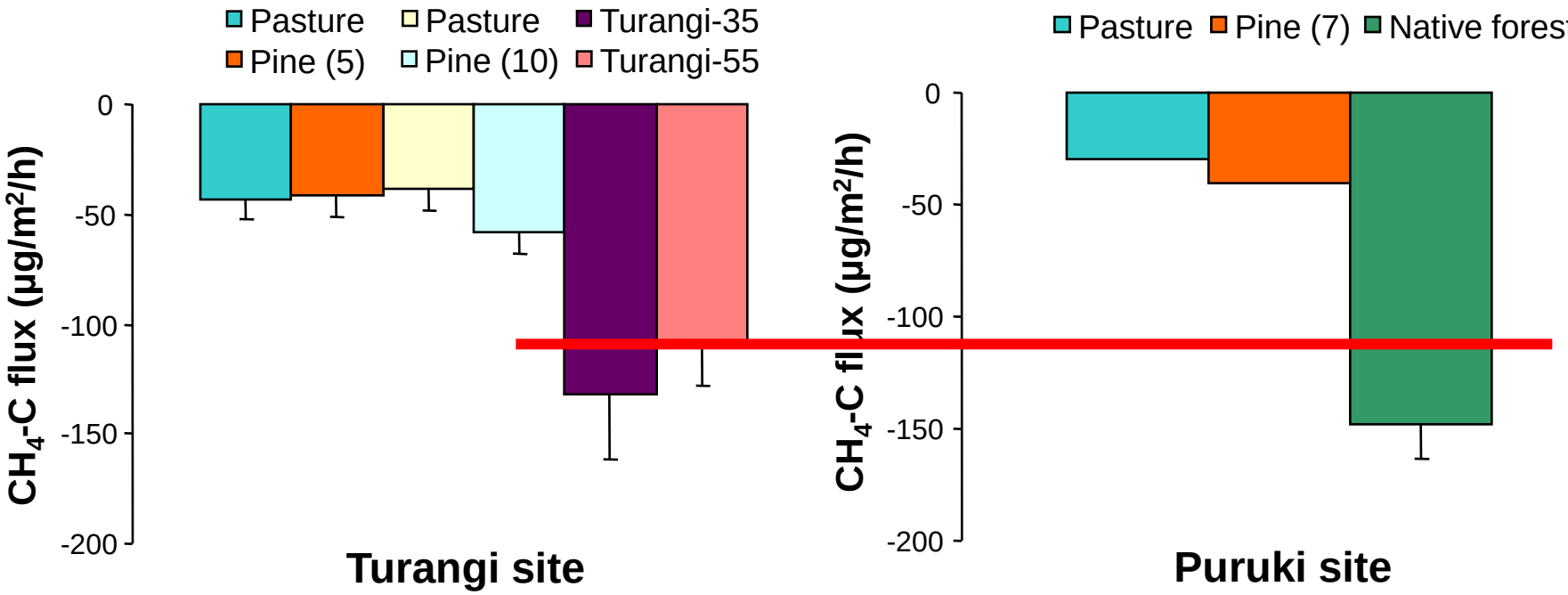
Molecular analysis

- Terminal-Restriction Fragment Length Polymorphism (T-RFLP)
- Analysis of three genetic markers:
  - 16S rRNA gene of type I and type II methanotrophs
  - *pmo*A gene
- Production of unique fragmentation patterns (or T-RFLP profiles)
  - Observation of specific fragments called terminal-restriction fragments (T-RFs)

- **Information on the structure and diversity of the methanotroph community**

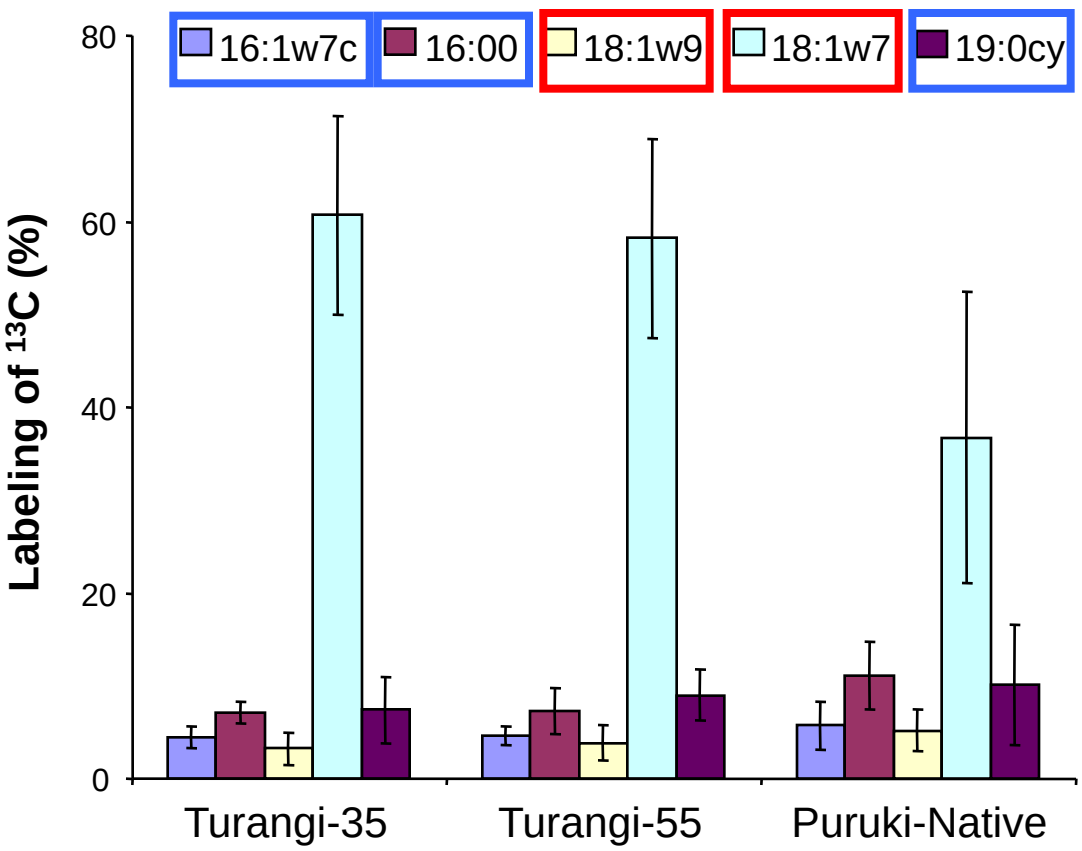
Results

Methane fluxes and afforestation



Higher oxidation rates in old and native forests

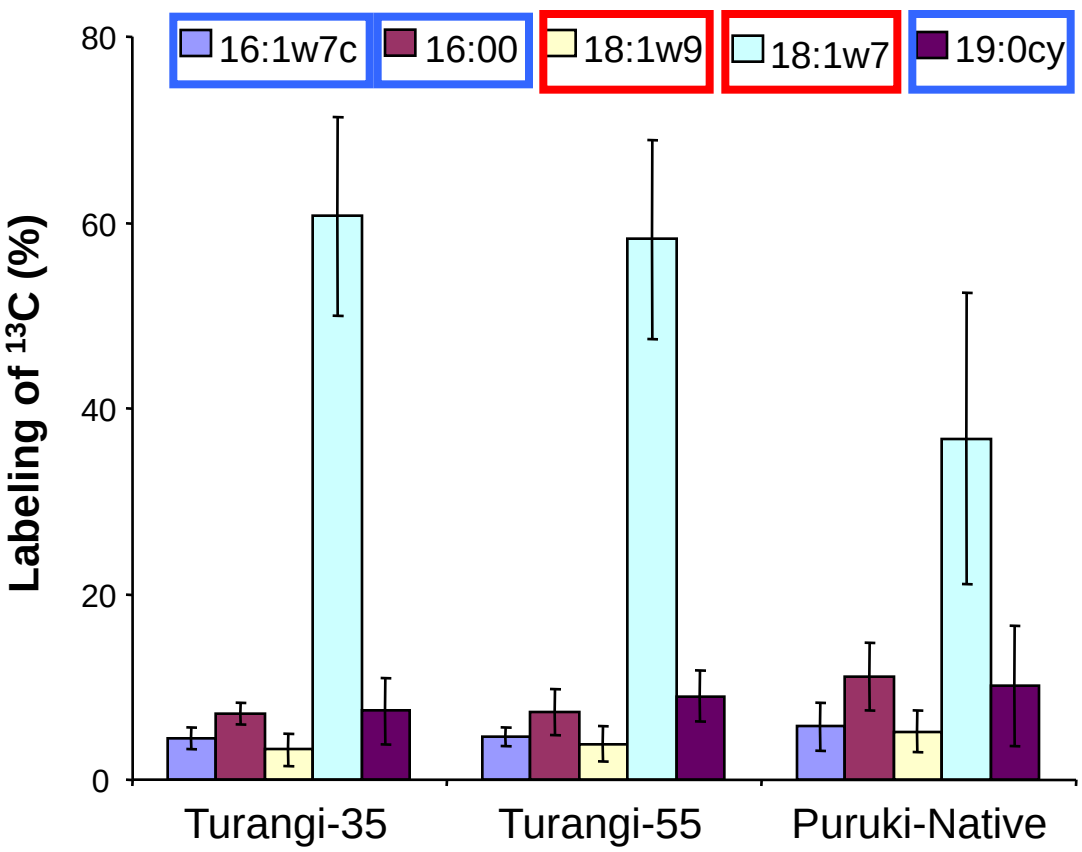
Linking community with function (PLFA-SIP)



Type I methanotrophs

Type II methanotrophs

Linking community with function (PLFA-SIP)



Type I methanotrophs

Type II methanotrophs

Type II methanotrophs most active at oxidising atmospheric CH_4

Methanotroph community structure (T-RFLP) – T-RF presence

Site	*pmo*A
Turangi	
Pasture [2]	T-RF 33/129 T-RF 245
Pine forest [2]	T-RF 33/129; T-RF 245
Turangi-35	T-RF 33/129
Turangi-55	T-RF 33/129

Methylocapsa spp.

(type II methanotrophs)

Methylococcus capsulatus

(type I methanotrophs)

[2] Singh *et al*., (2009)

Methanotroph community structure (T-RFLP) – T-RF presence

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Turangi-35	T-RF 33/129
Turangi-55	T-RF 33/129
Puruki	
Pasture [3]	T-RF 129 T-RF 245
Pine forest [3]	T-RF 129; T-RF 245
Native forest	T-RF 33/129

Methylocapsa spp.

(type II methanotrophs)

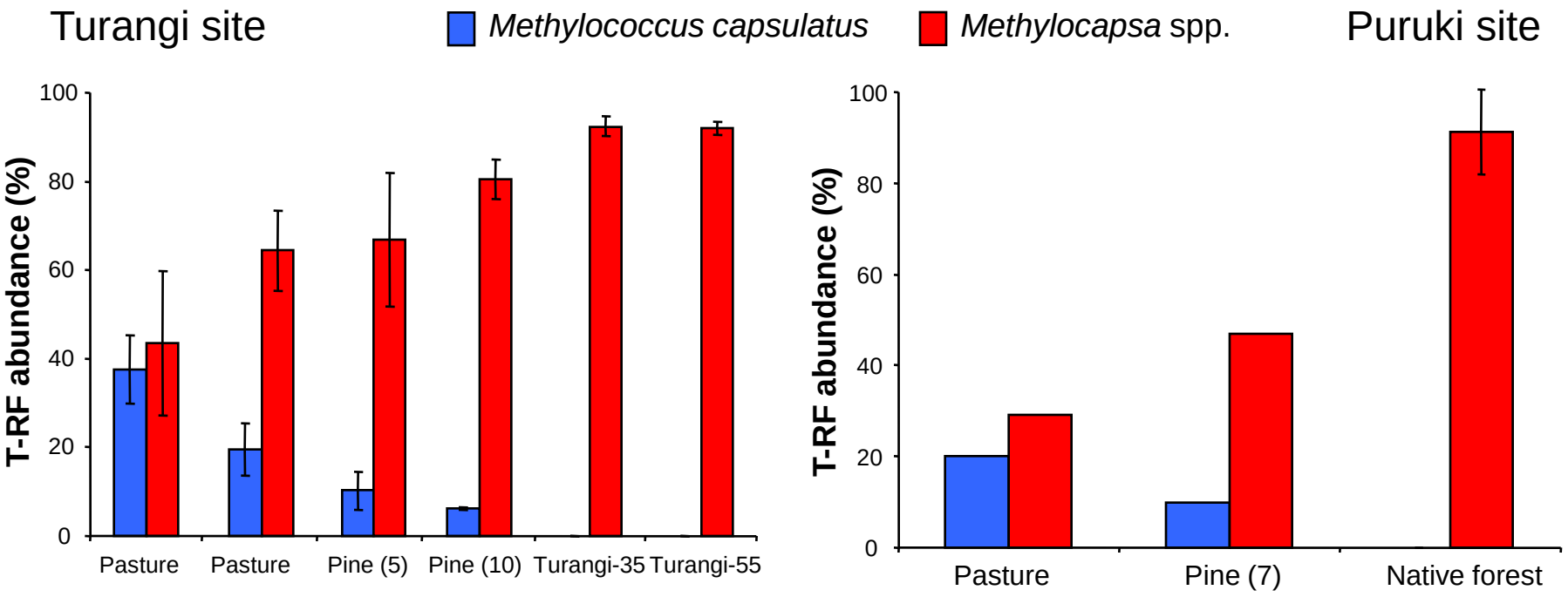
Methylococcus capsulatus

(type I methanotrophs)

Disappearance of *Methylococcus capsulatus* (type I methanotroph) in old and native forests

[2] Singh *et al*., (2009); [3] Tate *et al.,* (2007)

Methanotroph community structure (T-RFLP) – T-RF abundance



Pasture à young forest à old/native forest

***M. capsulatus* (type I) è *Methylocapsa* sp. (type II)**

Conclusions

- Rapid effect of afforestation of pastures (10-35 years)
  - Methane fluxes
  - Methanotroph activity and community structure
- Establishment of a stable and active population of type II methanotrophs in forests
  - Independent of vegetation
- No differences between the old forests (Turangi) and the native forest (Puruki)

On-going works

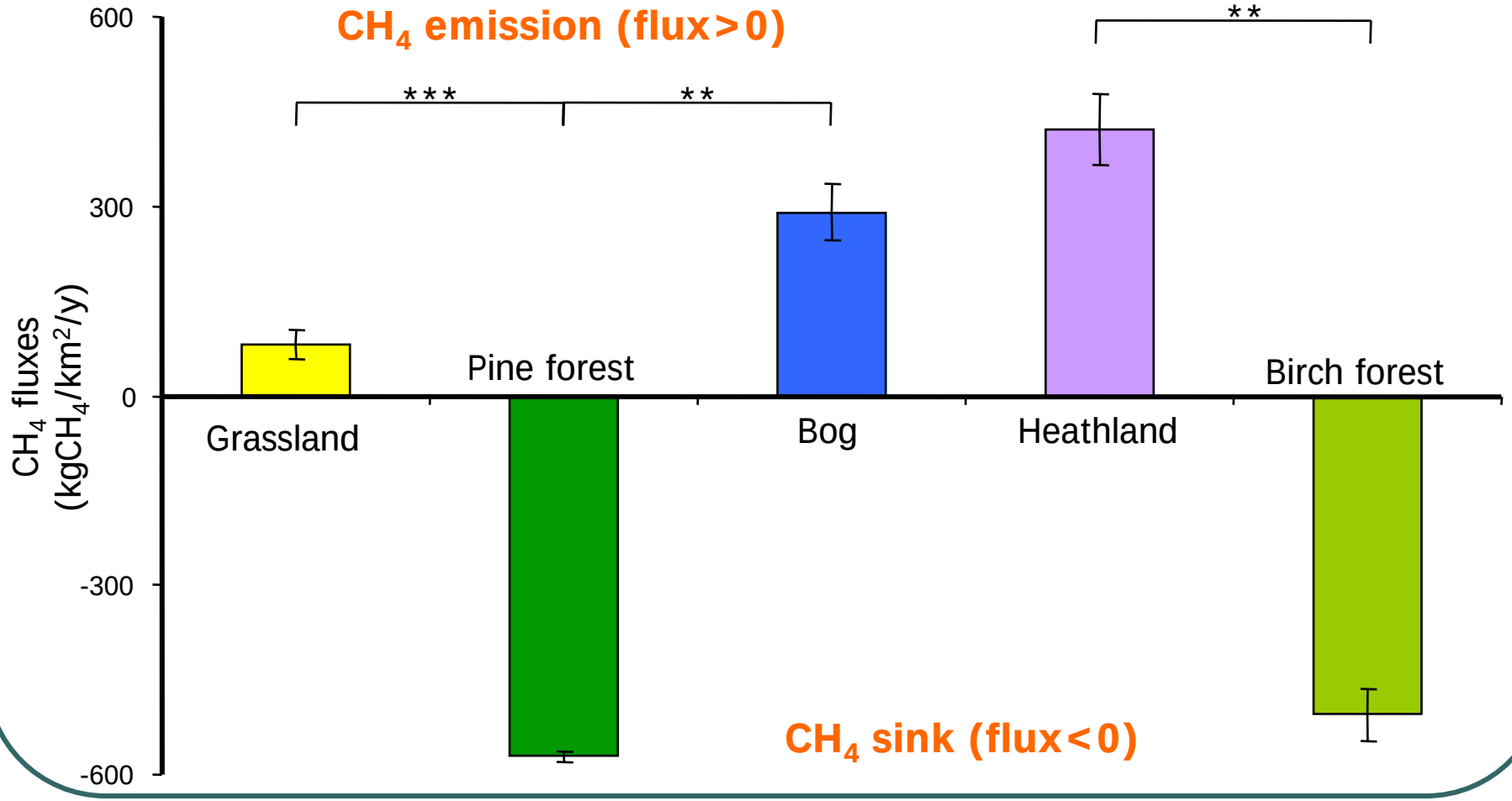
- Submission for publication

- Work on Scottish soils
  - Study the impact of land-use change on the CH_4 fluxes and shifts in methanotroph community structure

CH_4 fluxes in Scotland

- Effect of afforestation on methane fluxes
  - Compare methane fluxes from sites with differing land uses
    - Grassland or bog à pine forest
    - Heathland à birch forest

Effect of land-use change on methane fluxes



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Manaaki Whenua
Landcare Research


The End
Thank you!!




Questions?