# Drivers of Peatland Soil Carbon Composition and Potential Greenhouse Gas Production: A Global Perspective

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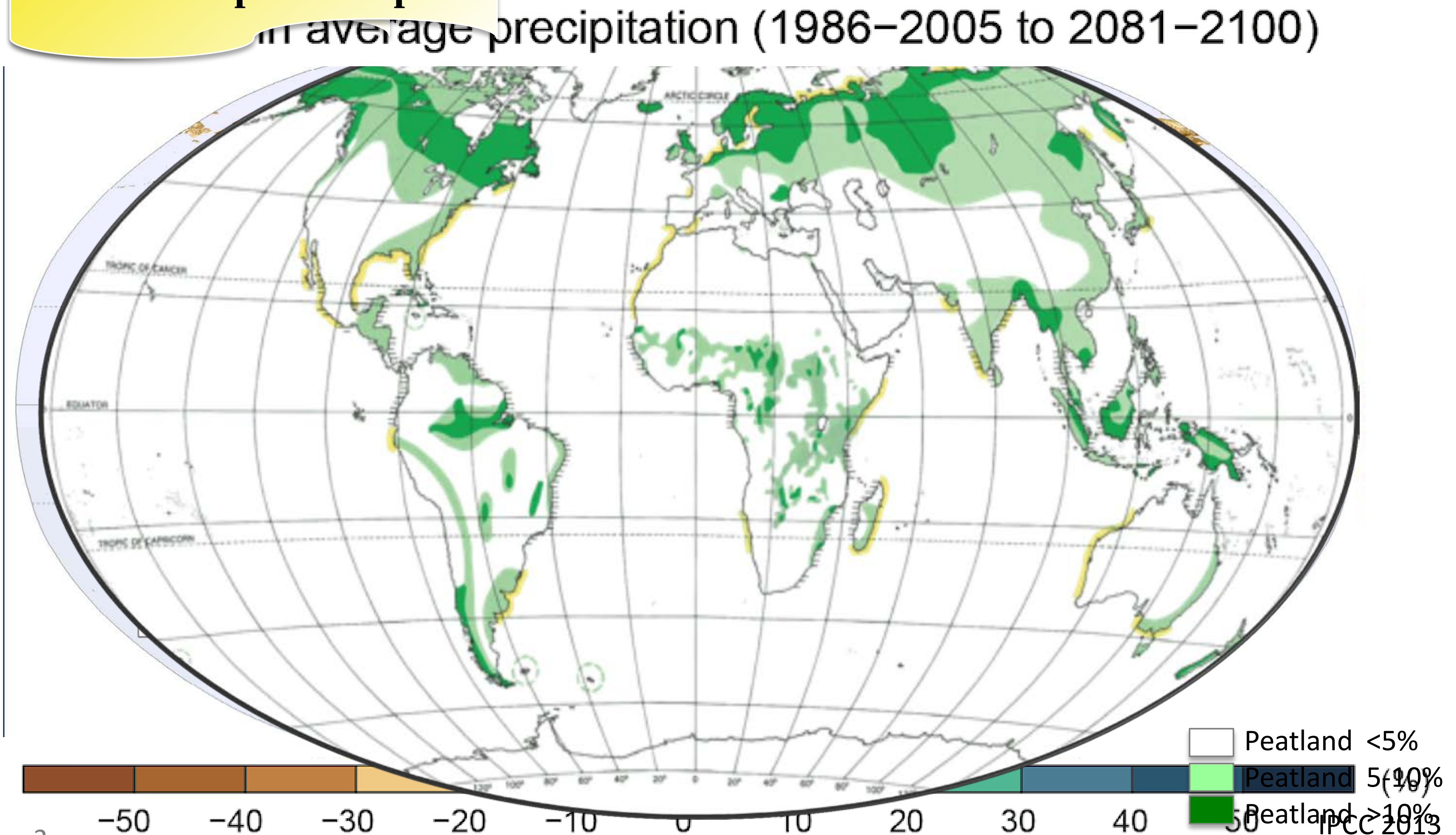
Volcano Poas, Costa Rica

# Global Perspective

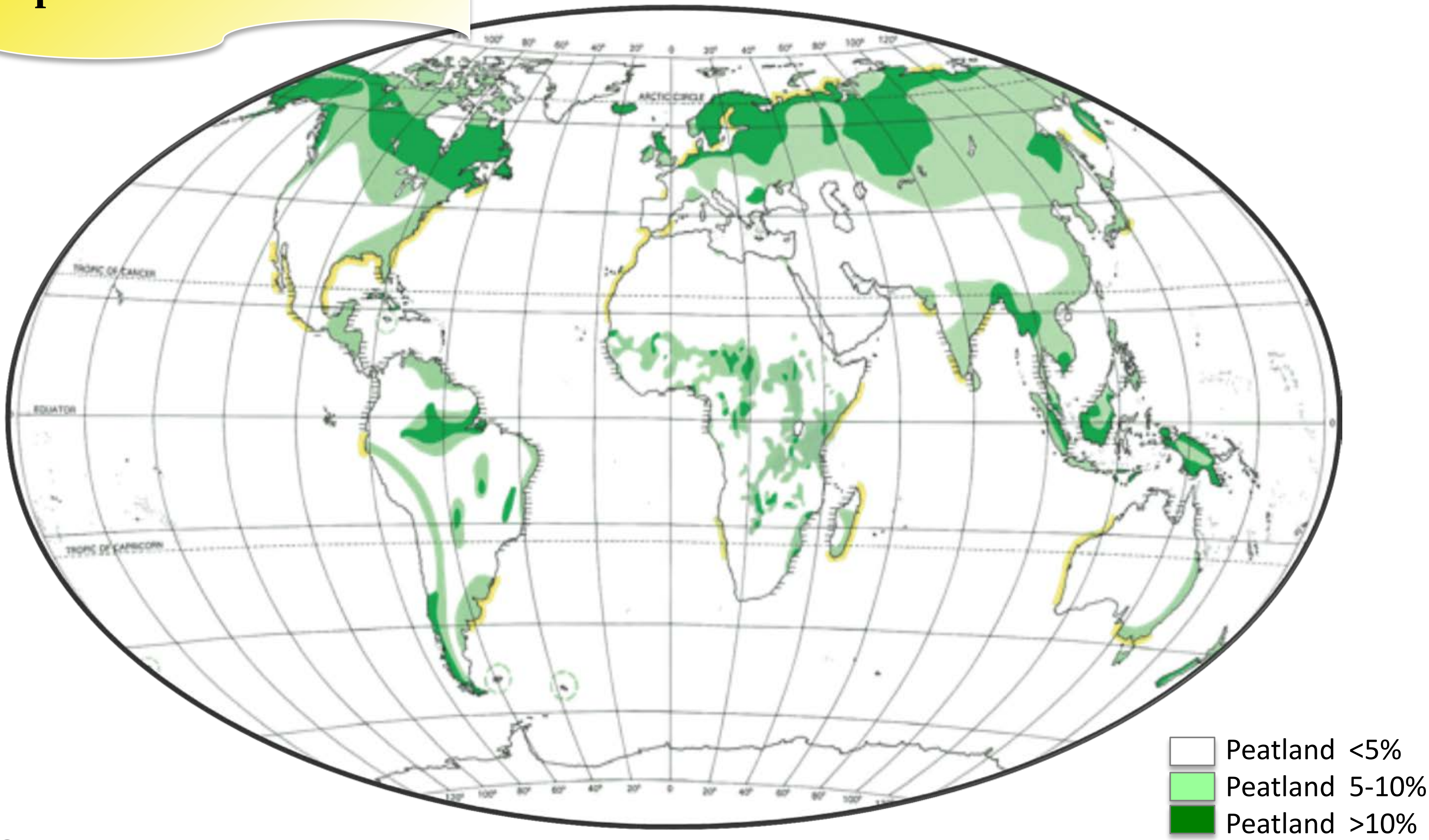
**Soil carbon: 4000-4800 Gt**
**3.3 x atmospheric C pool**




IPCC 2013
*Lappalainen 1996*

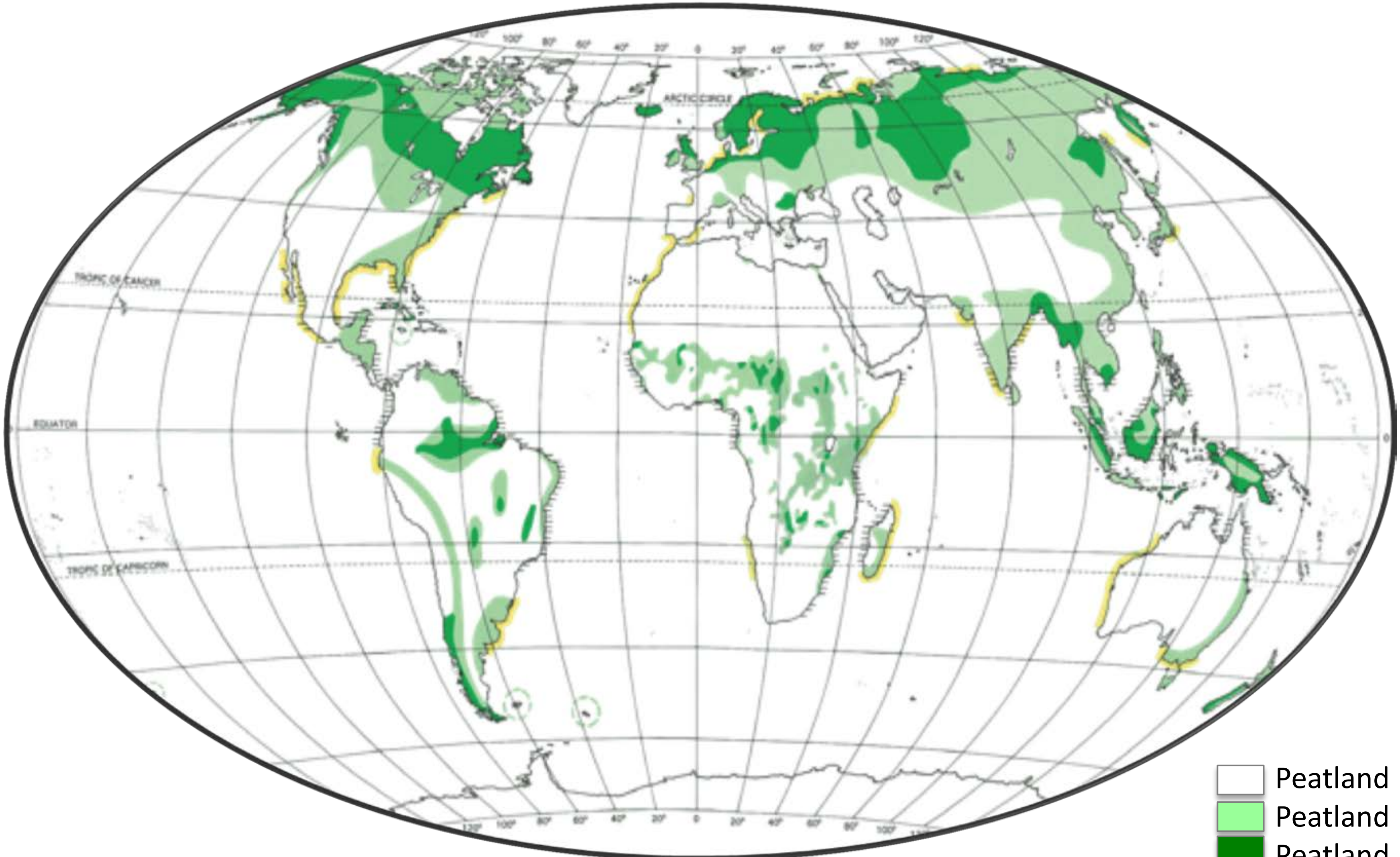
# Global Perspective

**What is the fate of peatland soil carbon?**




*Lappalainen 1996*

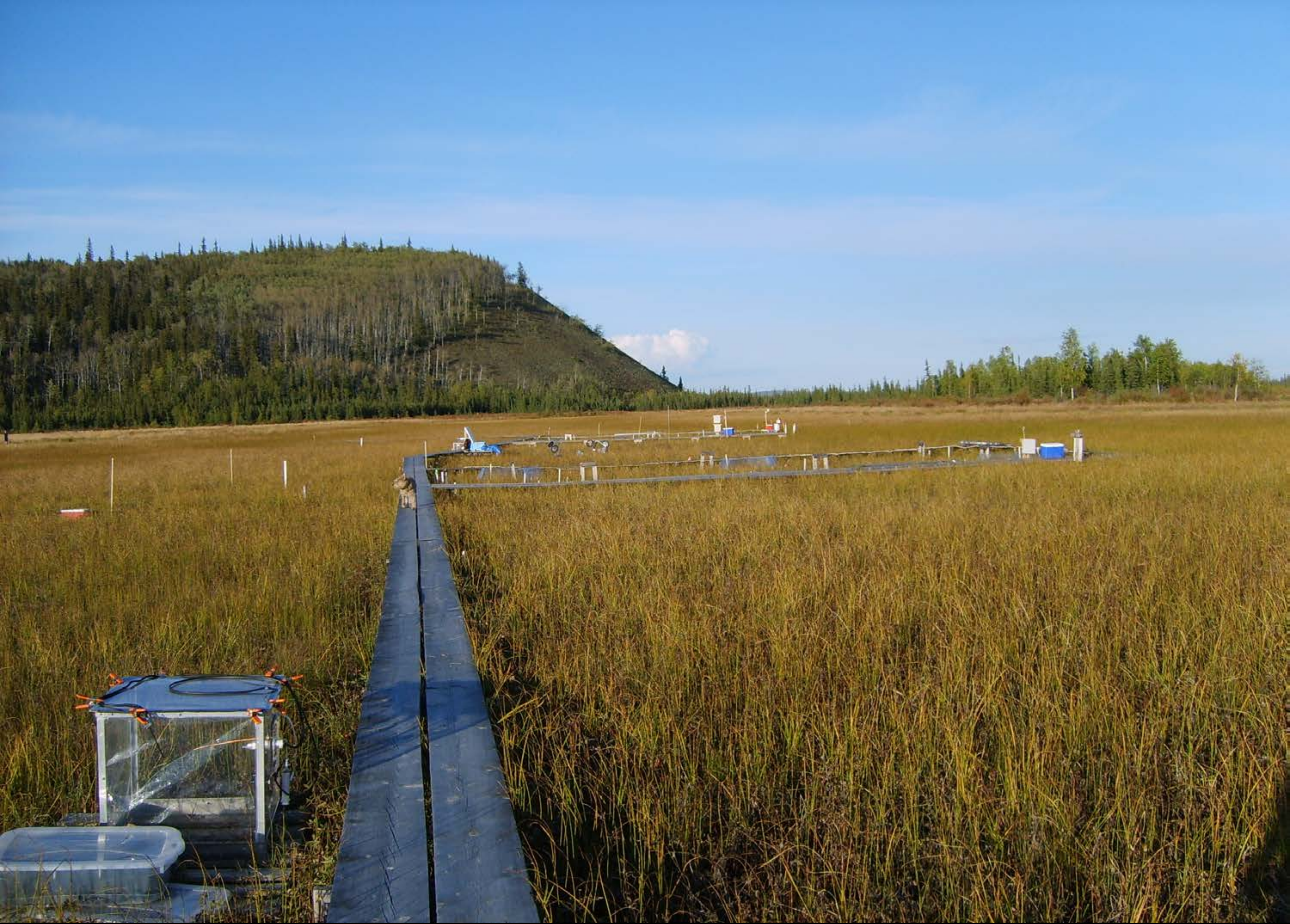
# What drives peatland soil carbon composition?




Peatland <5%
Peatland 5-10%
Peatland >10%

*Lappalainen 1996*

Stordalen, Abisko, Sweden





Bonanza Creek, LTER, Alaska


Everglades, FL
Herbaceous
Hawthorne, FL
Sphagnum
Bocas Del Toro, Panama
Forested

Cerro de la Muerte, Costa Rica
Pristine

Cerro de la Muerte, Costa Rica
Degraded?


Everglades Agricultural Area, FL


San Joaquin Valley, CA

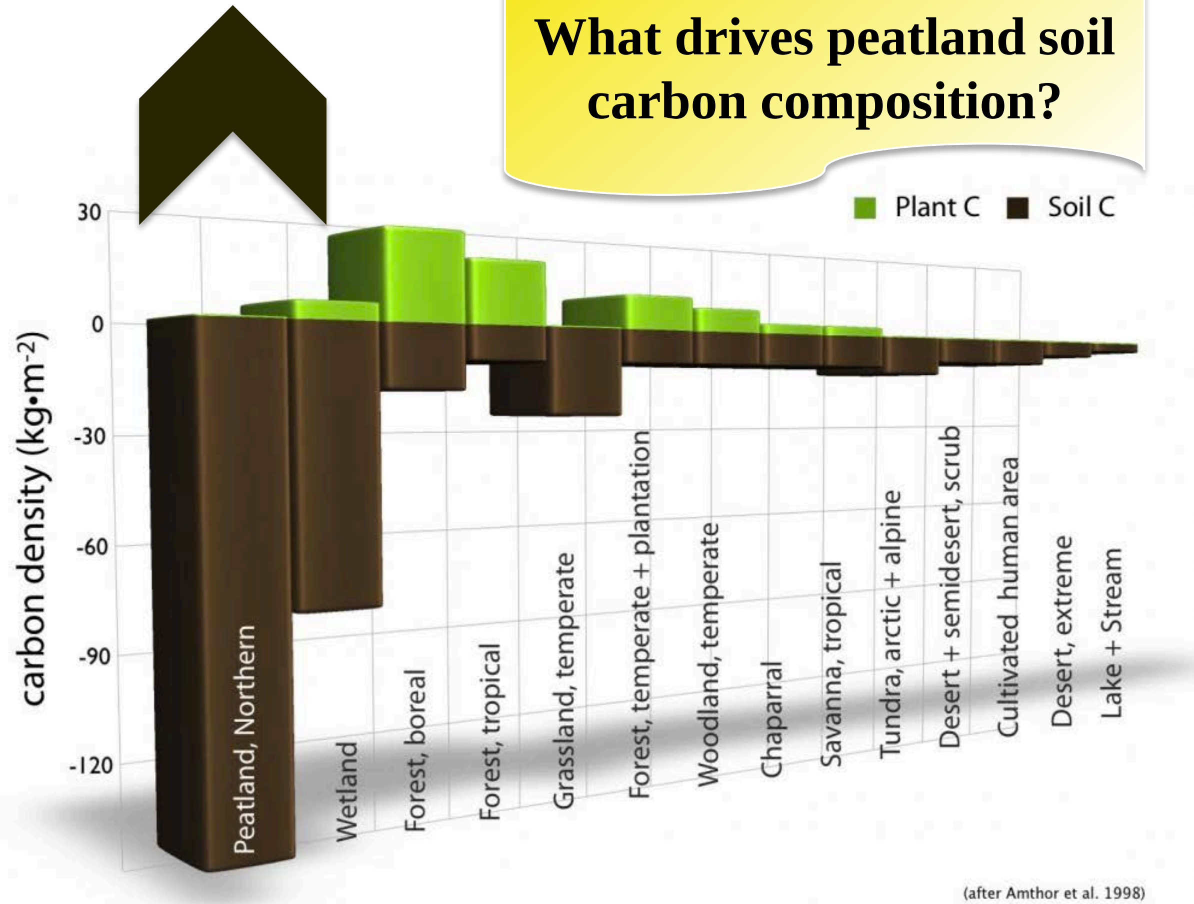
Holme, UK

Drained and burned, SE Asia

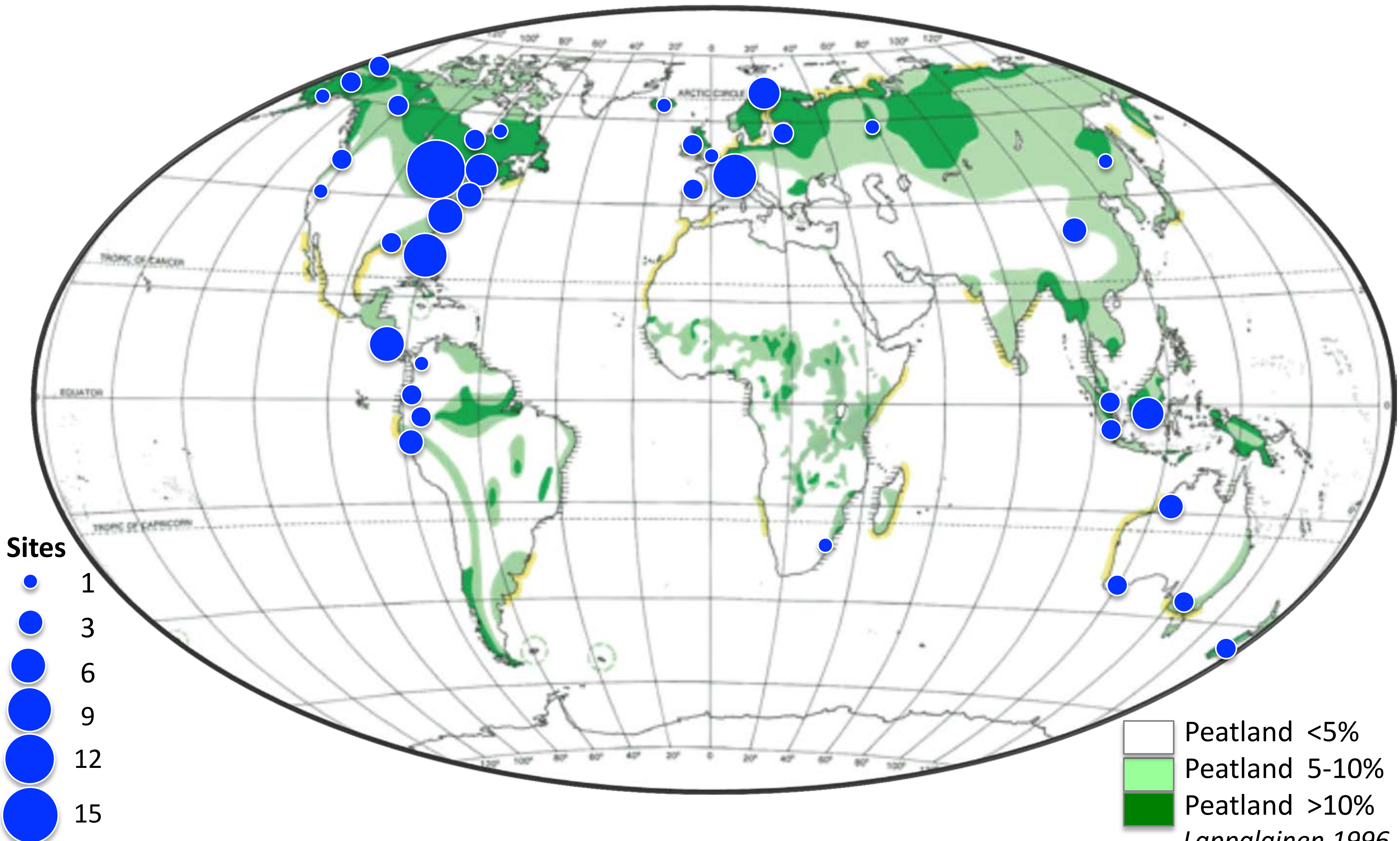
# Peatland Carbon

>40 cm


**What drives peatland soil carbon composition?**



# Global Peatland Locations




*Lappalainen 1996*

# Chemical Analysis of Peat SOM

**114 Peat Samples**

Vegetation
- Moss
- Herbaceous
- Shrub/Forest

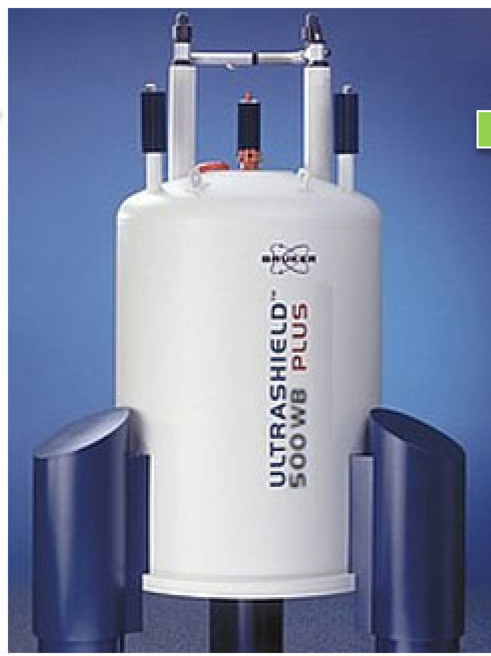
Mean Annual Temperature
-11 – 27 °C

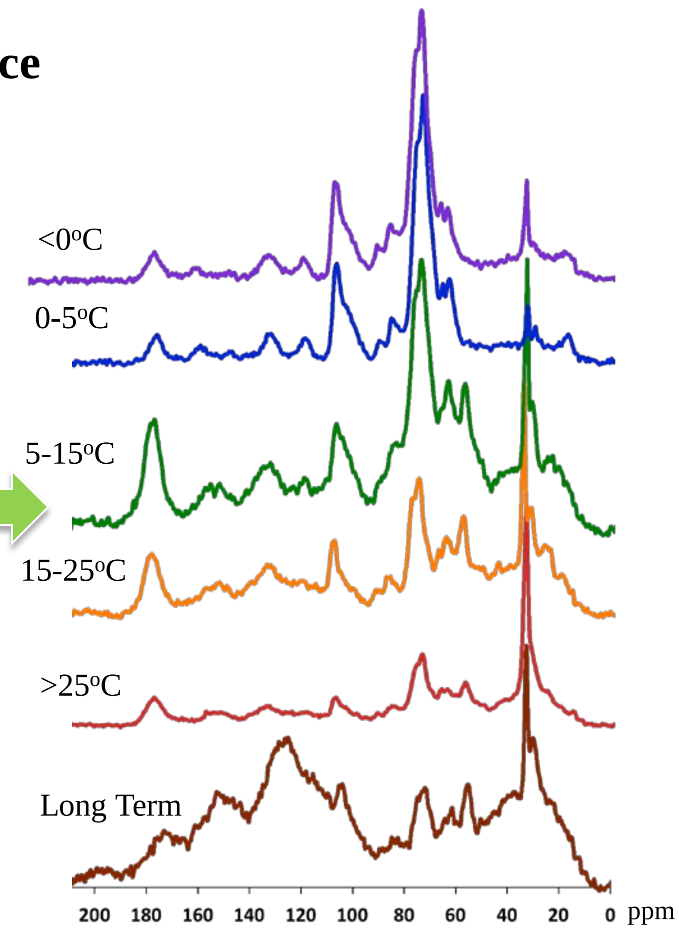
C/N Ratio 11-116

pH 2.8-7.8

Land Use
- Pristine
- Short term degraded
- Long term degraded

**$^{13}$C Solid State**
**Nuclear Magnetic Resonance**



# Nuclear Magnetic Resonance

## $^{13}C$ NMR Functional Groups

Decomposition

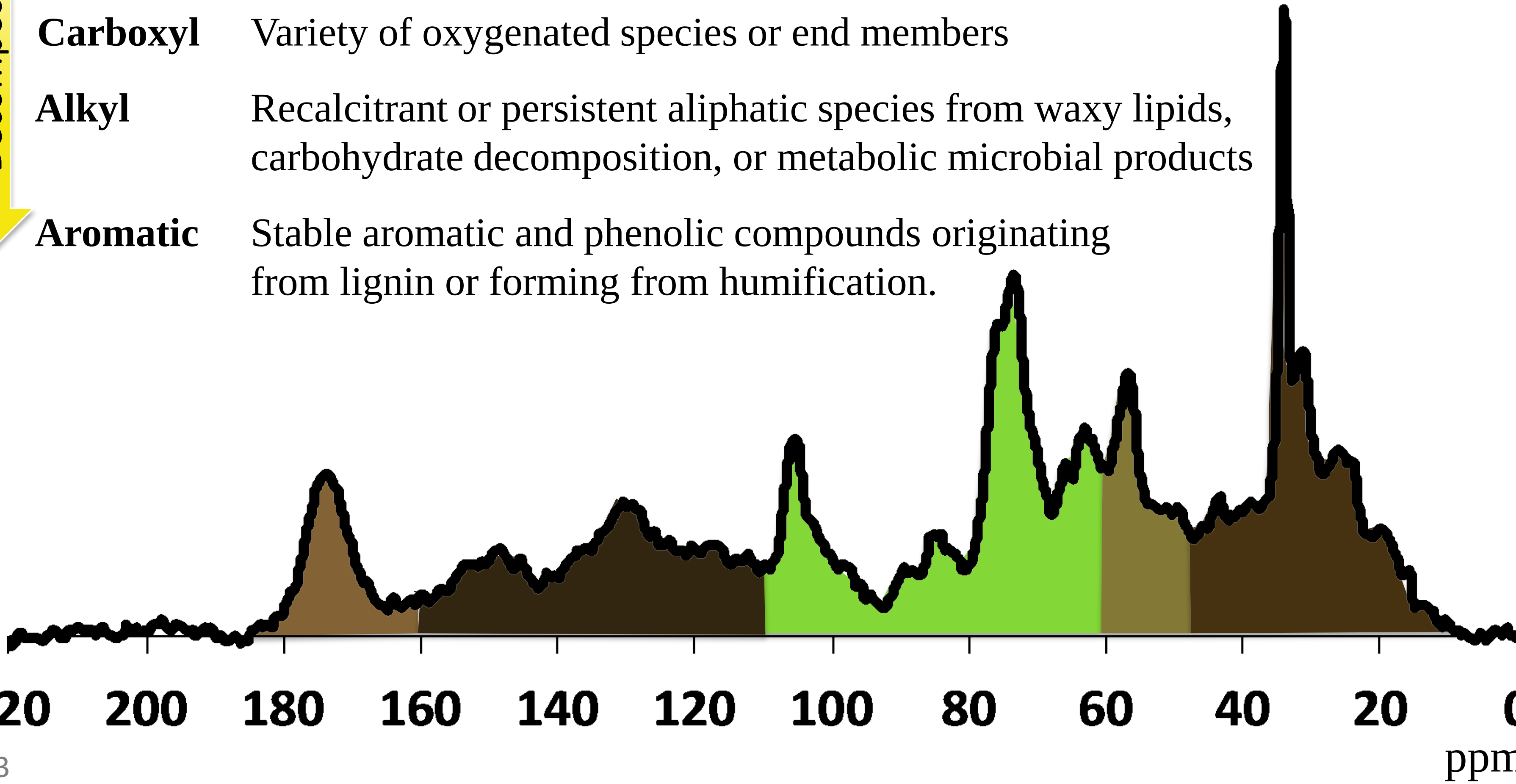
**O-alkyl** Plant-derived polysaccharide compounds

**Methoxyl** Amino acid and protein N from microbial activity, or lignin C and N

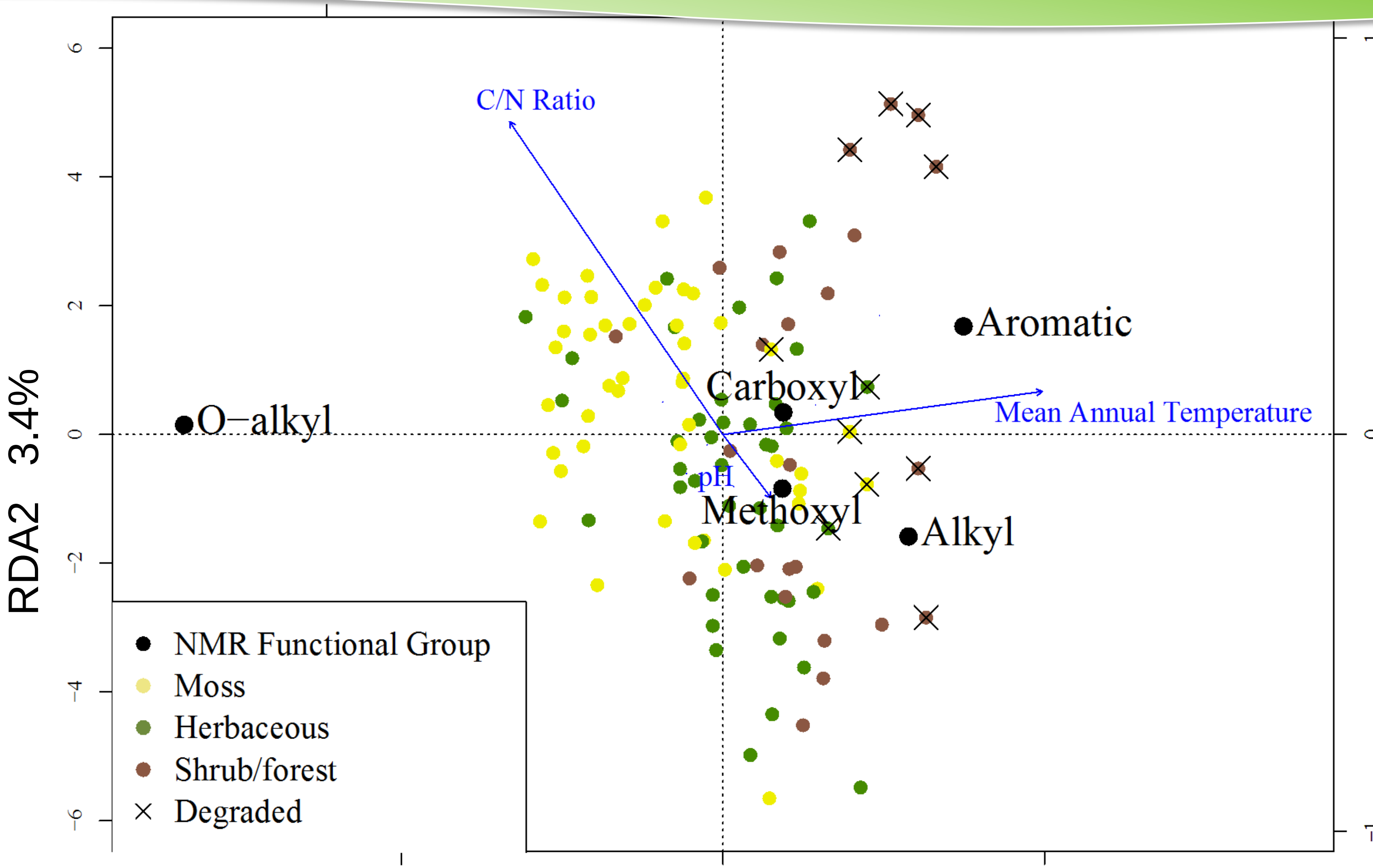
**Carboxyl** Variety of oxygenated species or end members

**Alkyl** Recalcitrant or persistent aliphatic species from waxy lipids, carbohydrate decomposition, or metabolic microbial products

**Aromatic** Stable aromatic and phenolic compounds originating from lignin or forming from humification.

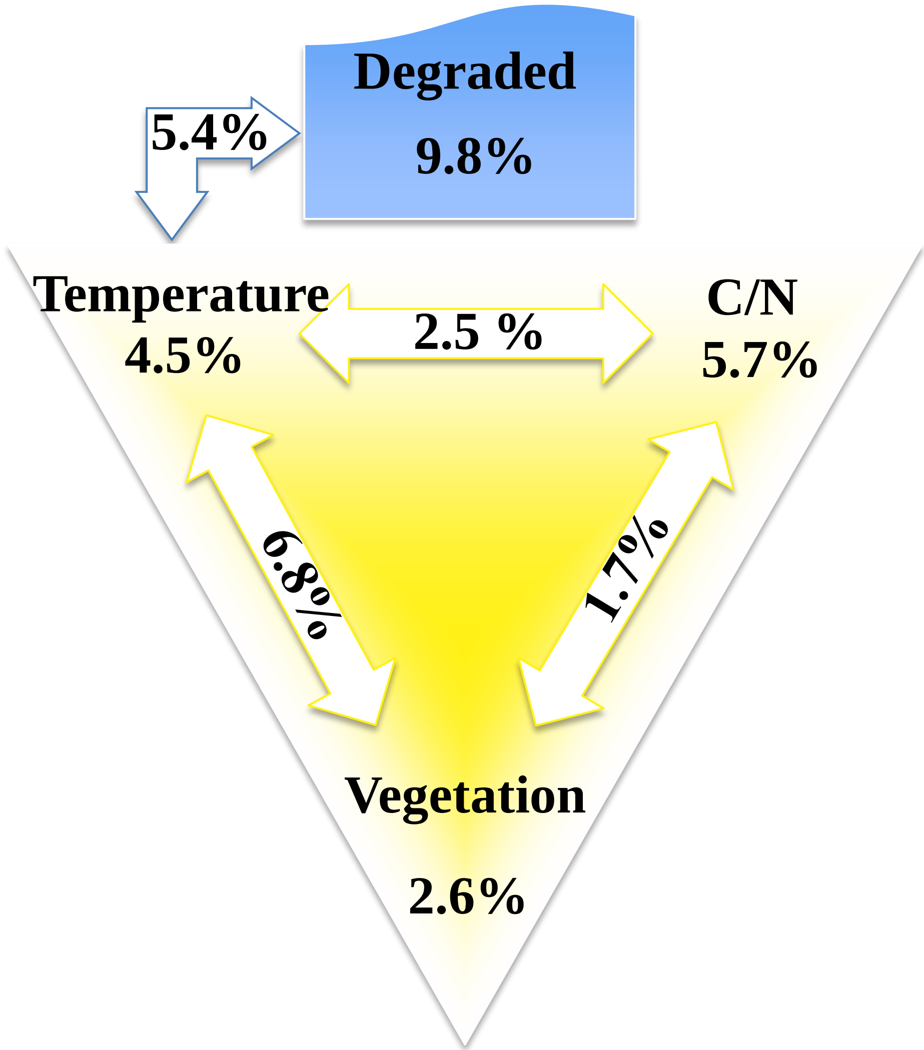


# Redundancy Analysis of Peat SOM:
## Vegetation, Temperature, Land Use, C/N Ratio, pH



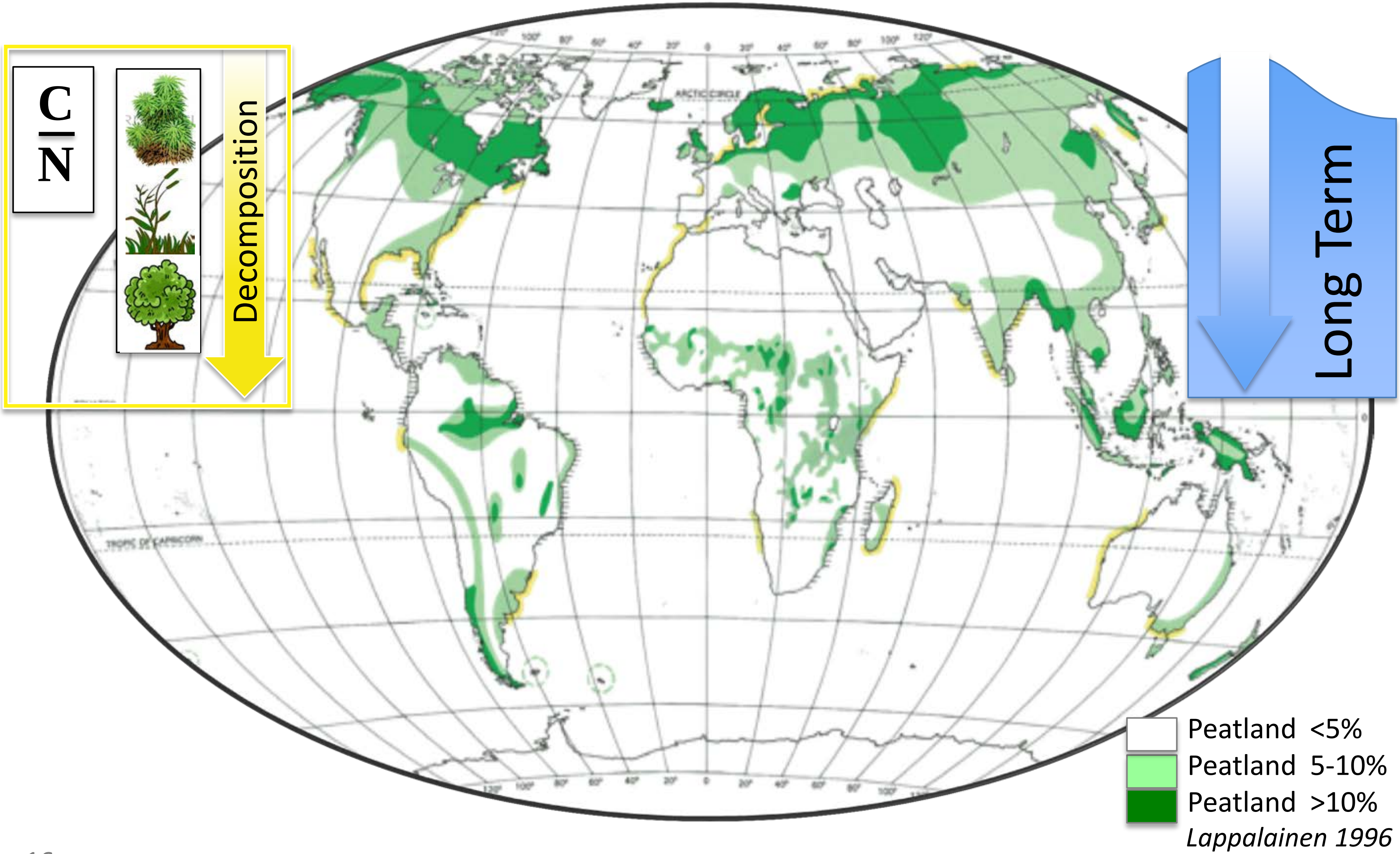

RDA1 52% Increased decomposition (stability)

# Explanation of Variance

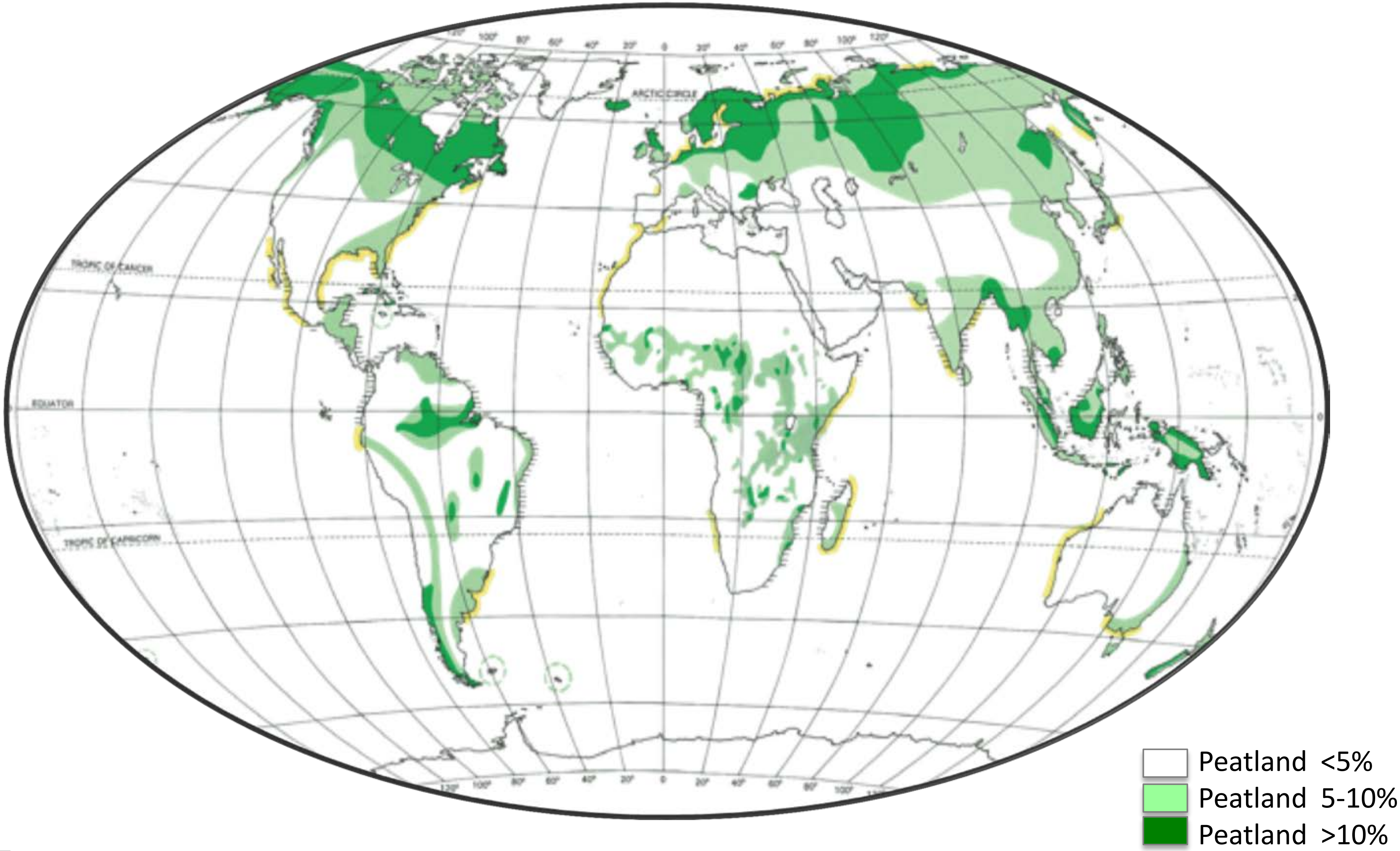



pH 0.5% Unexplained = 45.2%

# Summary of Drivers

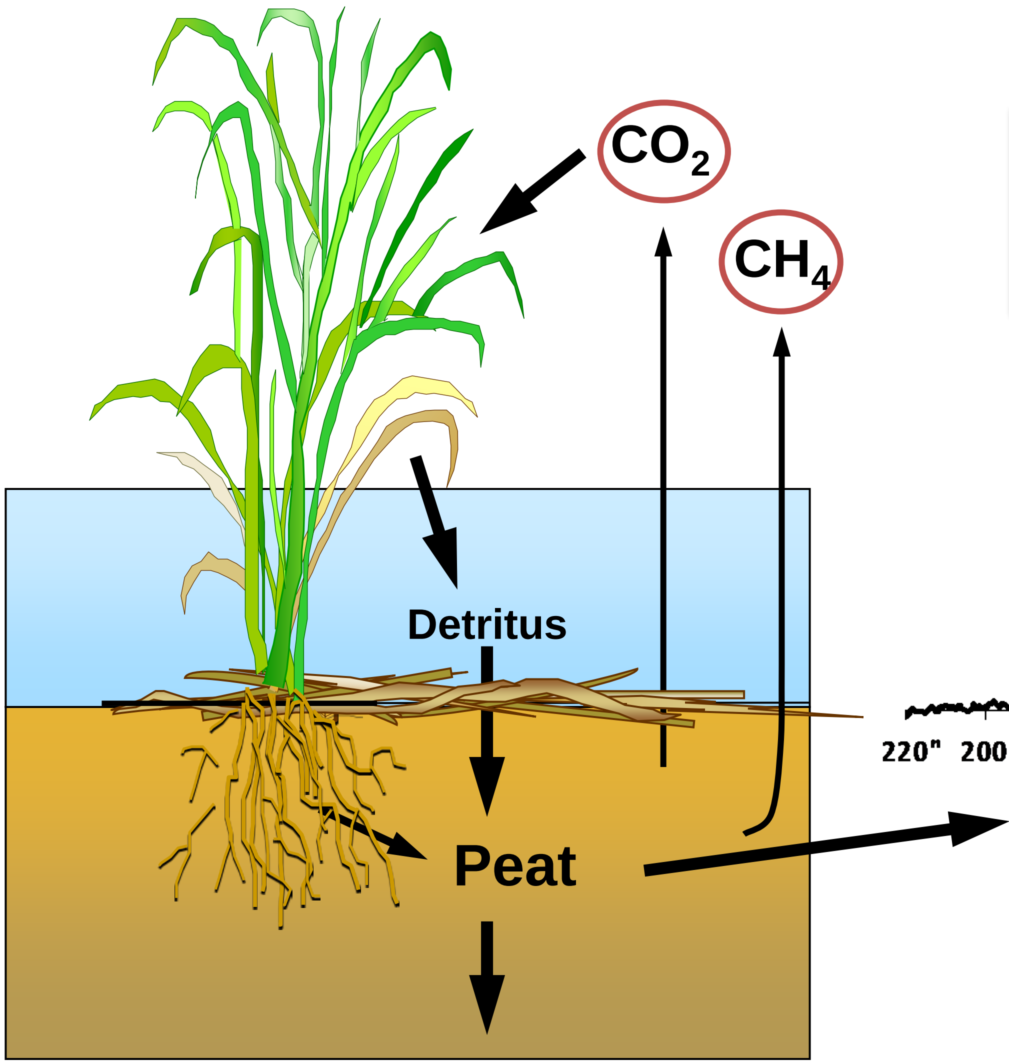


# Does carbon composition control GHG production?

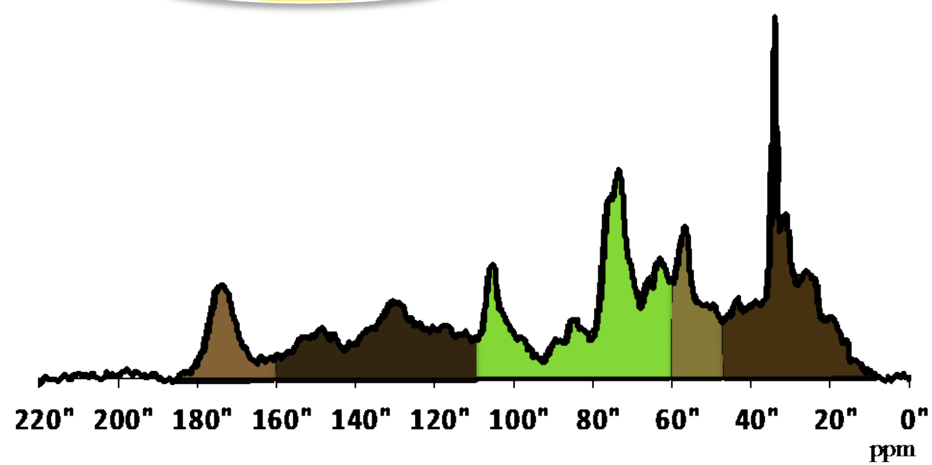



*Lappalainen 1996*

# Peatland Carbon Cycling



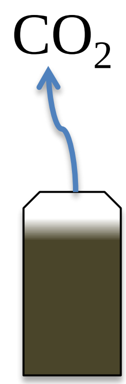

**Does carbon composition control GHG production?**



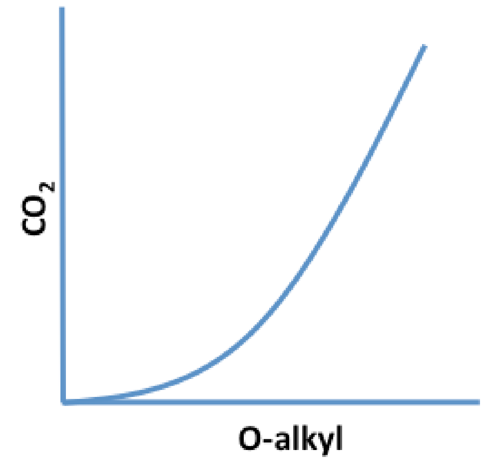

(Reddy and Delaune, 2008)

# Approach

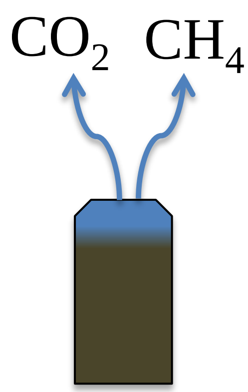
## Aerobic Incubation



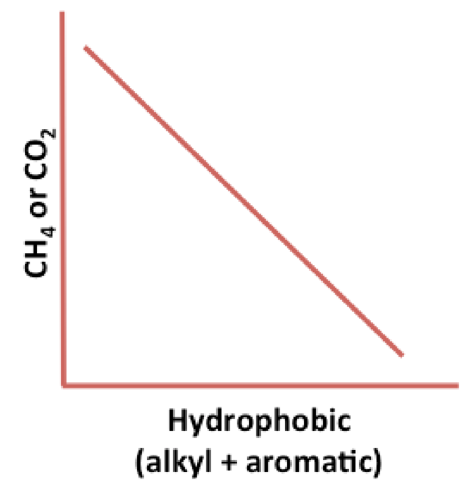

Aerobic



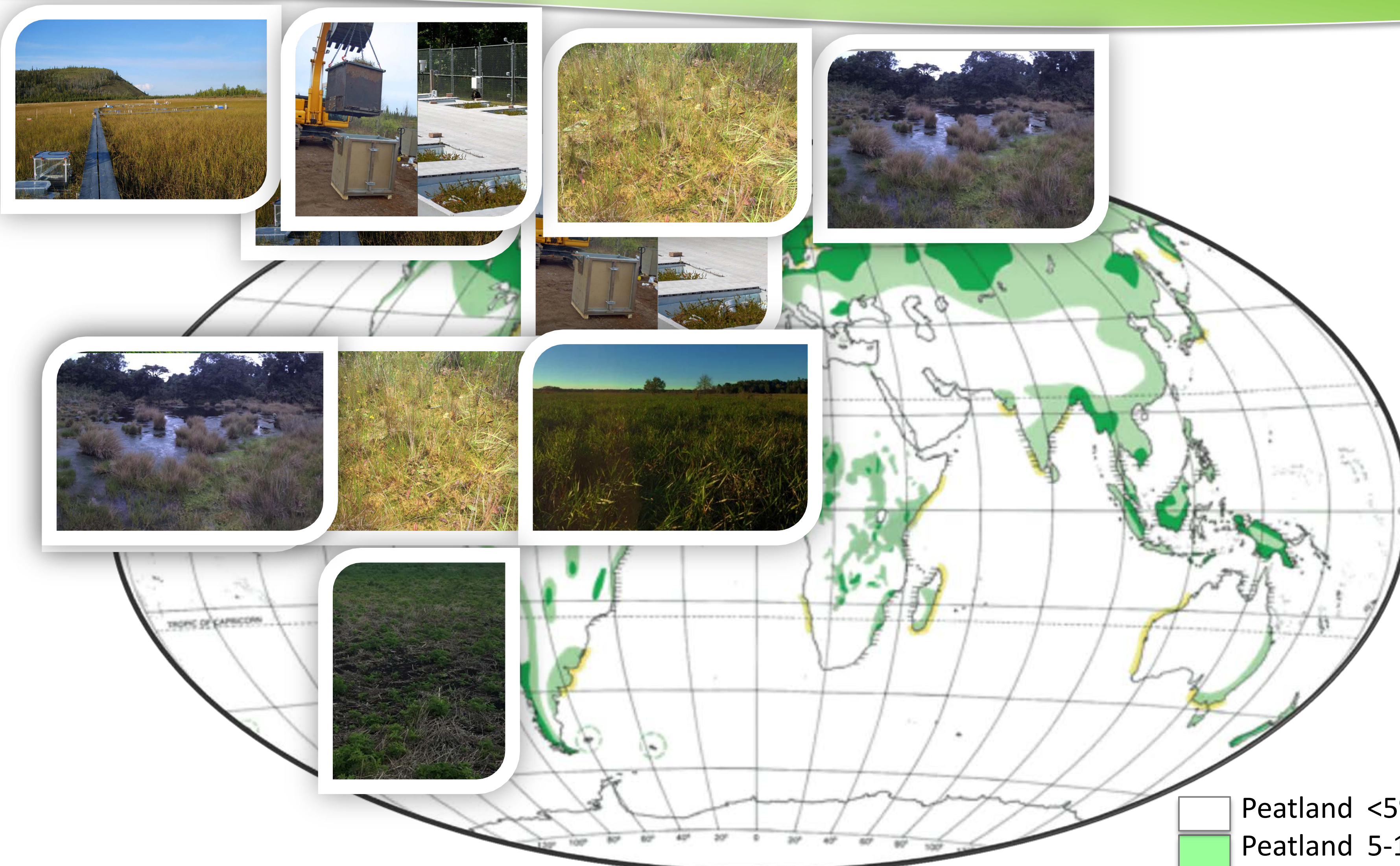

## Anaerobic Incubation




Anaerobic



# GHG Production Incubations Sites



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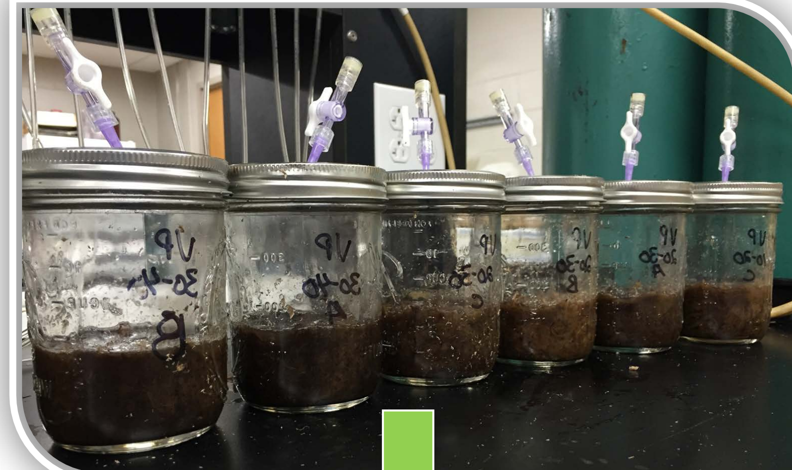
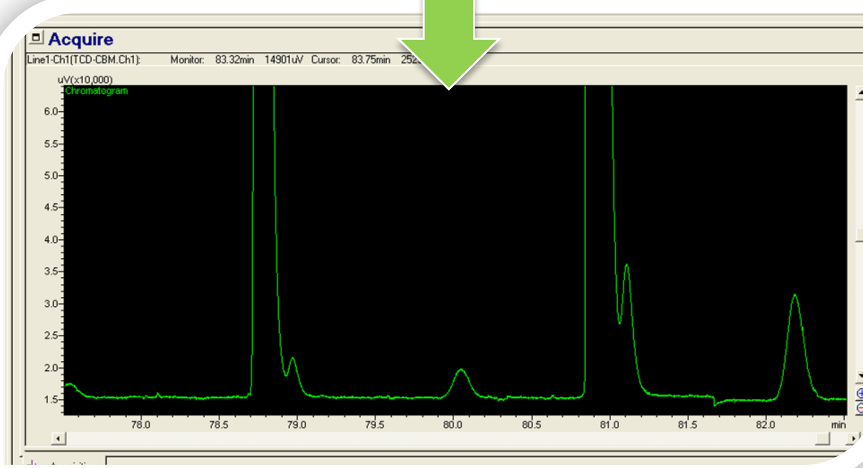
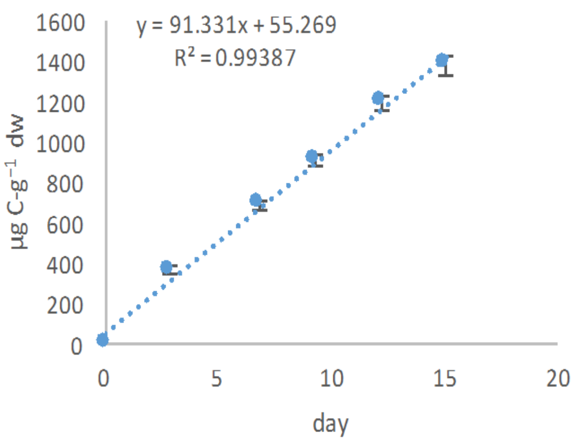
# GHG Production Incubations

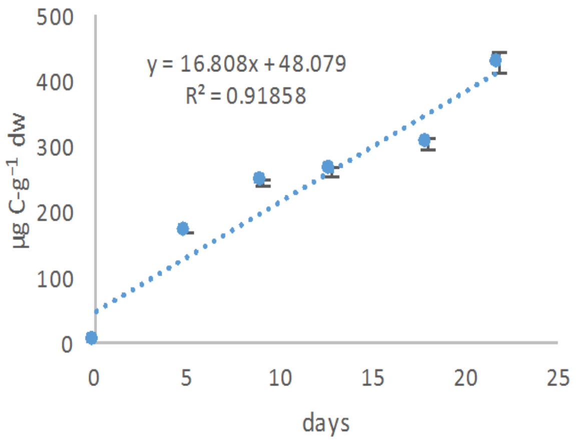


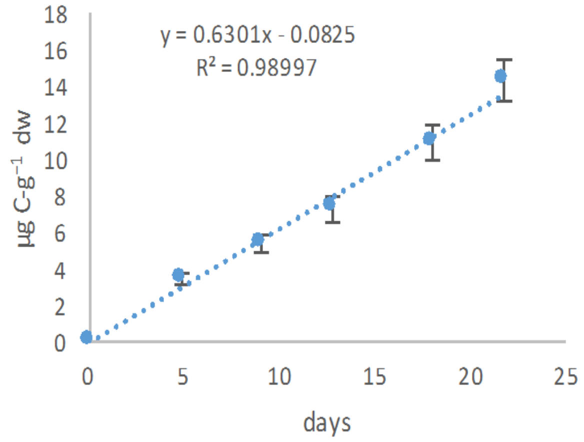



# GHG Production Incubations

| Aerobic $CO_2$ Production Rate | Anaerobic $CO_2$ Production Rate | Anaerobic $CH_4$ Production Rate |
|---|---|---|
| **91.3 µg C-g$^{-1}$ dw d$^{-1}$** | **16.8 µg C-g$^{-1}$ dw d$^{-1}$** | **0.6 µg C-g$^{-1}$ dw d$^{-1}$** |

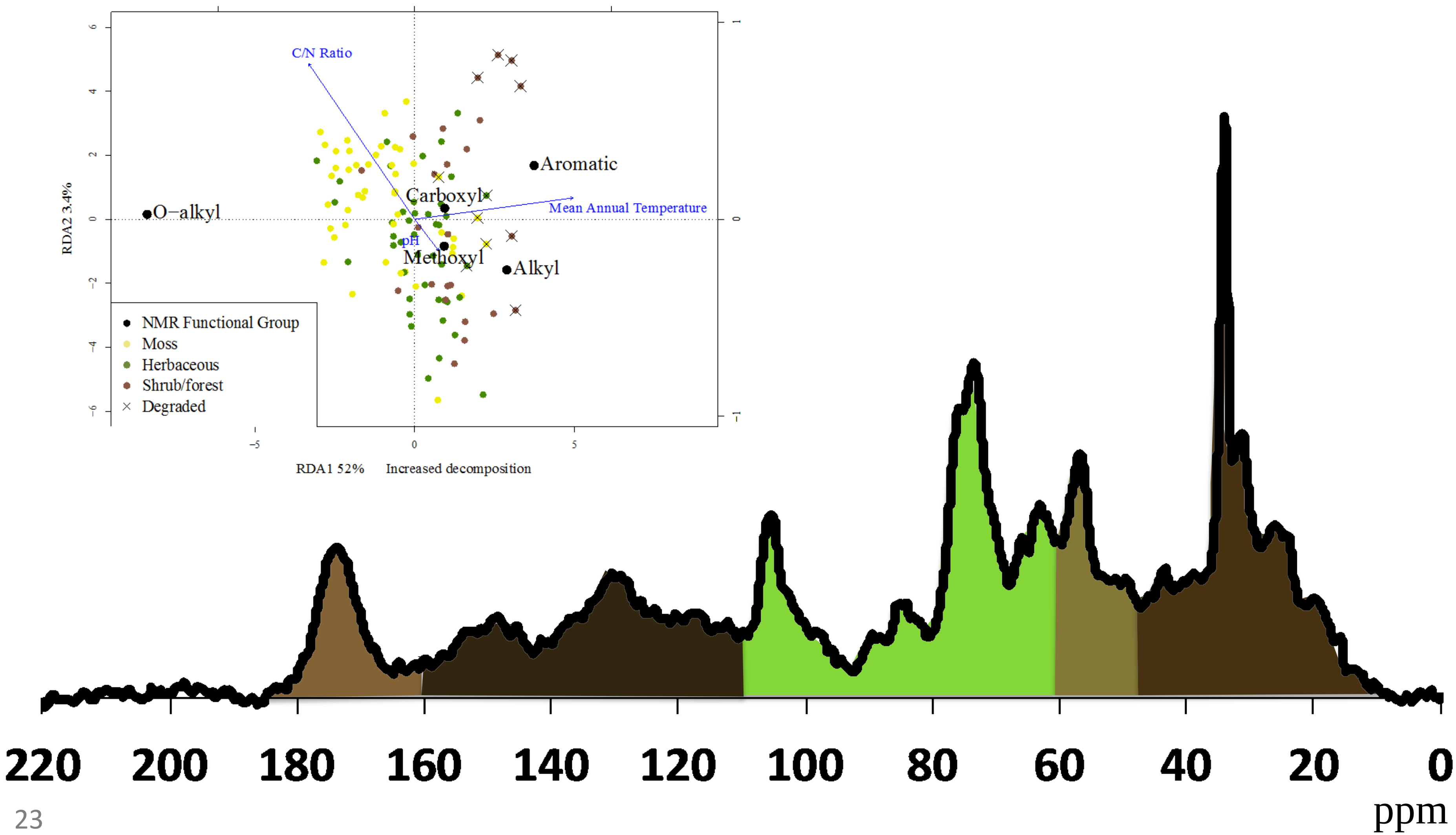


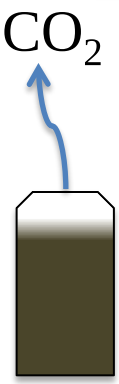



# Nuclear Magnetic Resonance

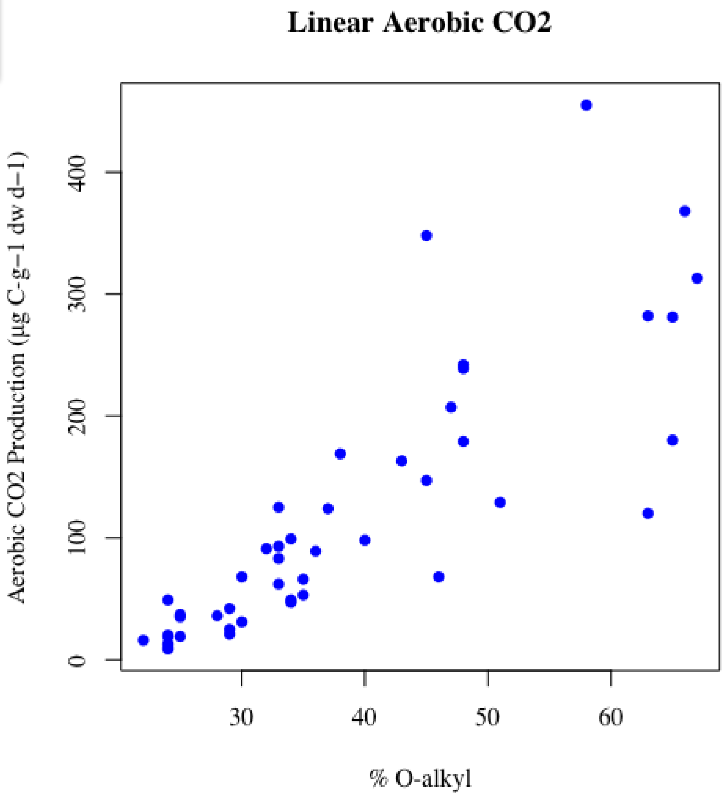
## $^{13}C$ NMR Functional Groups

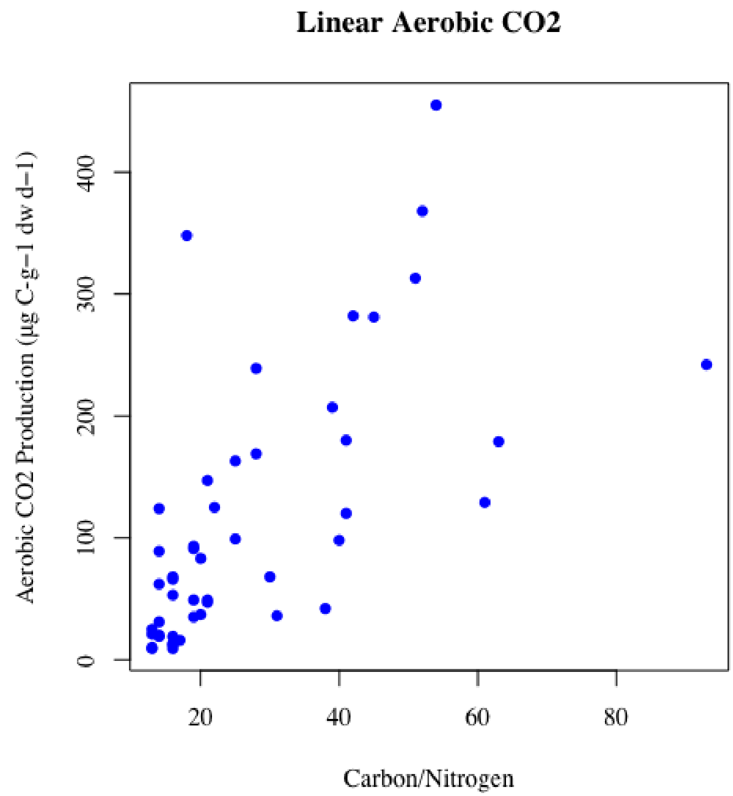


# Aerobic $CO_2$ Production = O-alkyl + Carbon/Nitrogen



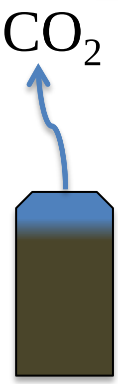

**y = 6.2 O-alkyl*** + 1.3 Carbon/Nitrogen -139.5** **$r^2$ = 0.70**



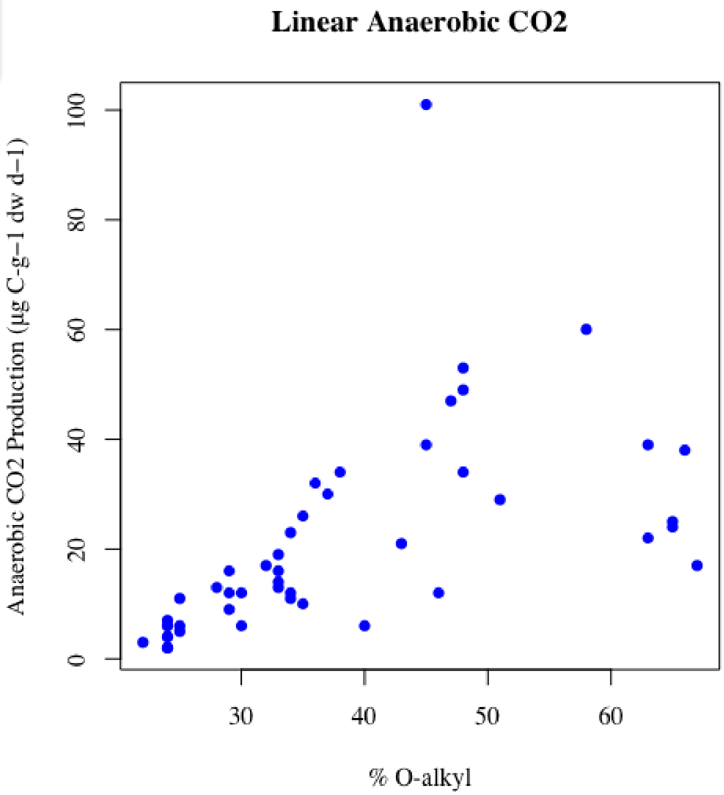



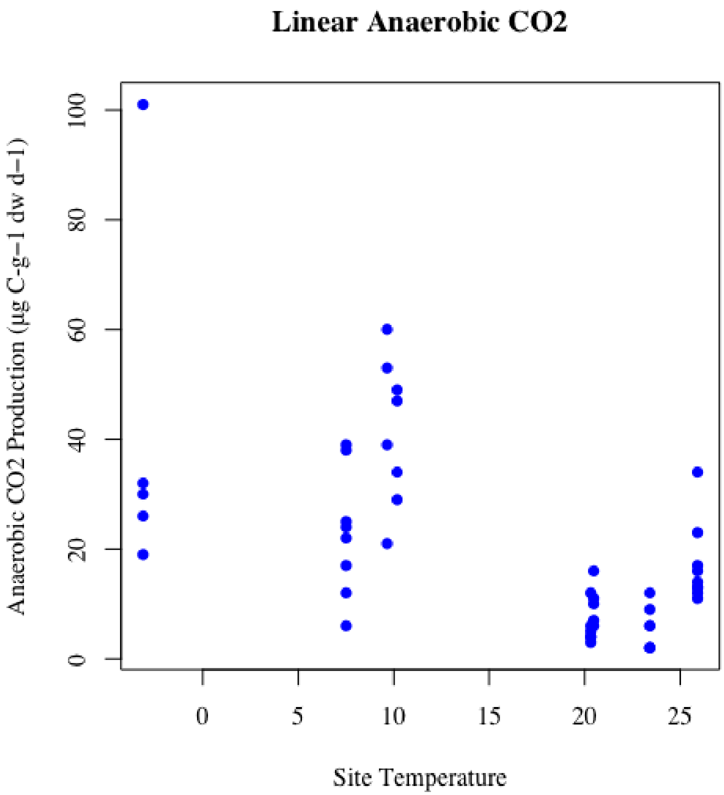

* = $p<0.0001$

# Anaerobic $CO_2$ Production = O-alkyl - Site Temperature



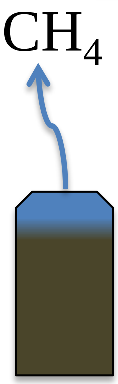

**$y = 0.5$ O-alkyl* $- 0.8$ Temperature** $+13.9$ $r^2 = 0.40$**



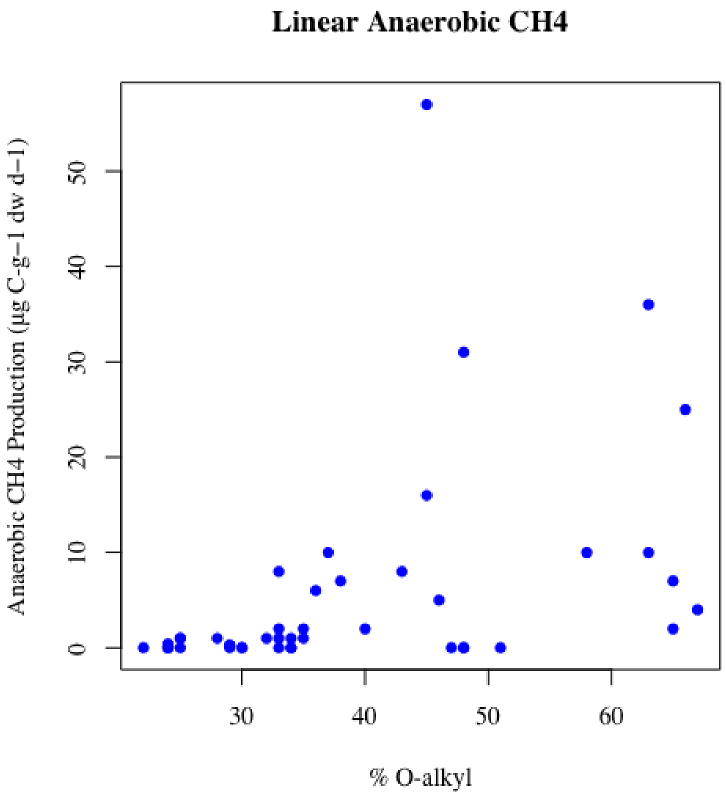



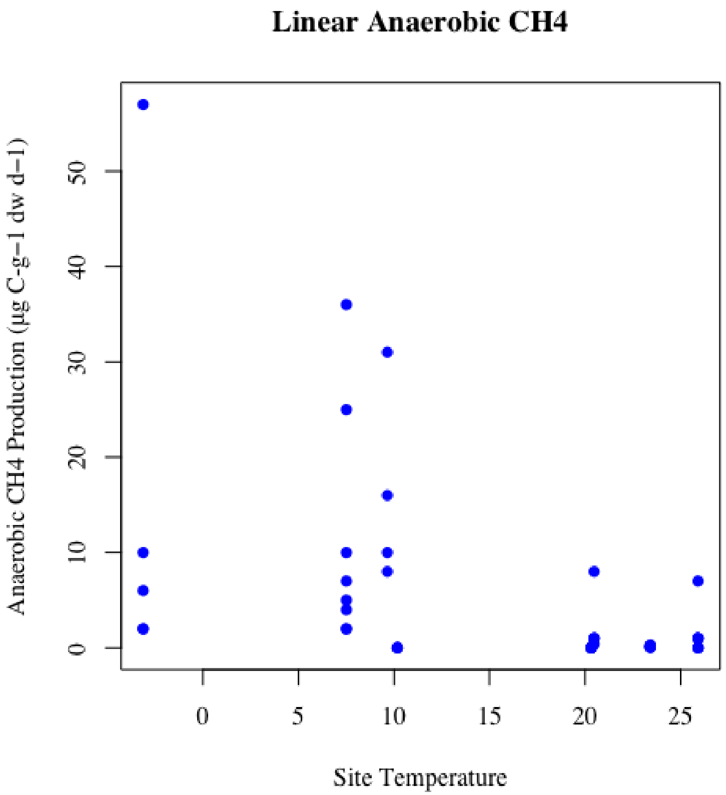

**= $p<0.001$ * = $p<0.05$

# Anaerobic $CH_4$ Production = O-alkyl - Site Temperature



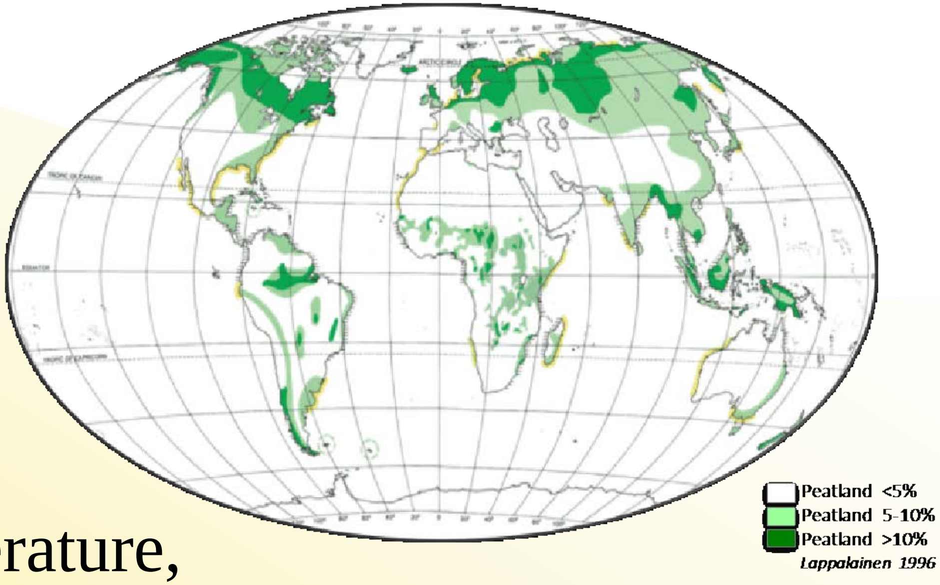

**y = 0.2 O-alkyl• -0.4 Temperature -8.9*** **$r^2$ = 0.25**




• = p<0.1 * = p<0.05

# What drives peatland soil carbon composition?




Not all peat is the same!

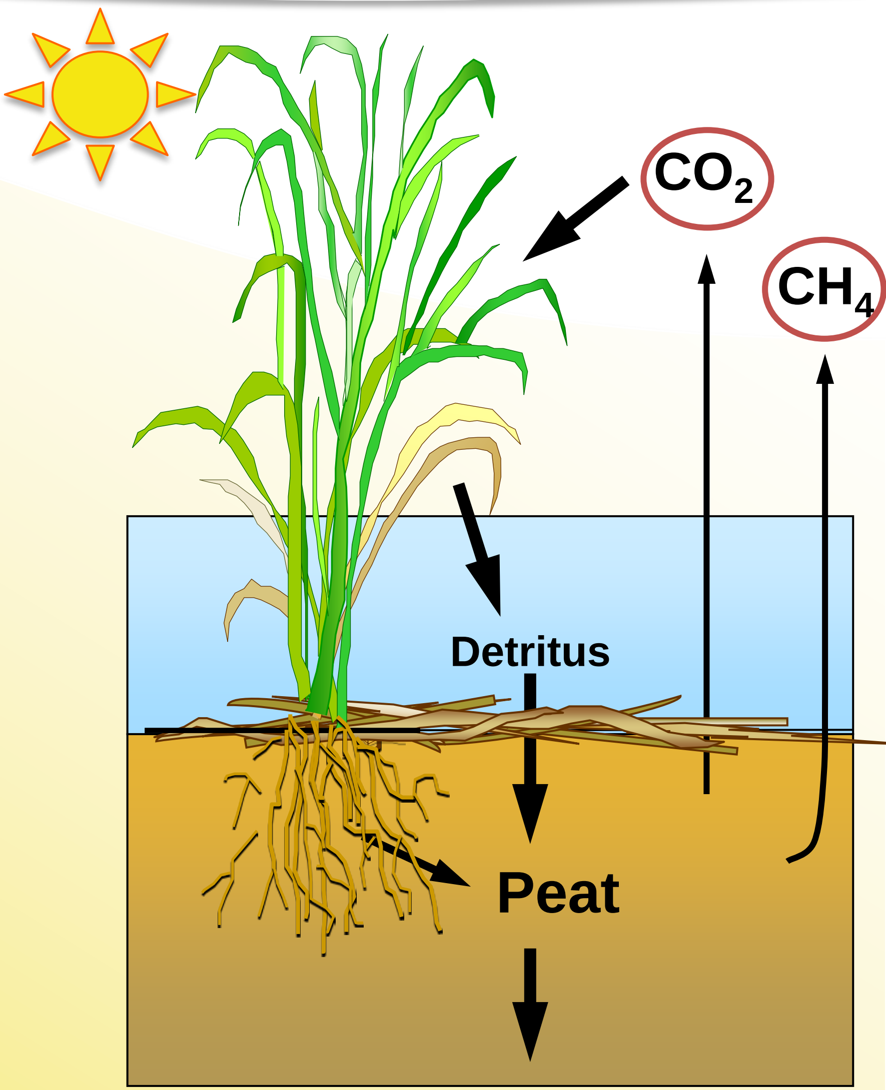
Peat soil carbon composition varies based on land use, temperature, nutrients, vegetation. But not pH.

Good news is that short term peatland degradation does not completely change carbon composition – restoration potential.

# Does carbon composition control GHG production?

Carbon composition matters!

Increased O-alkyl C can drive increased GHG production from aerobic and anaerobic conditions.




(Reddy and Delaune, 2008)

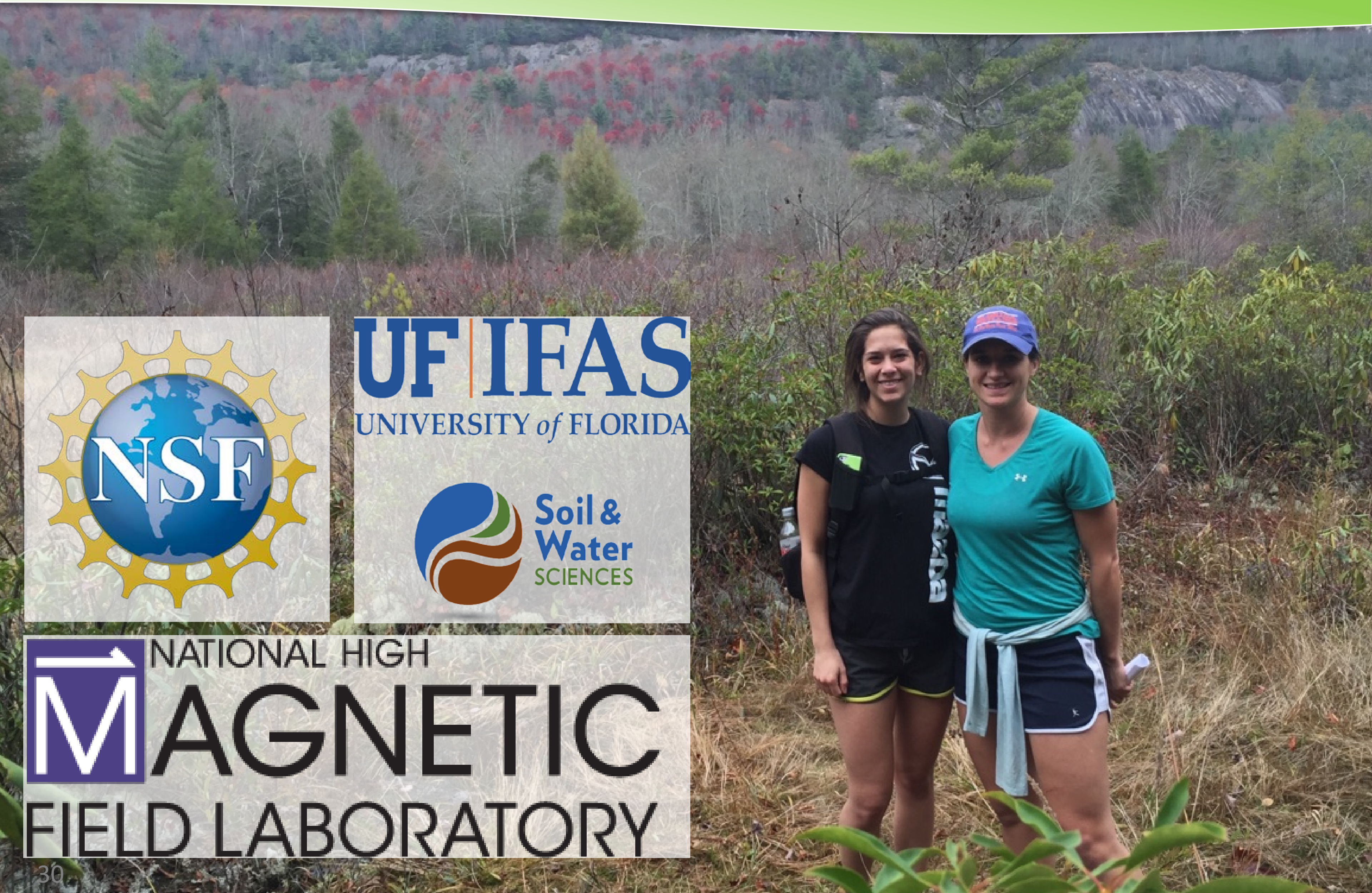
# Take Aways

We can predict carbon composition
of peatlands based on site properties.

Carbon composition signatures
likely drive GHG production,
especially when peatlands are drained.

International research is hard!
Don’t lose your corer in the peat!

# Thanks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