# Carbon sequestration and water table impacts on peat soils

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# The Challenges

- The National Climate Action Bill set Ireland a target to reduce national emissions by 51% by 2030 relative to 2018
- Agriculture comprises 34% of national GHG emissions
- Land-use is moving from net-net to gross-net reporting → LULUCF becomes a source of emissions due to high emissions from peat soils and low rates of afforestation
- AFOLU = 40% of national emissions
- GWP of methane is increasing from 25 to 28 times that of $CO_2$

# The Policy Requirement

- What are national AFOLU GHG emissions projected to be under a business as usual (BAU) scenario?
- How much can mitigation strategies reduce emissions over the period and how are these subdivided?
- What is the cost?

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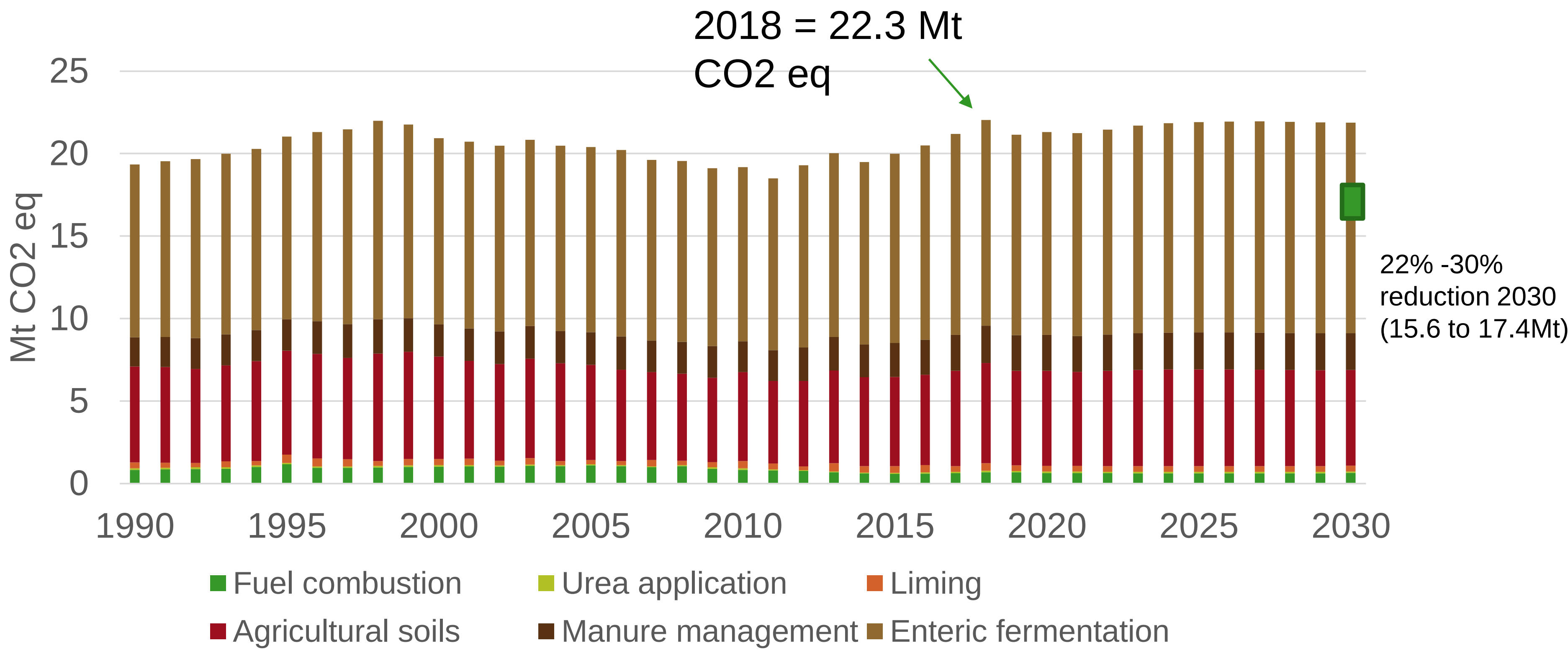
# Historical and Projected Agricultural Emissions (excludes mitigation actions)

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# Land-use emissions and removals

| BAU | Baseline | 2018 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Afforestation (New Bau projections) | | | -1.61 | -1.82 | -1.99 | -2.43 | -1.95 | -2.18 | -1.87 | -1.79 | -1.84 | -1.61 |
| Forest land (FL-FL) New Projections | | | 0.43 | 0.36 | 1.09 | 2.49 | 2.07 | 3.00 | 2.58 | 2.73 | 3.04 | 2.83 |
| Total forest land Incl (HWP) | | -3.321 | **-2.04** | **-1.46** | **-0.90** | **0.06** | **0.11** | **0.81** | **0.71** | **0.95** | **1.20** | **1.23** |
| Defor to settlement and other | | | **0.36** | **0.36** | **0.36** | **0.35** | **0.35** | **0.36** | **0.36** | **0.36** | **0.35** | **0.34** |
| Cropland (CL)** | 0.01 | -0.129 | **-0.01** | **0.01** | **0.13** | **-0.08** | **0.01** | **-0.15** | **0.10** | **0.03** | **-0.11** | **0.10** |
| Grassland (GL)** | 6.8 | 6.683 | **7.33** | **7.30** | **7.27** | **7.25** | **7.22** | **7.20** | **7.20** | **7.19** | **7.18** | **7.17** |
| Wetlands (WL)** | 2.2 | 2.32 | **2.34** | **2.24** | **2.16** | **2.08** | **1.98** | **1.91** | **1.83** | **1.74** | **1.66** | **1.58** |
| Settlements | | 0.09 | **0.22** | **0.22** | **0.22** | **0.22** | **0.22** | **0.22** | **0.22** | **0.21** | **0.21** | **0.21** |
| Other | | 0.0 | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** | **0.05** |
| Total | | **5.7** | **8.25** | **8.36** | **8.93** | **9.57** | **9.60** | **10.04** | **10.11** | **10.17** | **10.19** | **10.33** |
| Net-net total | | -3.46 | -1.39 | -0.92 | -0.35 | 0.29 | 0.32 | 0.76 | 0.83 | 0.91 | 0.93 | 1.07 |

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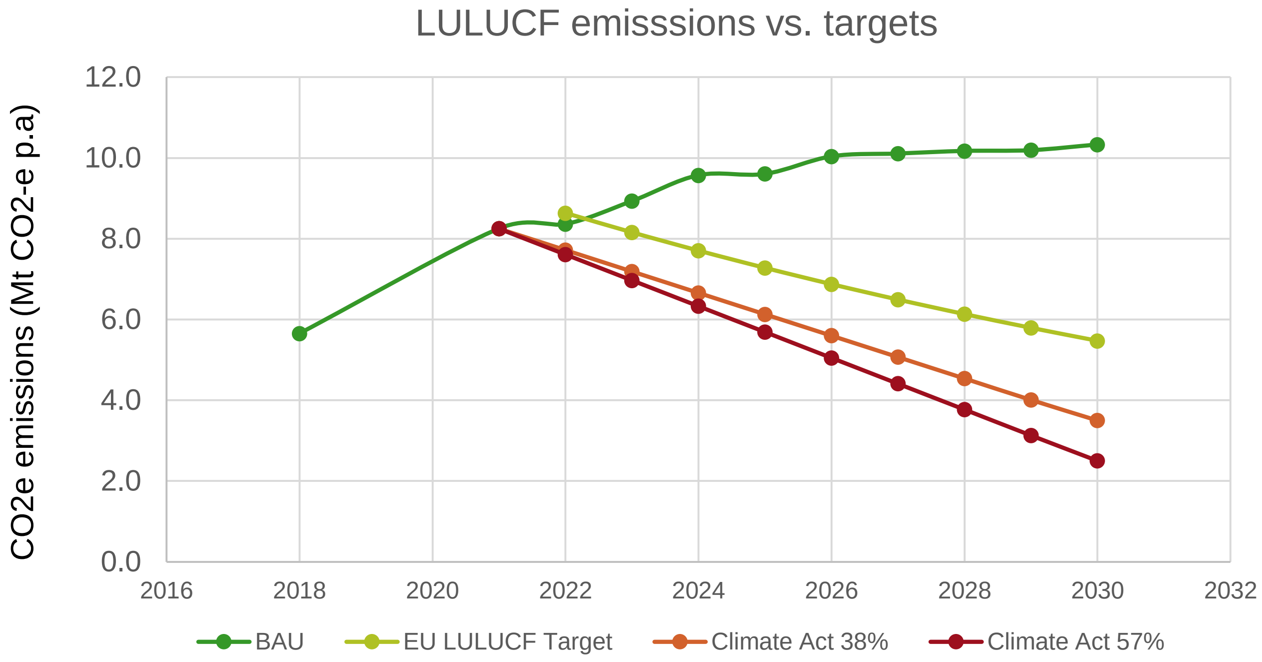


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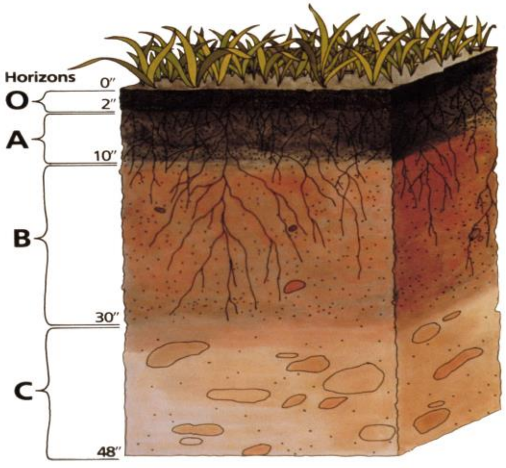
# How can C sequestration help achieve these targets?

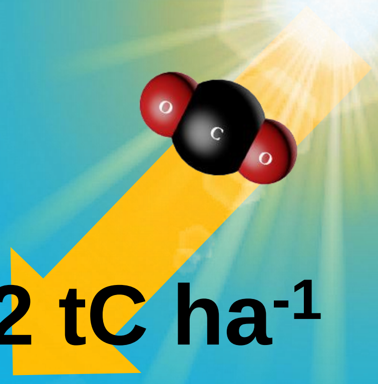
- **Under 2030 Climate Framework ESD - carbon sinks ~ 6% (2.7 MT $CO_2$e)**
- Beyond – can contribute to a) achieving neutrality and b) reducing C footprint of agricultural produce
- Carbon can be sequestered long term in:

Woody biomass – 20-30 years (conifers), 60-150 years (broadleaves)

Soils – decades to several centuries

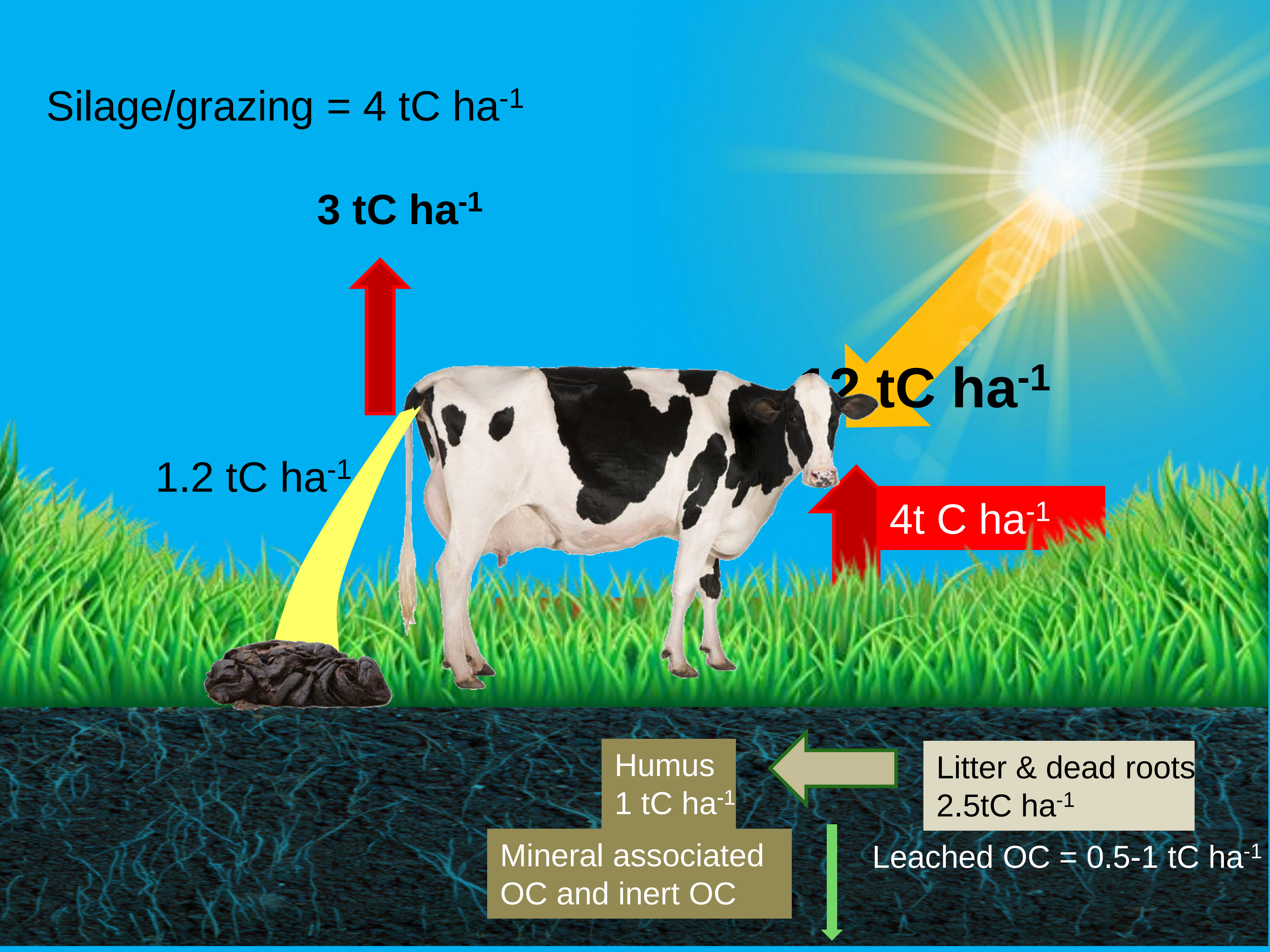


# How much Carbon does a grassland take up?



**12 tC $ha^{-1}$**

1

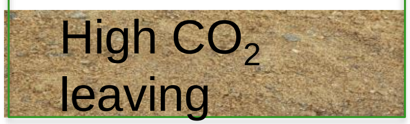

Silage/grazing = 4 tC ha$^{-1}$
3 tC ha$^{-1}$
12 tC ha$^{-1}$
1.2 tC ha$^{-1}$
4t C ha$^{-1}$
Humus
1 tC ha$^{-1}$
Litter & dead roots
2.5tC ha$^{-1}$
Mineral associated
OC and inert OC
Leached OC = 0.5-1 tC ha$^{-1}$

# Carbon Sequestration

## Sandy soil

**$CO_2$ Uptake**

High $CO_2$ uptake



High $CO_2$ leaving system

**$CO_2$ Loss**

**Sequestration Potential**

## Clay soil

High $CO_2$ uptake

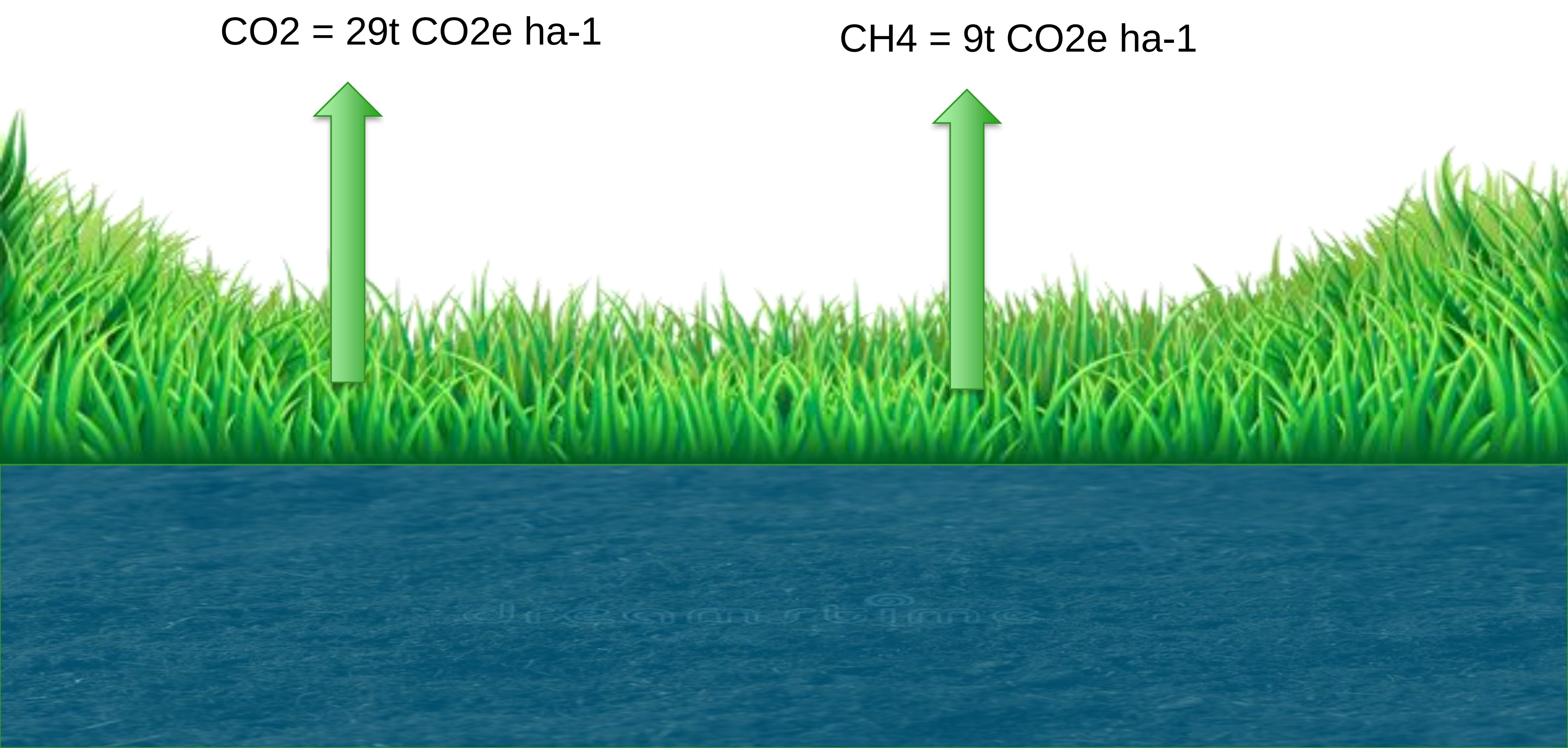
SOC changes with LUC OTHERWISE CONSTANT

## Peat soil

Low $CO_2$ uptake

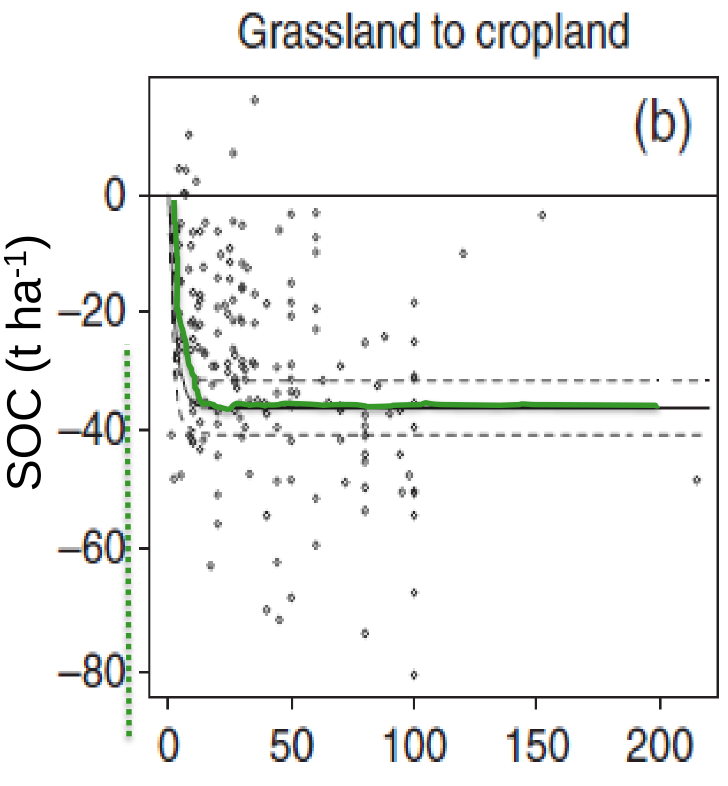
No loss so SOC builds up

# Peatland



# IPCC peatland emission factors

| Land use | Emissions Drained | Emissions Rewetted | Δ Emissions |
|---|---|---|---|
| | [t $CO_2$e $ha^{-1}$*$yr^{-1}$] | | |
| Cropland, nutrient poor | 37.6 | 3.1 | 34.5 |
| Cropland, nutrient rich | 37.6 | 9.9 | 27.7 |
| Grassland, nutrient-poor, shallow drained | 23.3 | 3.1 | 20.2 |
| Grassland, nutrient-poor, deep drained | 24.1 | 3.1 | 21.0 |
| Grassland, nutrient-rich, shallow-drained | 16.7 | 9.9 | 6.8 |
| Grassland, nutrient-rich, deep-drained | 29.2 | 9.9 | 19.3 |




*Poeplau et al. 2011 GCB*

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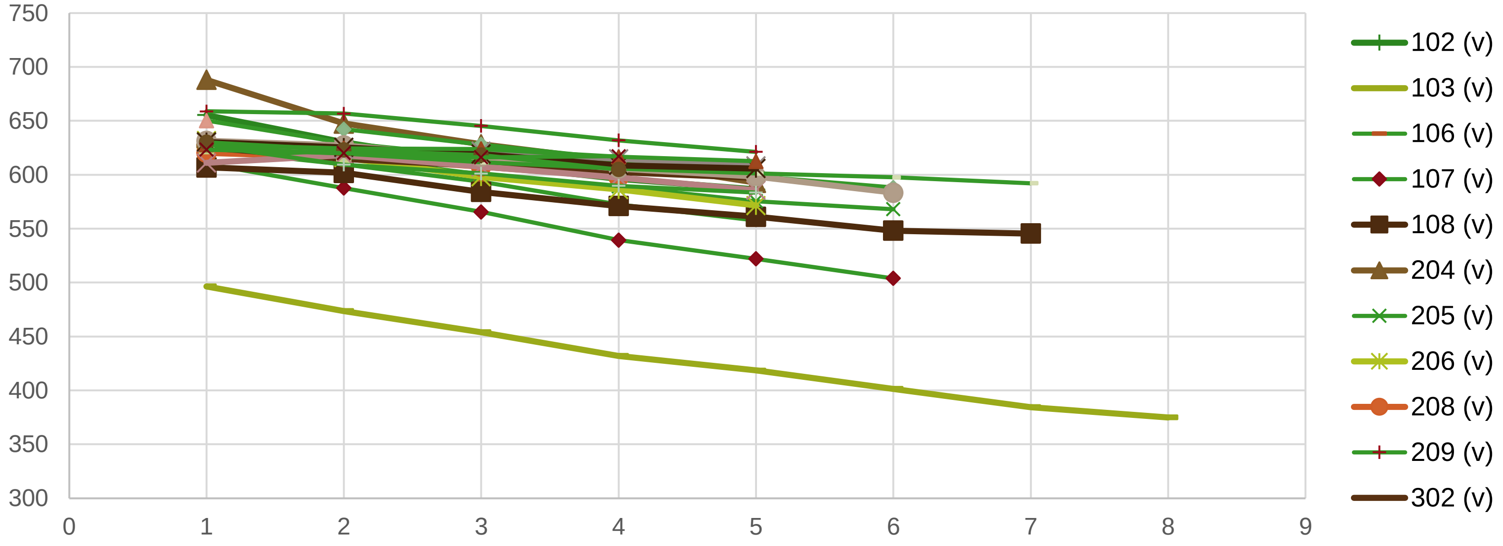
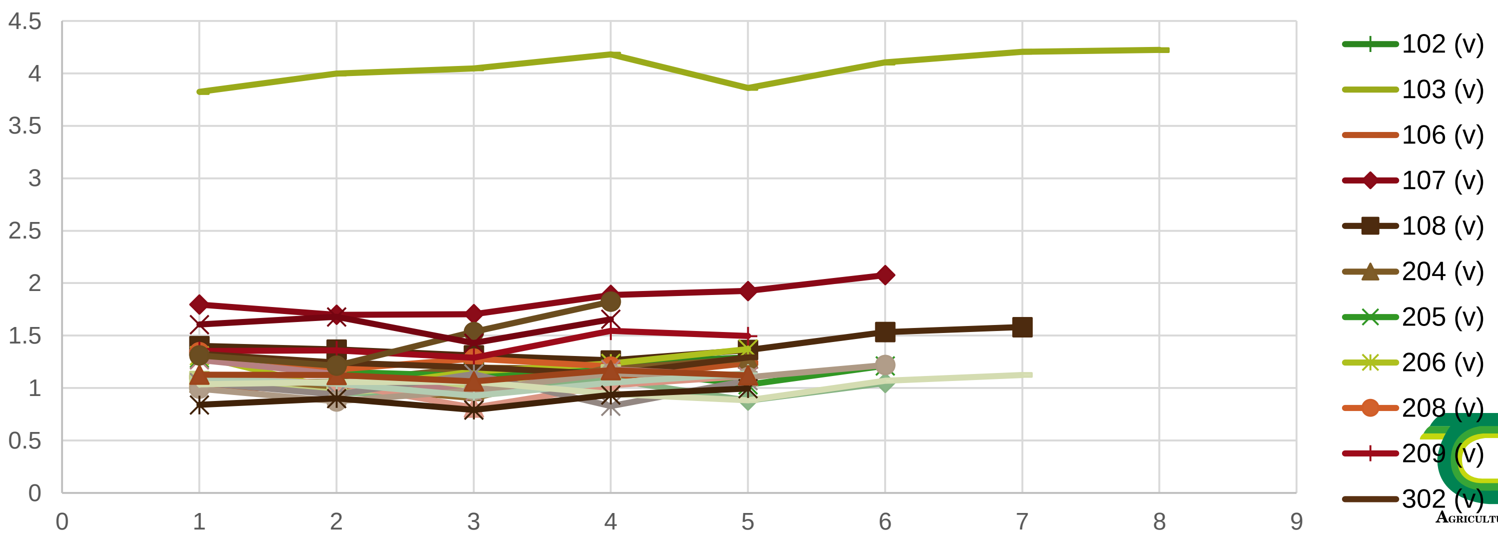
transparent chamber - CO2 - vegetated cores (11am-14pm)




transparent chamber - CH4 - vegetated cores (11am-14pm)

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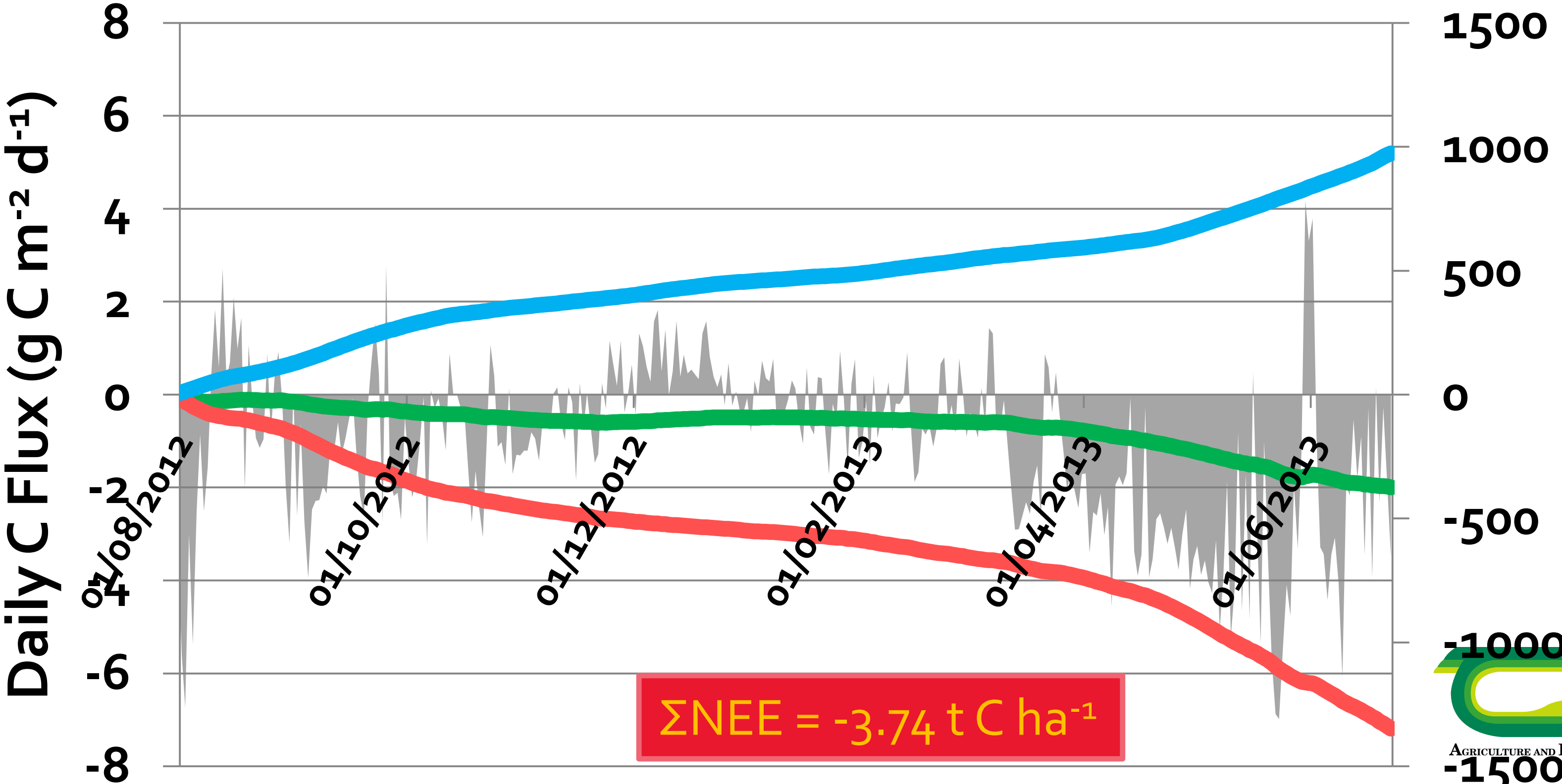
# Flux measurements

- Gives an annual estimate
- Elucidate drivers of C gain and loss
- Useful for constraining models

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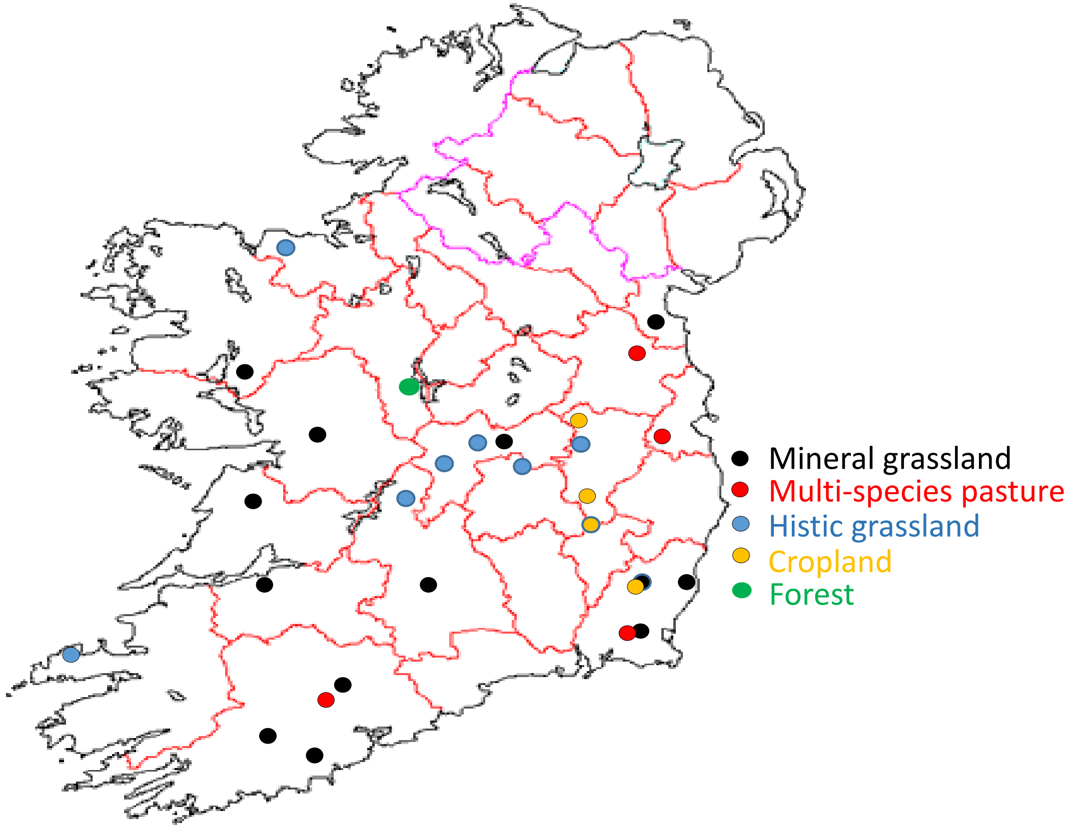
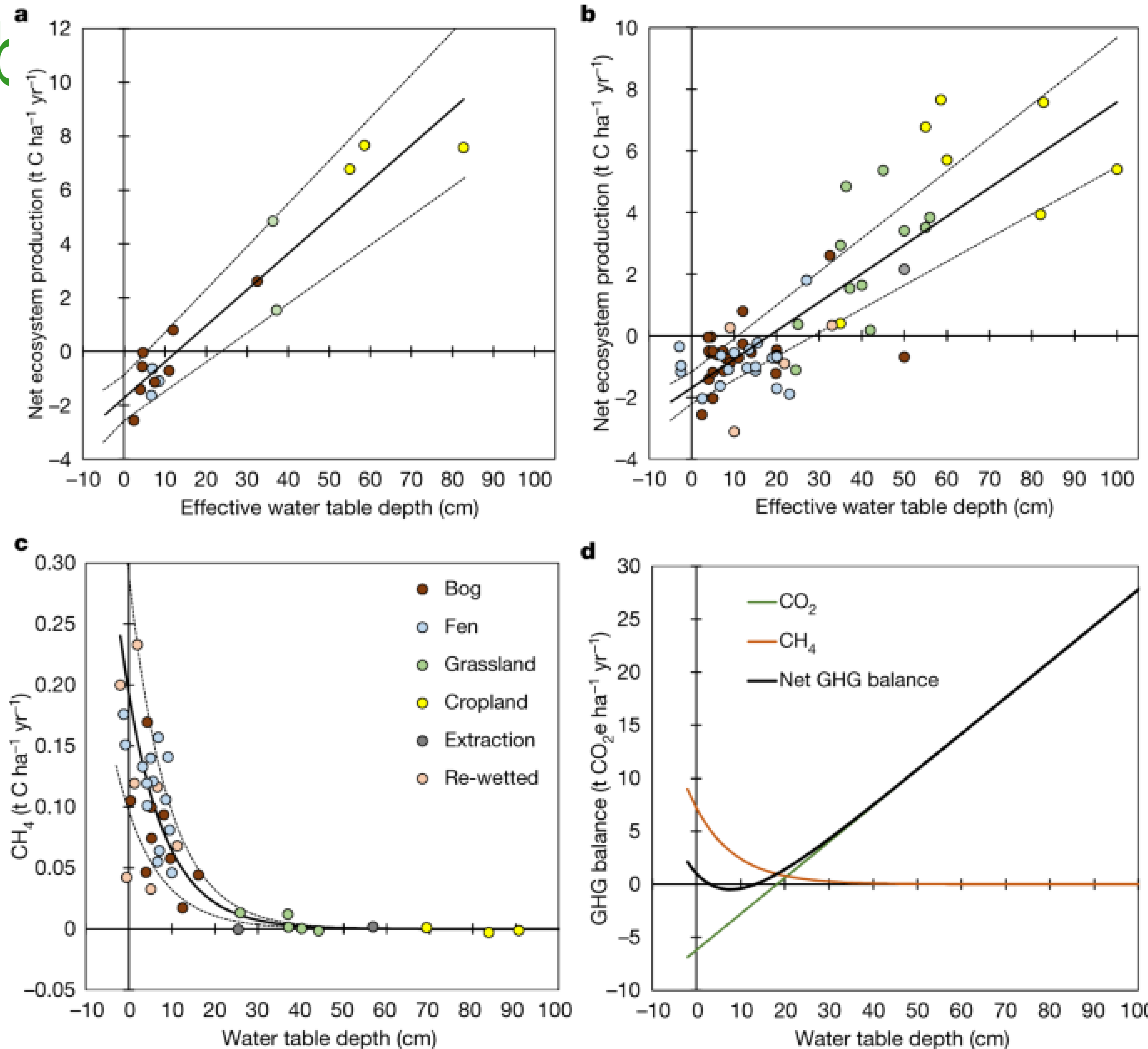
# Eddy Covariance Flux Towers

- 10 Towers purchased (4 peat and 6 mineral soils)
- NASCO = 32 flux towers
- Investigate management impacts – rewetting and reducing fertiliser
- Gives annual C estimates
- Elucidate drivers of C gain and loss
- Used to constrain C models



# Peatland emissions and water tab



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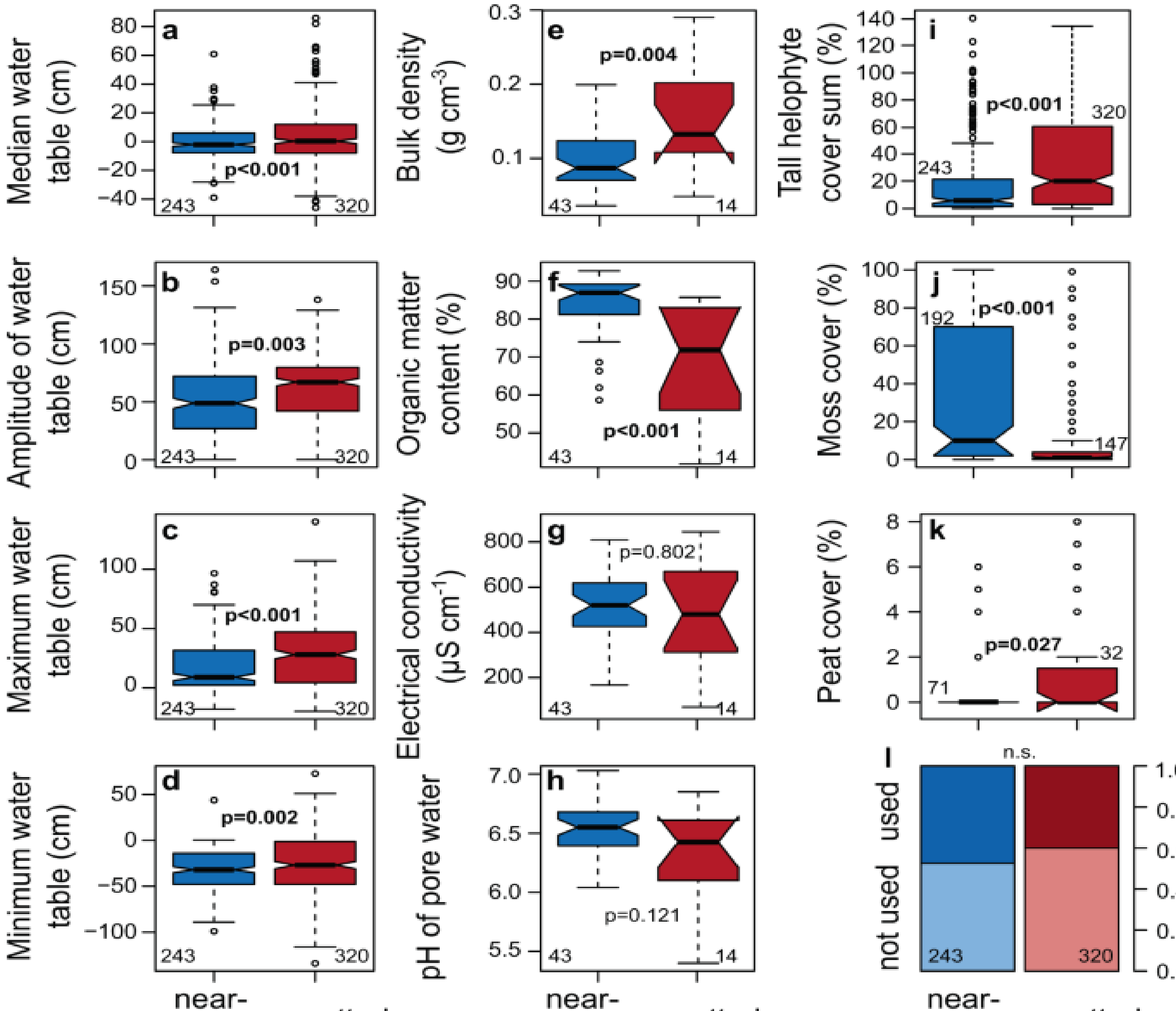
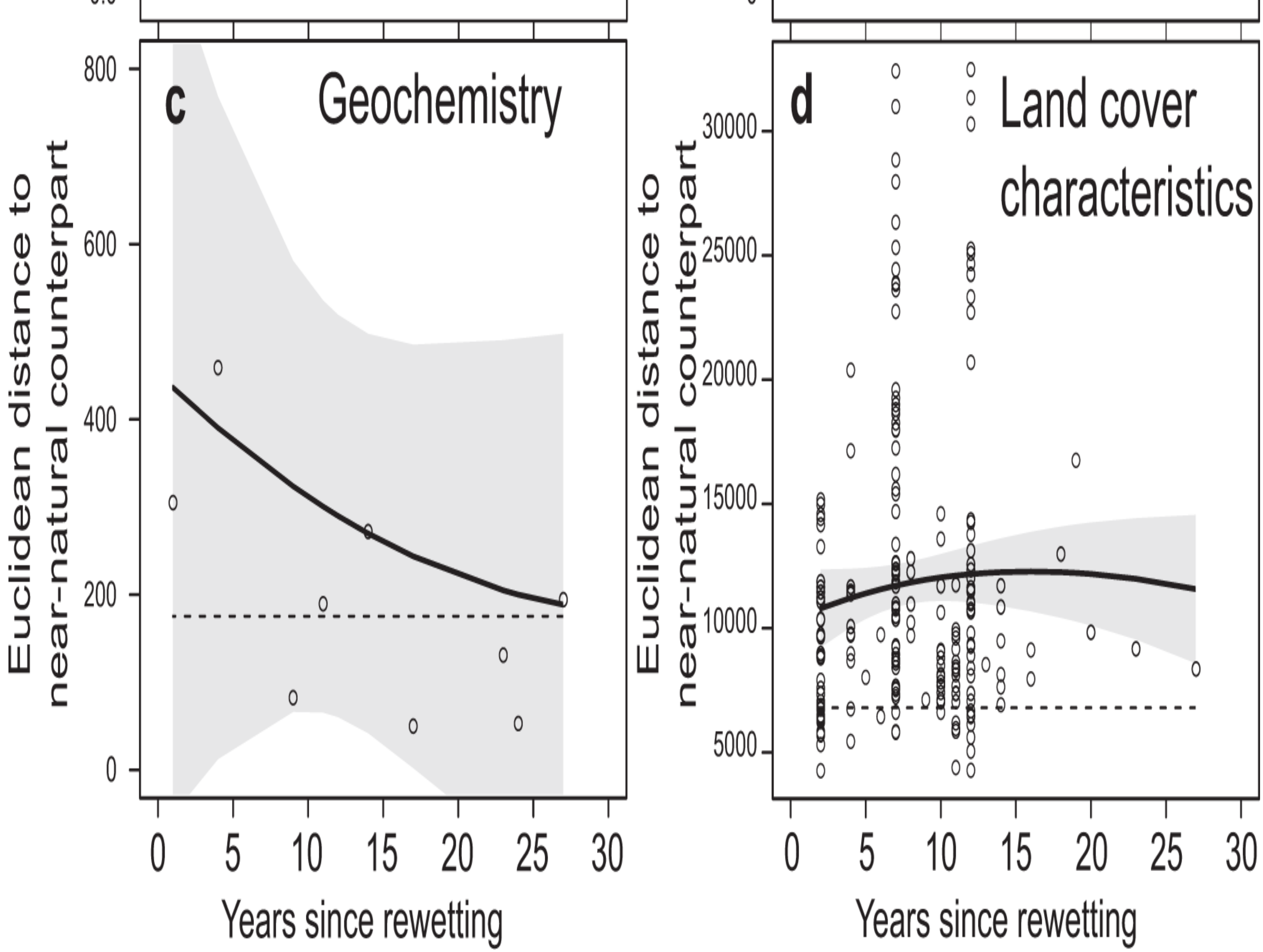
# Rewetting does not mean restoration




c
Geochemistry
Euclidean distance to near-natural counterpart
800
600
400
200
0
0
5
10
15
20
25
30
Years since rewetting
d
Land cover characteristics
Euclidean distance to near-natural counterpart
30000
25000
20000
15000
10000
5000
0
5
10
15
20
25
30
Years since rewetting

# Impact of water table

## 14C analysis

Pasture

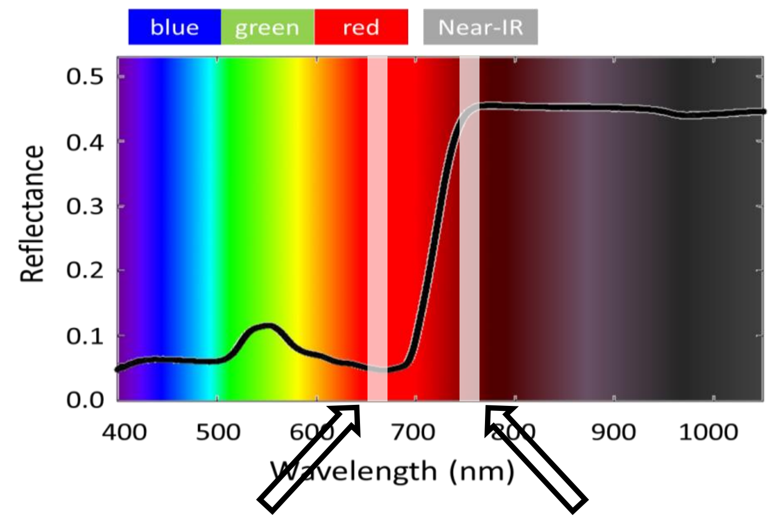
Bog

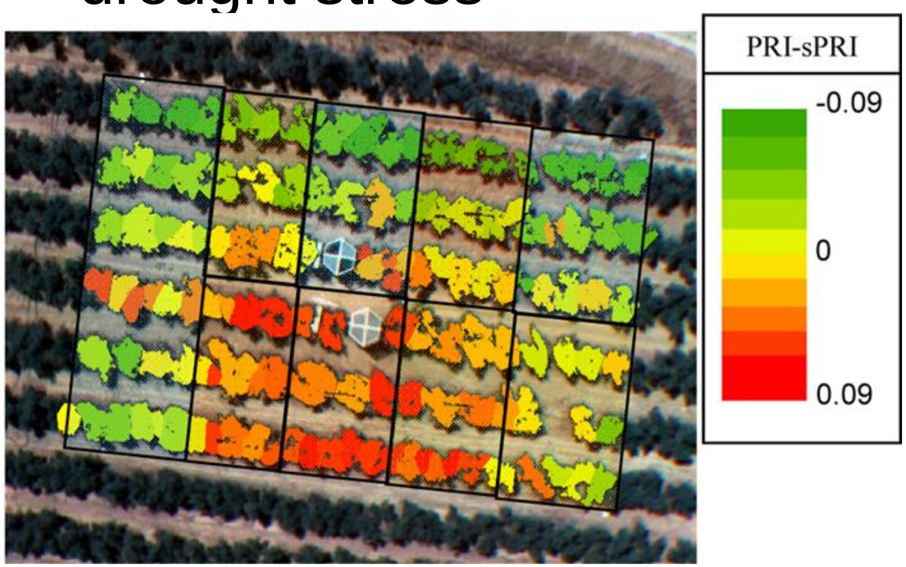
Cutaway

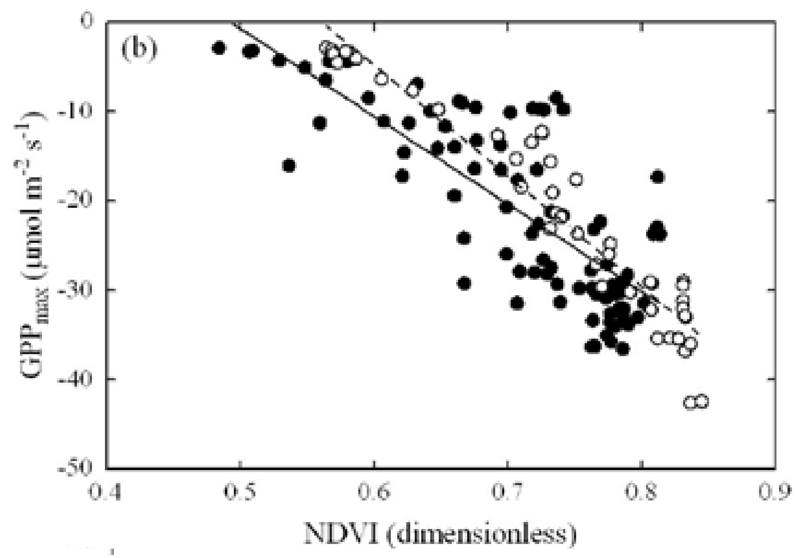

en

# Can link EC and remote sensing

- Use NDVI ‘greenness index’ as a proxy
- Solar-Induced Florescence as a proxy for photosynthesis
- Photochemical Reflectance Index – proxy for Light use efficiency – diagnostic for drought stress

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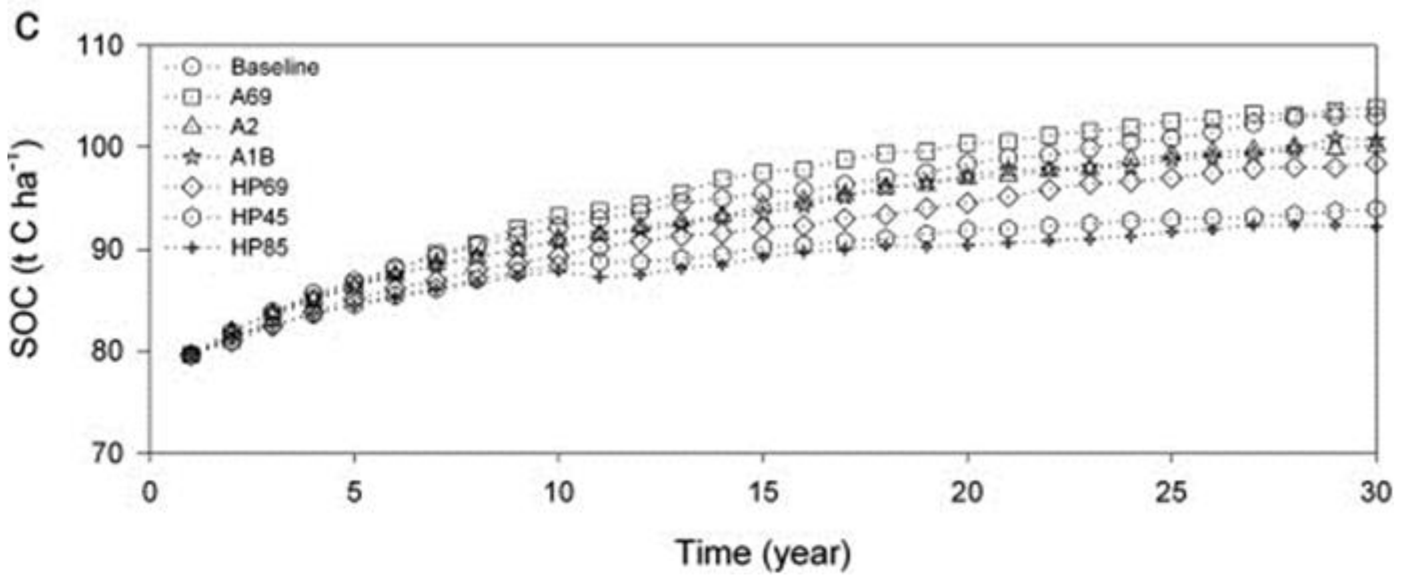
# Model management impacts

- Legume & multi-species – 0.16 tC $ha^{-1}$ $yr^{-1}$
- Manure addition – 0.3 tC $ha^{-1}$ $yr^{-1}$
- Good nutrient status (liming) - 0.21 tC $ha^{-1}$ $yr^{-1}$

# Model climate impacts

- How climate-proof is sequestration?



# Conclusions

- Have good C baselines for grassland – know how much C and type of C
- Gathering data on management impacts
- Need to understand underlying processes – $^{13}C$ isotope tracing including soil microbiology and esp. rhizosphere
- Require long-term monitoring where activity data is gathered
- Require EC monitoring at a field and regional scale – link to remote sensing products and use for model validation