Carbon sequestration and water table impacts on peat soils

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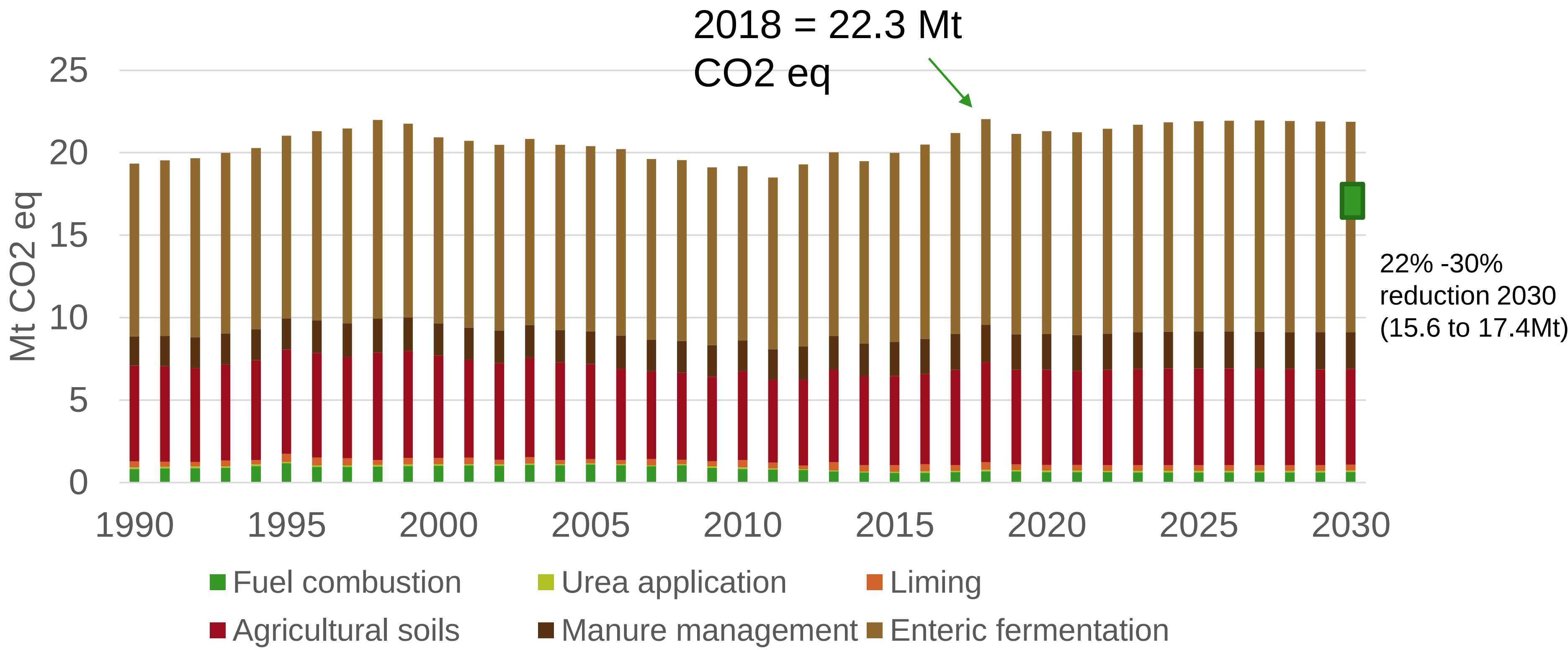
The Challenges

- 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?

Historical and Projected Agricultural Emissions (excludes mitigation actions)



2018 = 22.3 Mt CO2 eq

22% -30% reduction 2030 (15.6 to 17.4Mt)

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Land-use emissions and removals

	Baseline	2018	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BAU												
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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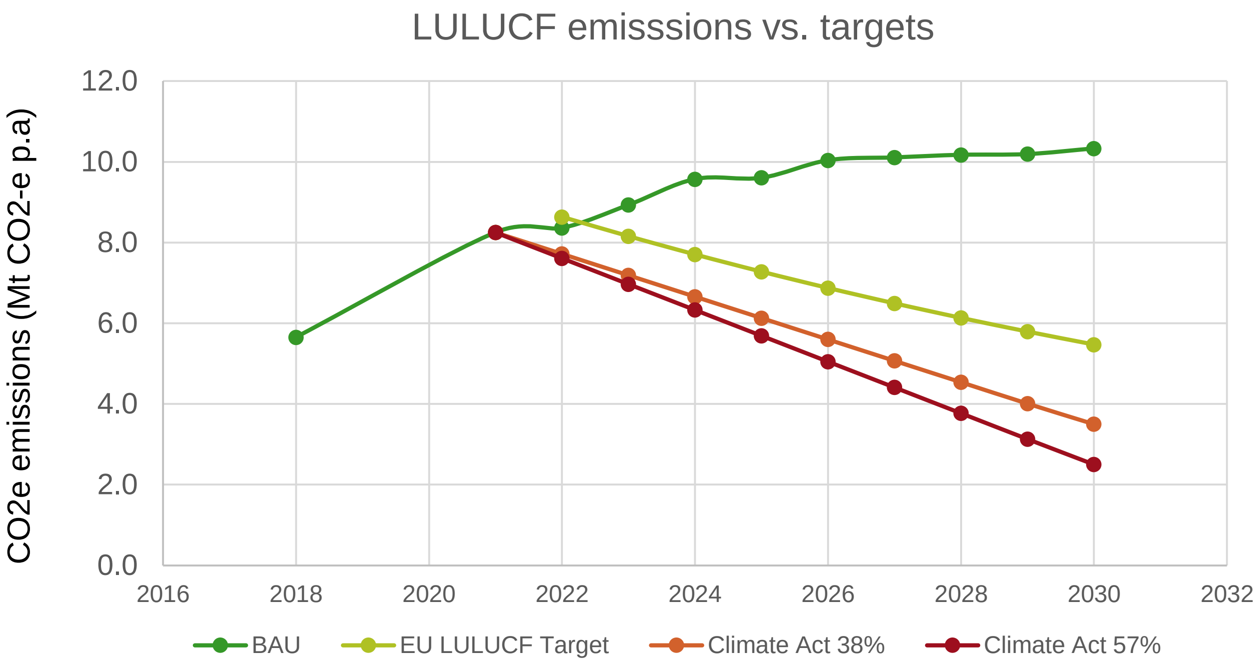

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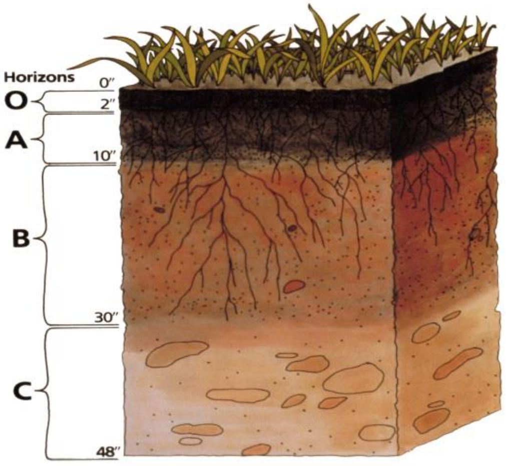
How can C sequestration help achieve these targets?

- **Under 2030 Climate Framework ESD - carbon sinks ~ 6% (2.7 MT CO_2e)**
- 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)

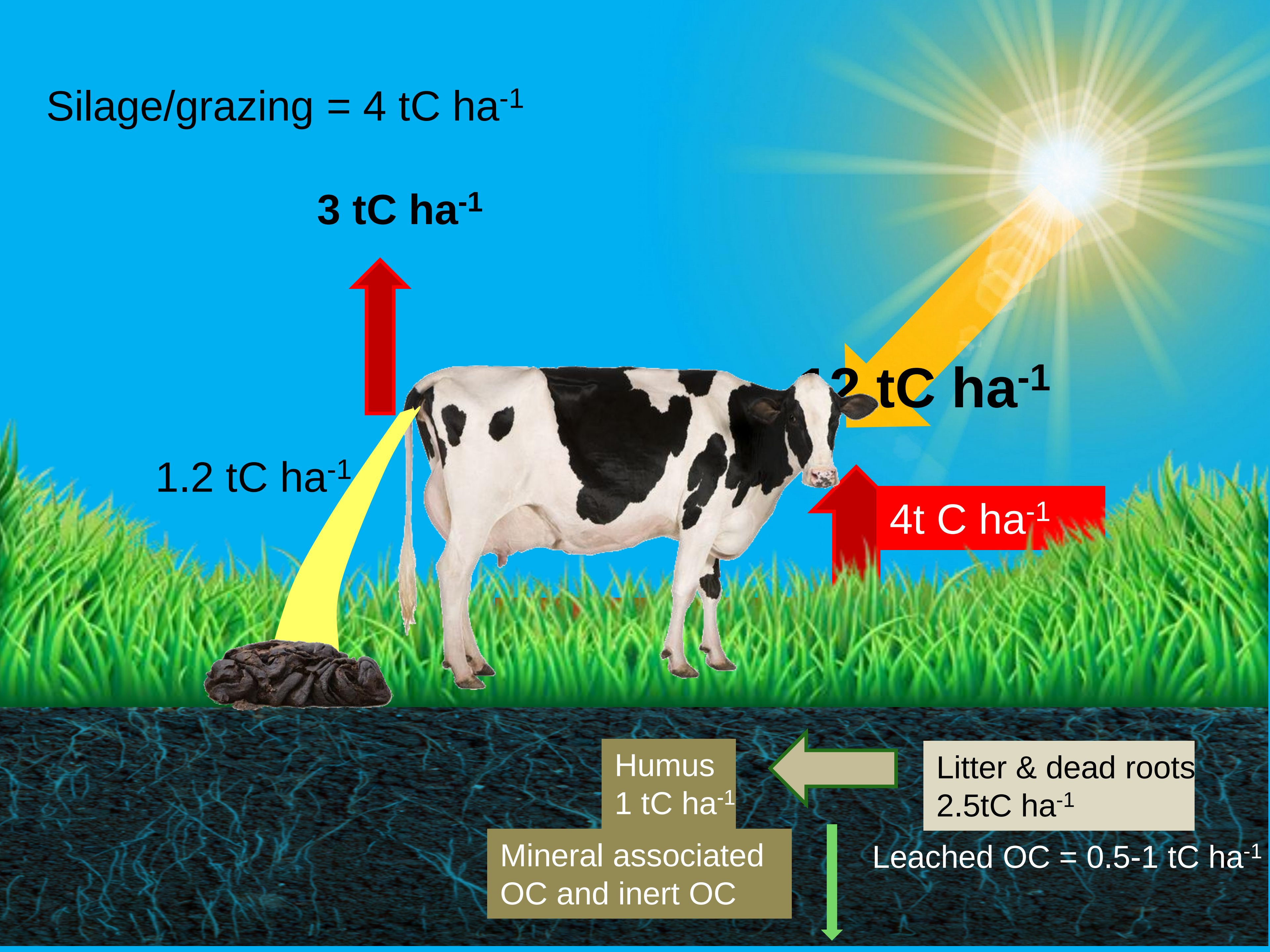


Soils – decades to several centuries

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

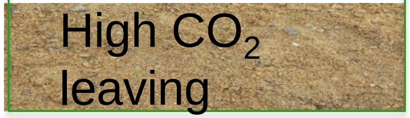
CO_2 Uptake

CO_2 Loss

Sequestration Potential

Sandy soil

High CO_2 uptake



High CO_2 leaving system

Clay soil

High CO_2 uptake

SOC changes with LUC OTHERWISE CONSTANT

Peat soil

Low CO_2 uptake

No loss so SOC builds up

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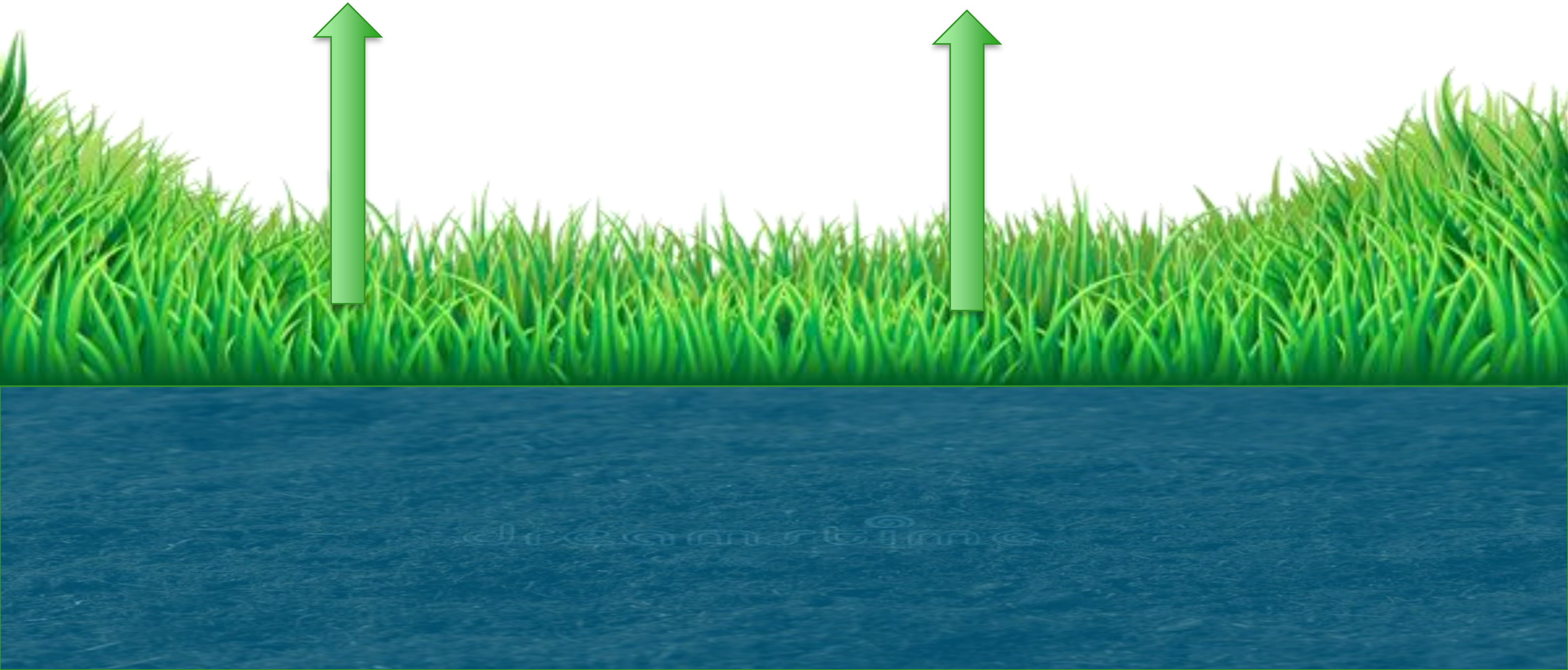
Peatland

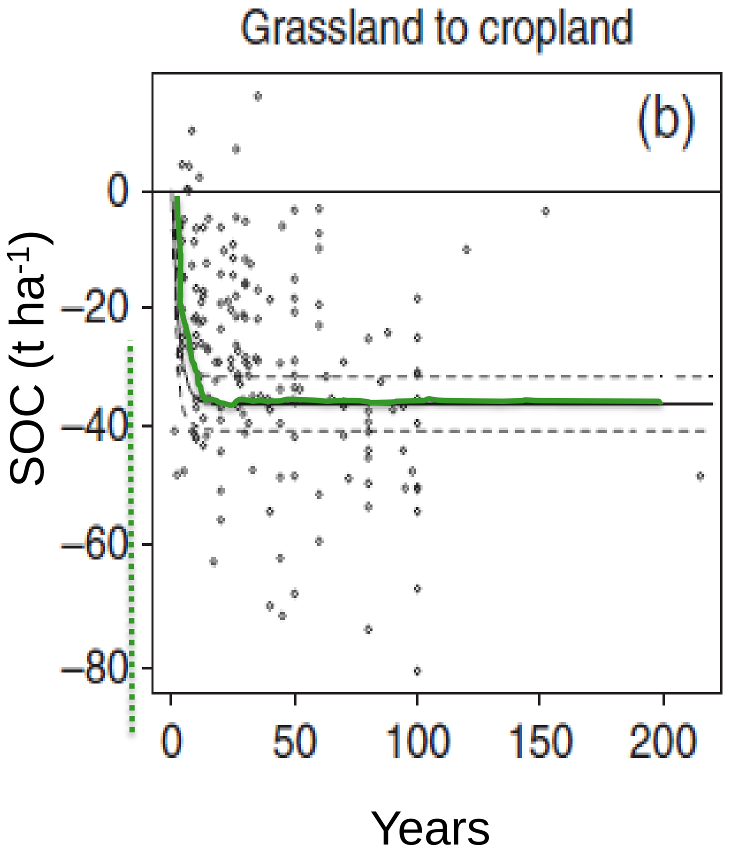


CO2 = 29t CO2e ha-1

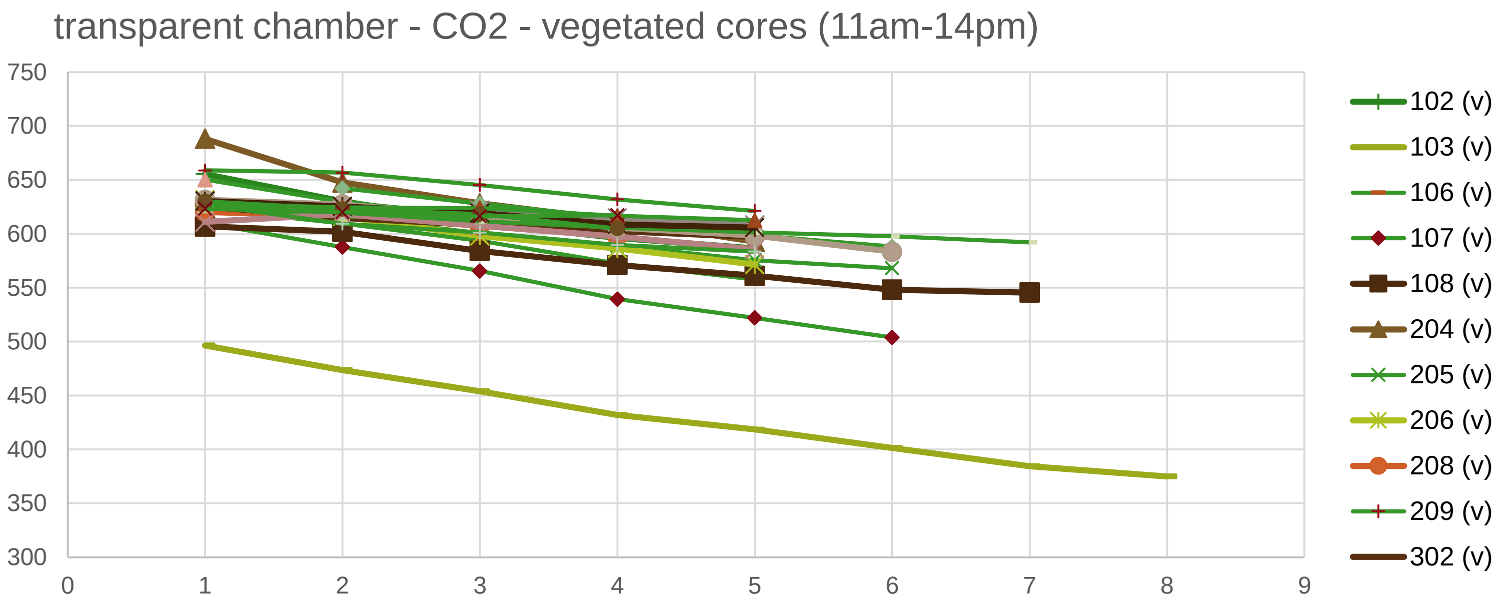
CH4 = 9t CO2e ha-1

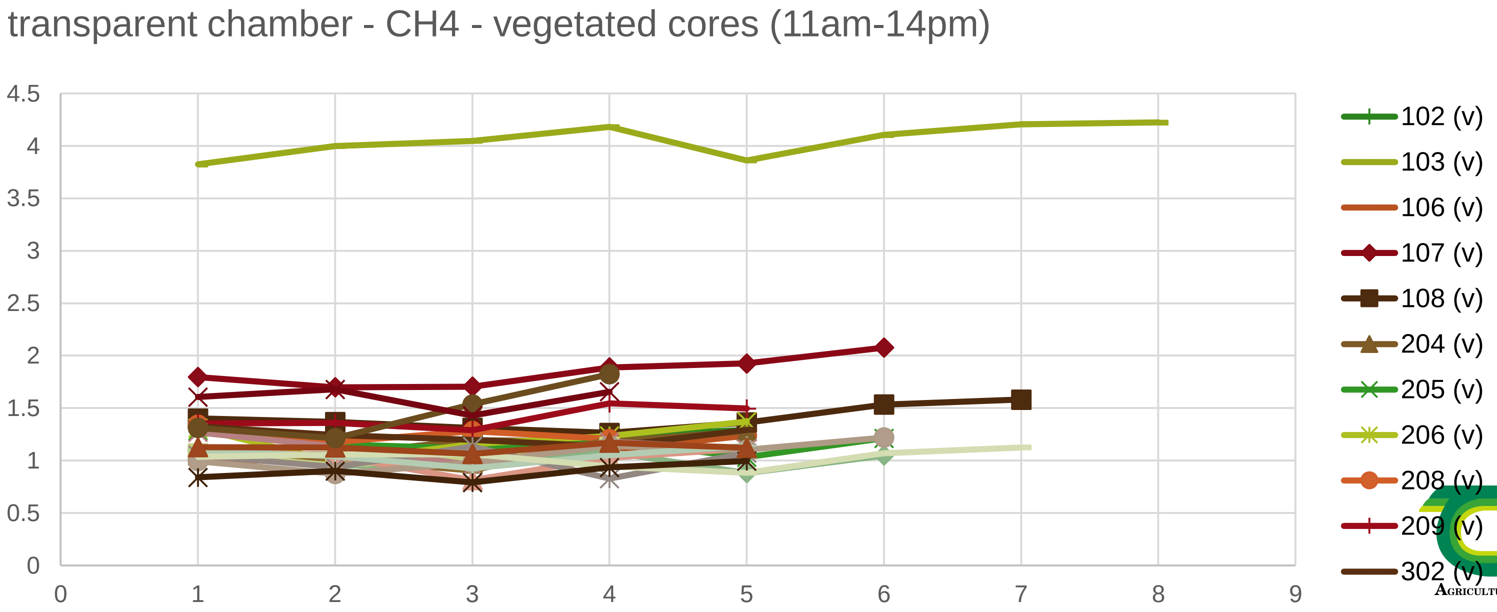
IPCC peatland emission factors

	Emissions Drained	Emissions Rewetted	Δ Emissions
Land use	[t CO_2e $ha^{-1}*yr^{-1}$]		
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


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


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

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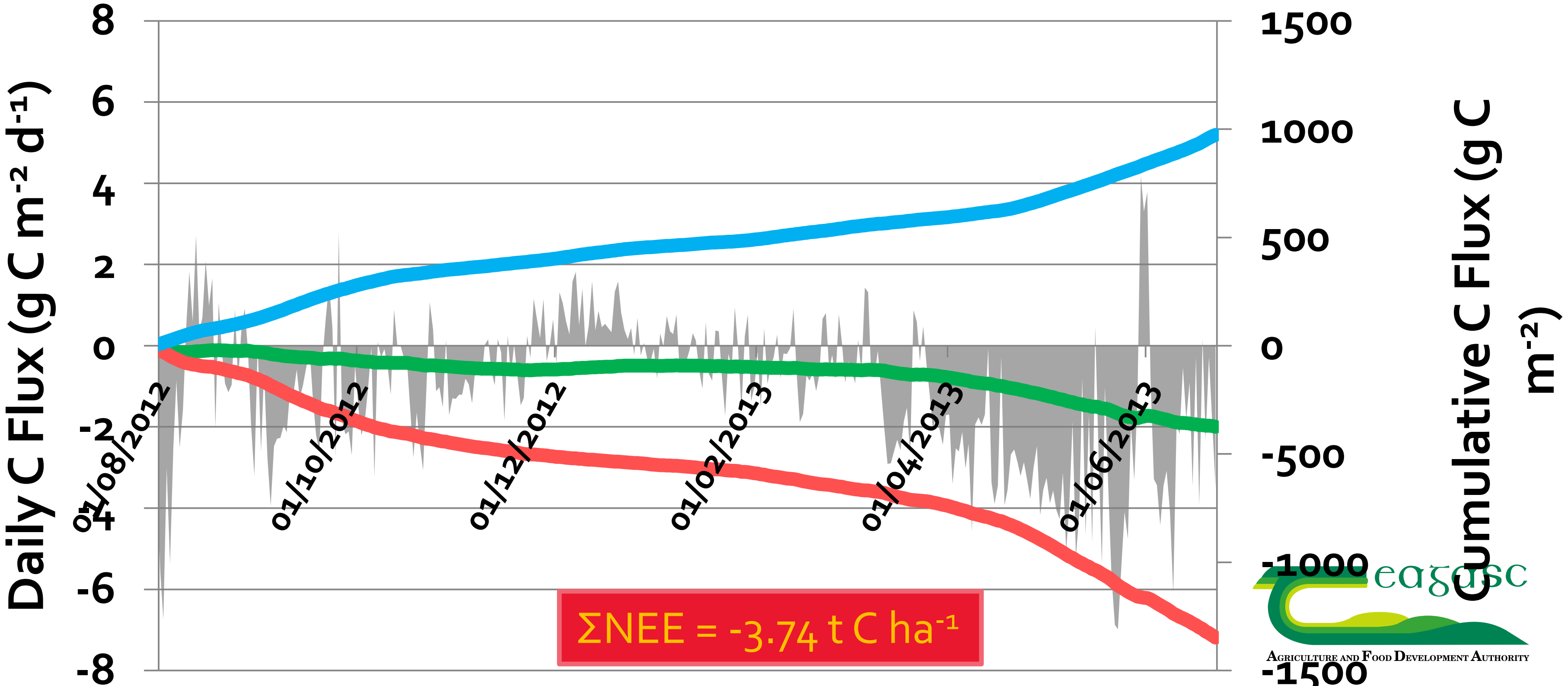
Flux measurements

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



ΣNEE = -3.74 t C ha^{-1}

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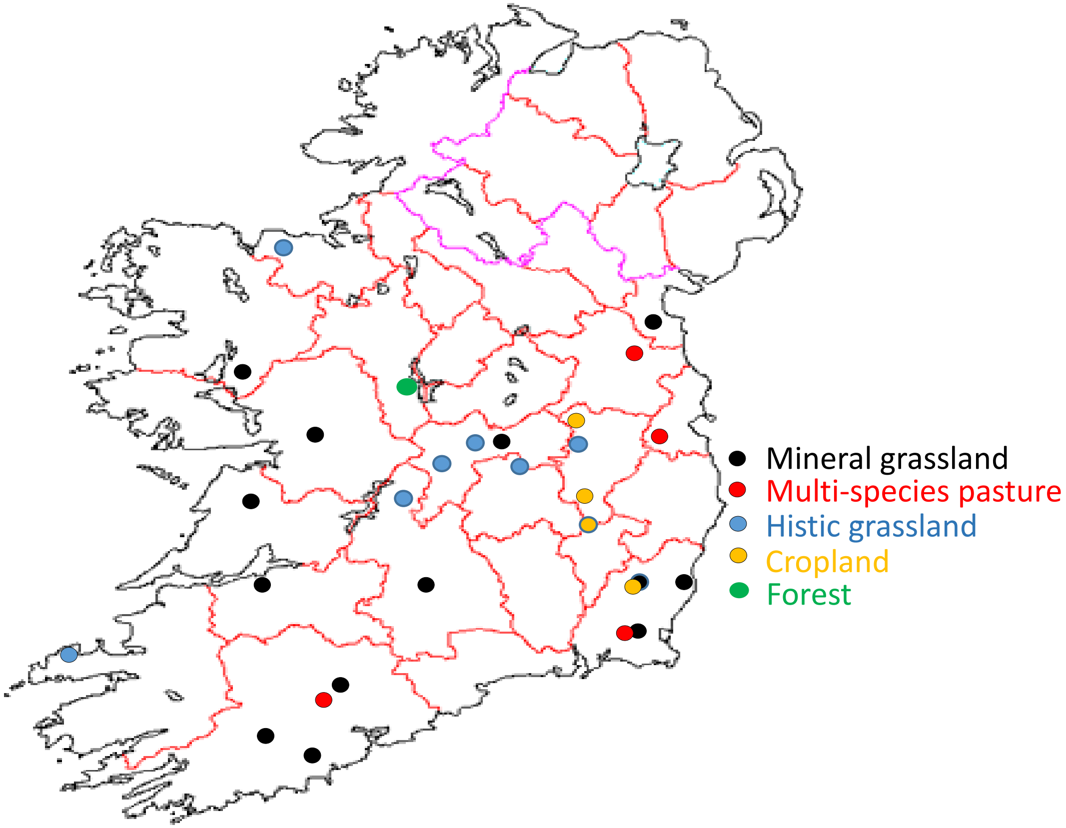
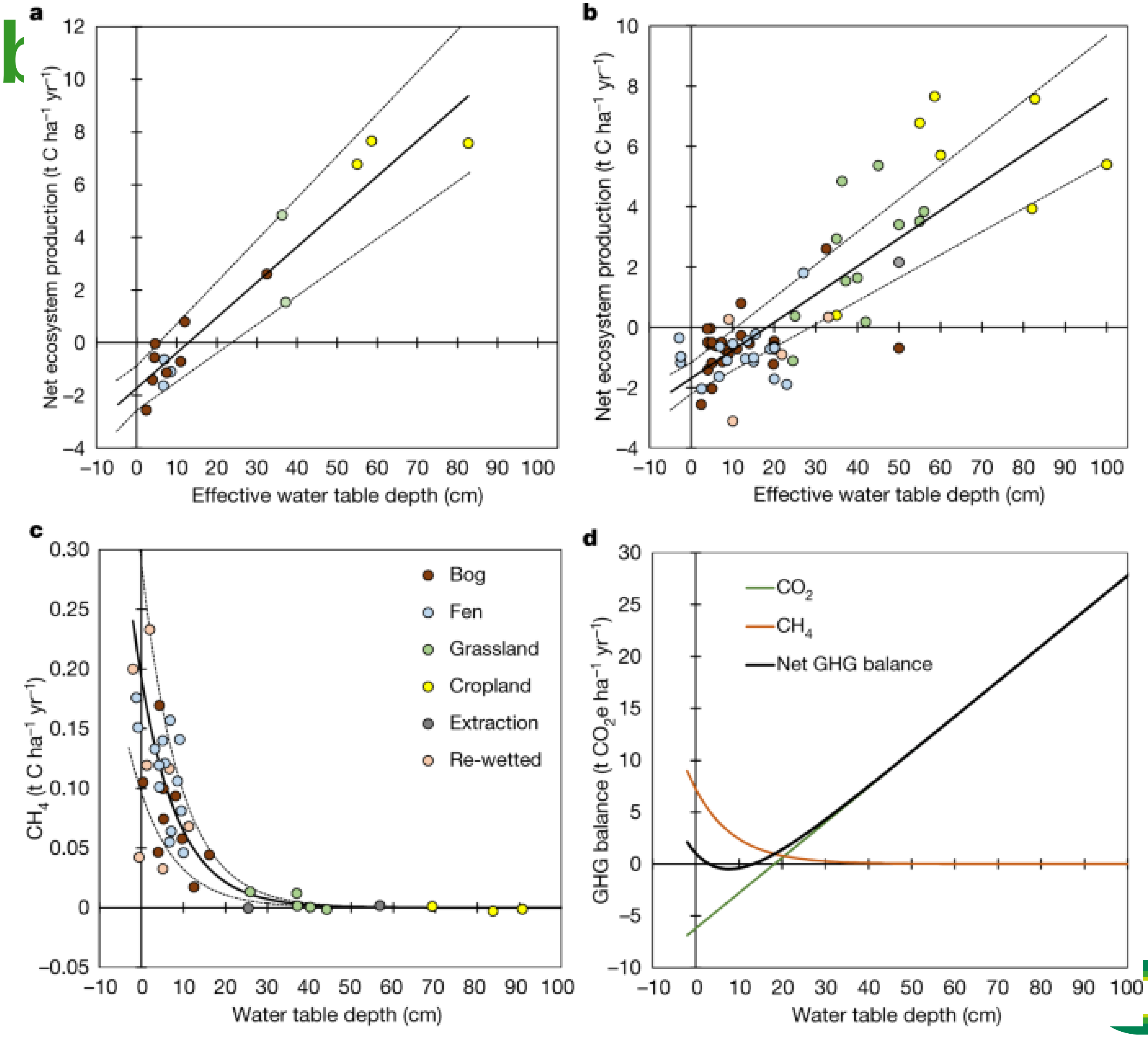
Eddy Covariance Flux Towers

- 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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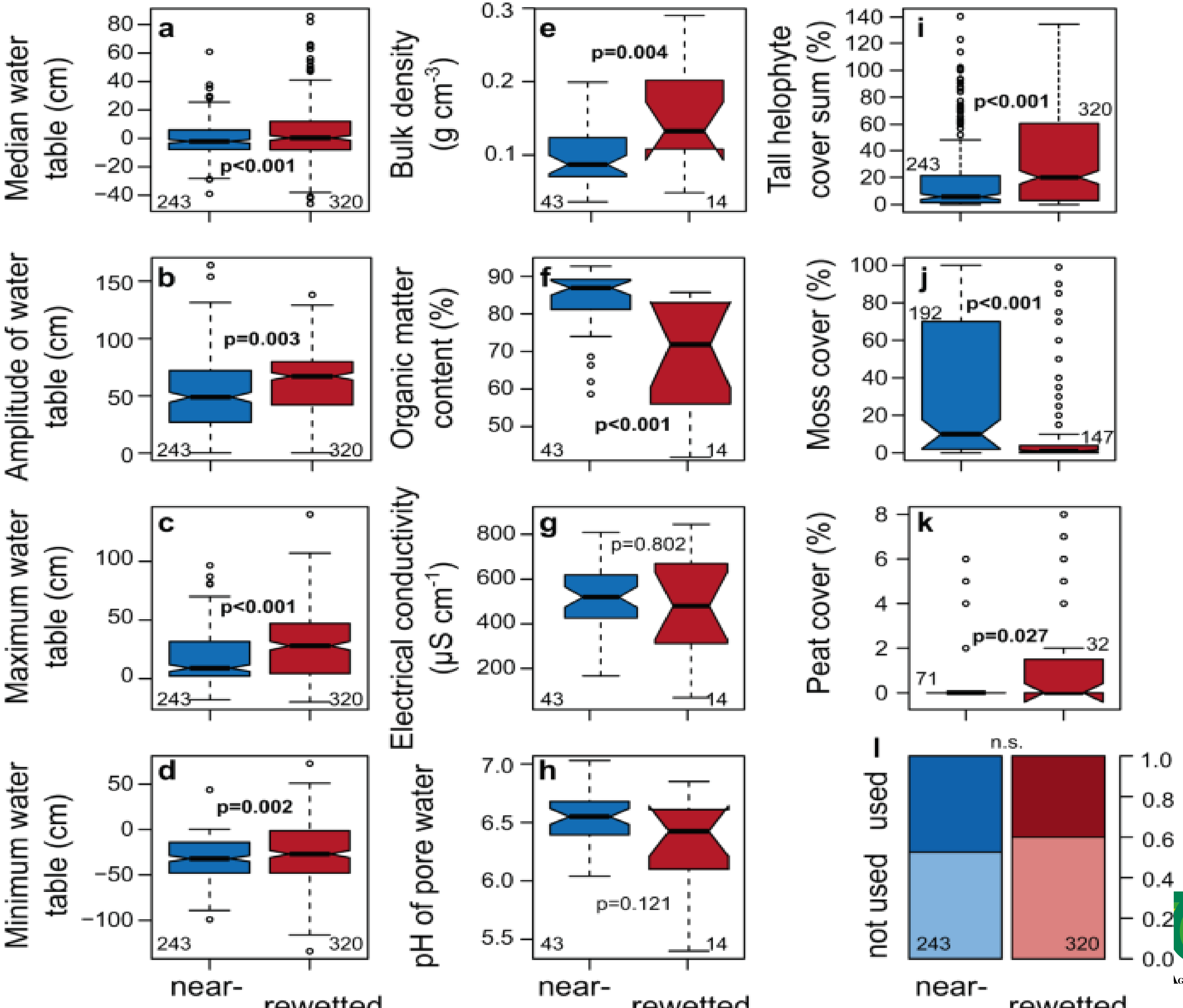
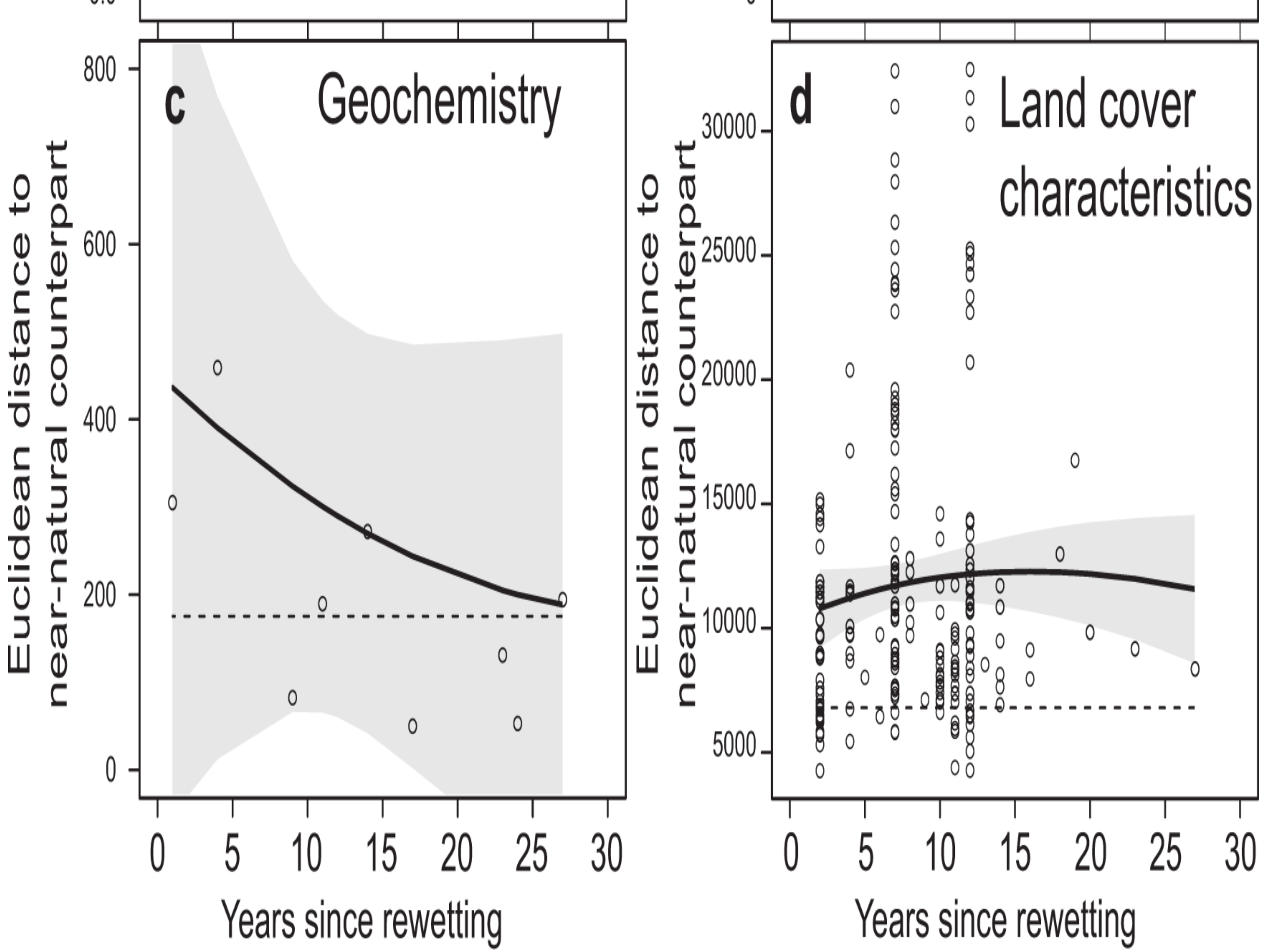
Rewetting does not mean restoration




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

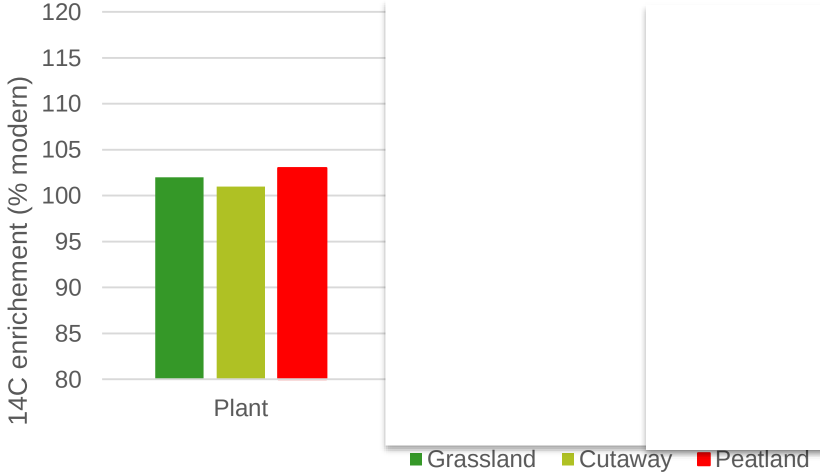
Impact of water table

14C analysis

Pasture

Bog

Cutaway



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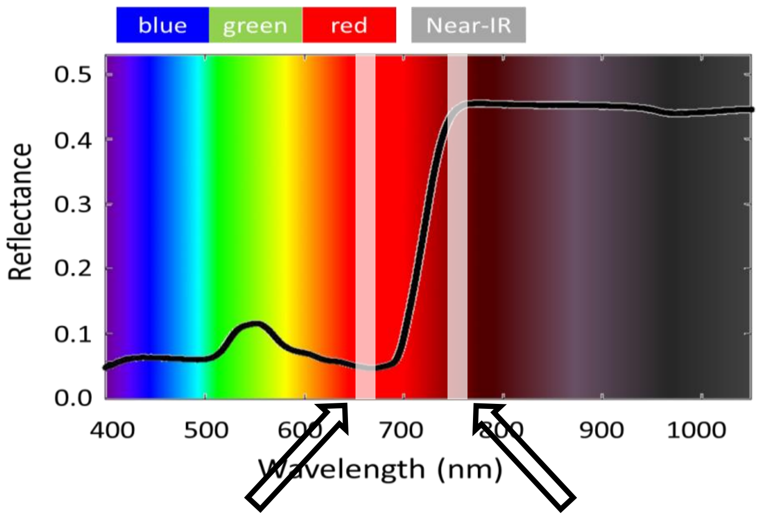
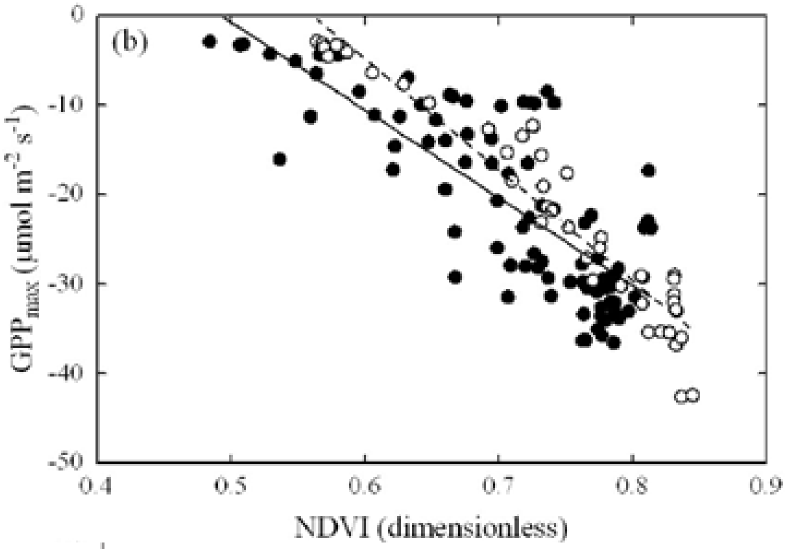
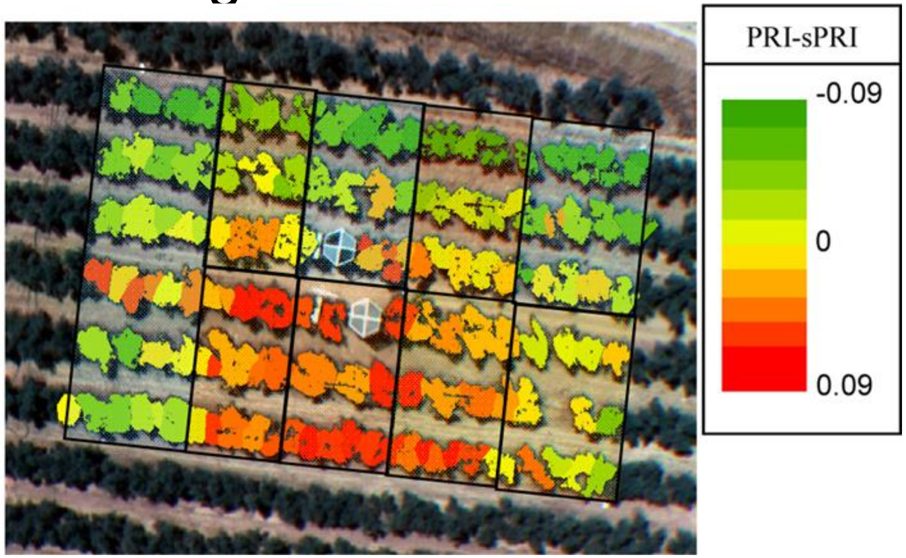
Can link EC and remote sensing

- 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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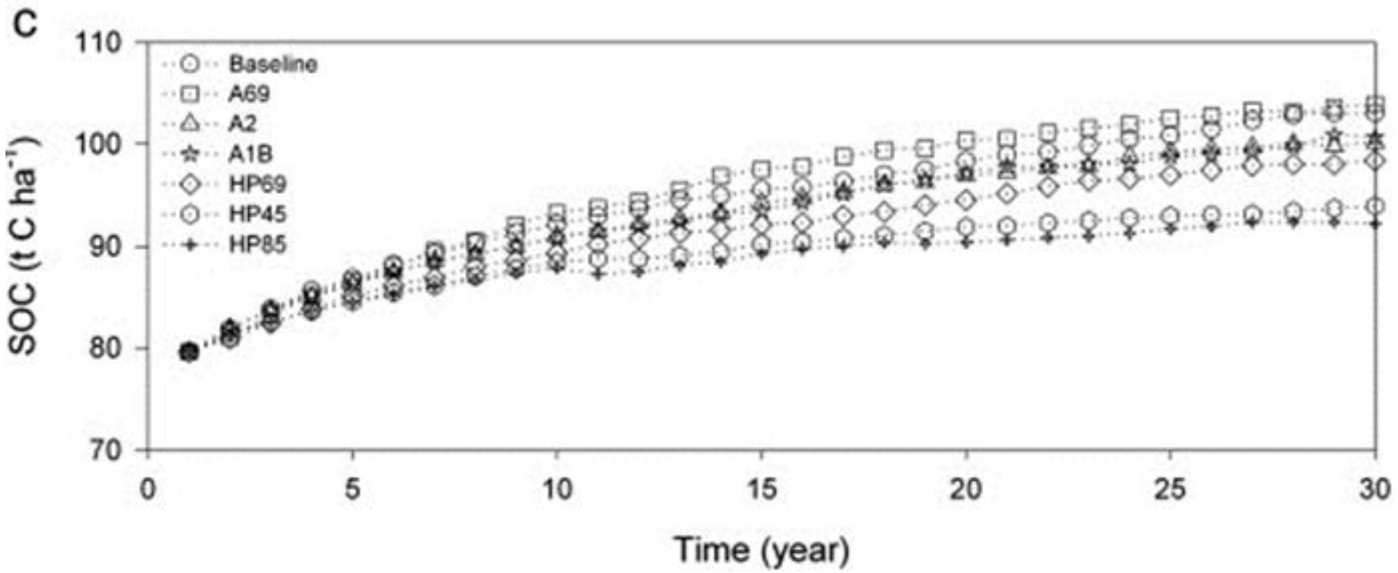
Model management impacts

- 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