



Soil and Water Protection: Peatland Conservation and Degradation – Experience from Ireland

Raymond Flynn

School of the Natural and Built Environment
Queen's University Belfast

Helsinki 28th January 2025



What are we dealing with?

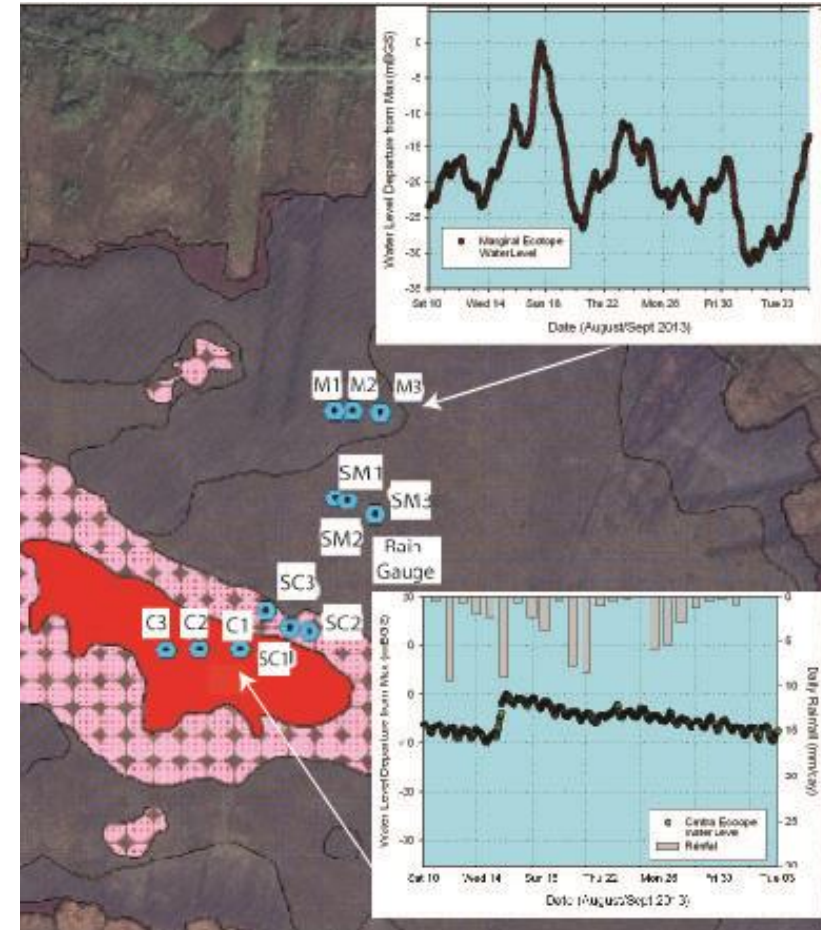
- Peat: >30% dry mass dead organic carbon ^{1,2}
- Peatland coverage depends on thickness threshold³.
- Approximately 23.3% of Ireland underlain by peat >10cm thick⁴.
- Total afforested land on peat using Gilet *et al.* (2024) 334,463ha (35,820ha on thinner soils, <35cm)⁴.



1. Connolly, J. and Holden, N.M., 2009. Mapping peat soils in Ireland: updating the derived Irish peat map. *Irish Geography*, 42(3), pp.343-352
2. Renou-Wilson, Florence, and Kenneth A. Byrne. "Irish peatland forests: lessons from the past and pathways to a sustainable future." *Restoration of boreal and temperate forests* 13 (2015): 321-335.
3. Kopansky, D., Reed, M., Kaplan, M. and Hughes, J., 2022. UNEP-2022. Global Peatlands Assessment-The State of the World's Peatlands.
4. Gilet, L., Morley, T.R., Flynn, R. and Connolly, J., 2024. An adaptive mapping framework for the management of peat soils: A new Irish peat soils map. *Geoderma*, 447, p.116933.

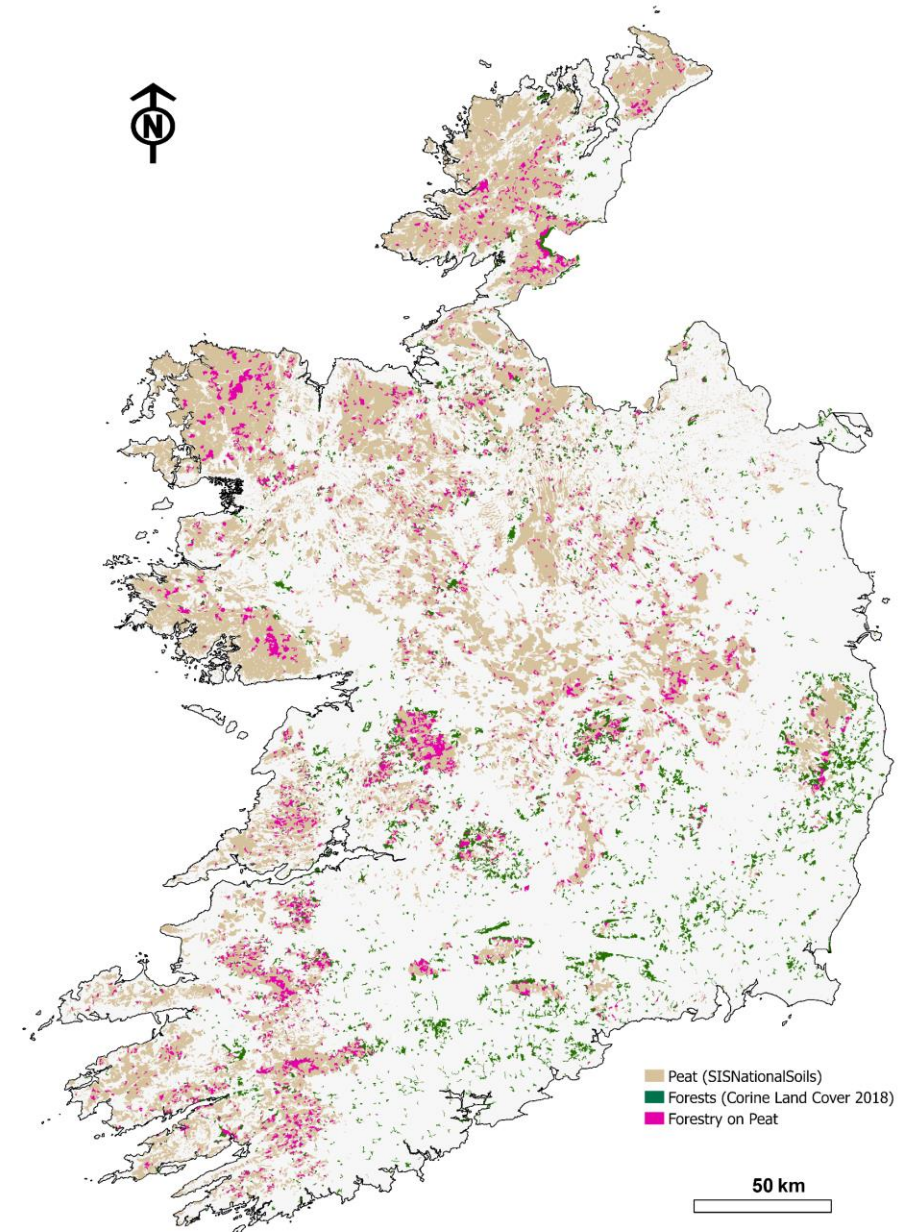
Irish Peatlands and Biodiversity

- In areas of high and frequent rainfall.
- Waterlogged conditions all year round.
- **Naturally treeless².**
- Specialised vegetation adapted to ombrotrophic (nutrient poor) conditions.
- Natural carbon sink.
- Approximately 2.2 Billion Tonnes of Carbon stored in Irish Bogs ⁵.
- Where affected by drainage – peatlands become carbon source.



Peatlands and Land use

- Considerable alteration of Irish Peatlands over the last century
- Main land uses⁵
 - “Near Natural”: 18%
 - Cutover (Energy/Horticulture): 15%-20%
 - Agriculture: 29%
 - Forestry: 31% (since 1950s)
(~41% of total forestry)
- Ground preparation for forestry on Irish Peatlands involves ploughing (up to 1m deep), which lowers water table.
- Considerable legacy of forestry on thick peat (>1m).
- Can be economically unproductive⁶.



6. Flynn, R., Mackin, F. and Renou-Wilson, F., 2021. Towards the quantification of blanket bog ecosystem services to water. *Environmental Protection Agency (EPA), Co., Wexford, Ireland.*

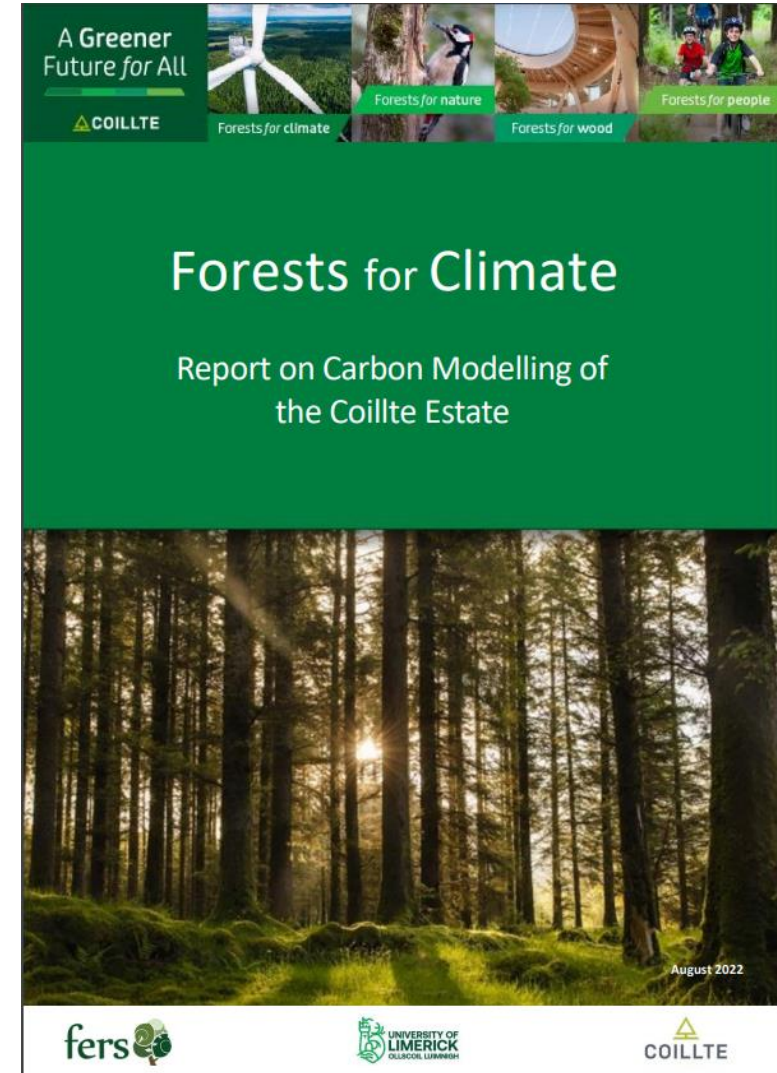
Drainage and Forestry

- Irish peatlands is estimated to contribute approximately 4% of total national emissions, with contributions from peat soils under forestry 5.
- For forestry, artificial drainage lowers water tables...
- ...declines further enhanced by evapotranspiration from forestry (including interception of precipitation)
- This allows oxygen into previously water-logged anaerobic environments.
- Rates of peat decomposition increase, leading to peatlands turning from carbon sinks to carbon sources.
- Decomposition of peat is offset to variable degrees by accumulation of biomass.
- What is the net impact?



Biomass and Emissions Modelling

- Modelling undertaken for largest landowner of forest in Ireland (Coillte Teo.).
- Coillte has a dual mandate –timber production and protection of nature/climate
- Significant areas of Coillte estate considered to have uneconomic timber production.
- Coillte wished to optimise both timber production and sequestration –examined through numerical modelling.
- Simulations considered both emissions and biomass uptake ⁷.
- Contrasting scenarios considered, including “business as usual” and alternative land uses with “management for nature”.
 - Abandon
 - Replant with native species
 - Rewetting



7. Black, K. et al. (2022) Forests for Climate-Report on Carbon modelling of the Coillte Estate. https://www.coillte.ie/report-on-carbon-modelling-of-the-coillte-estate_august2022/

Model outputs

- Overall, modelling suggested shorter term net cooling effect from forests but becoming carbon sources in the longer term (peat decomposition overtakes sequestration).
- Recognition that, using available emissions factors, some currently afforested peatlands are better used for other purposes, including rewetting.
- Overall, there is a sustained decomposition of sequestered carbon in peat, if reforestation continues.
- Need to consider *wider impacts* from continued afforestation of peatlands.

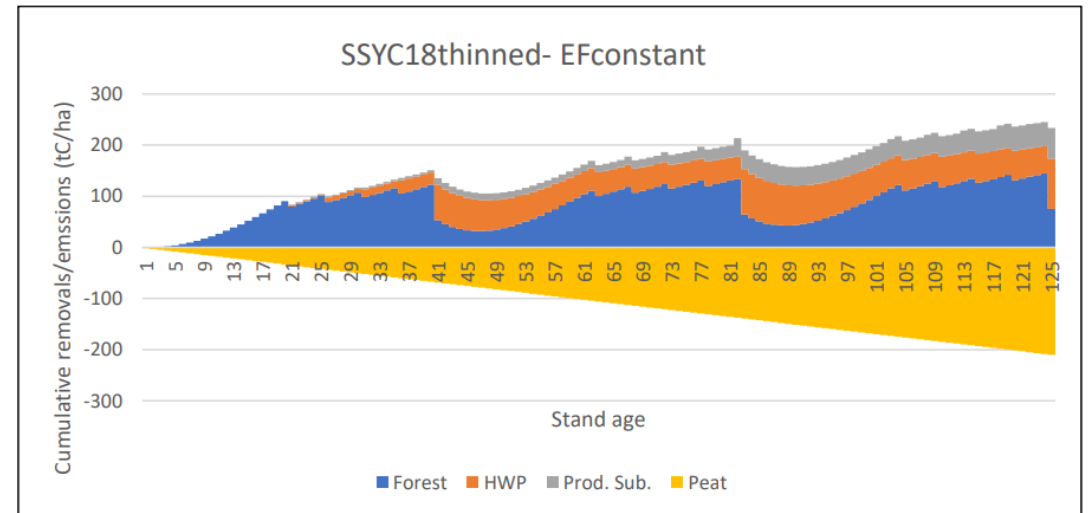
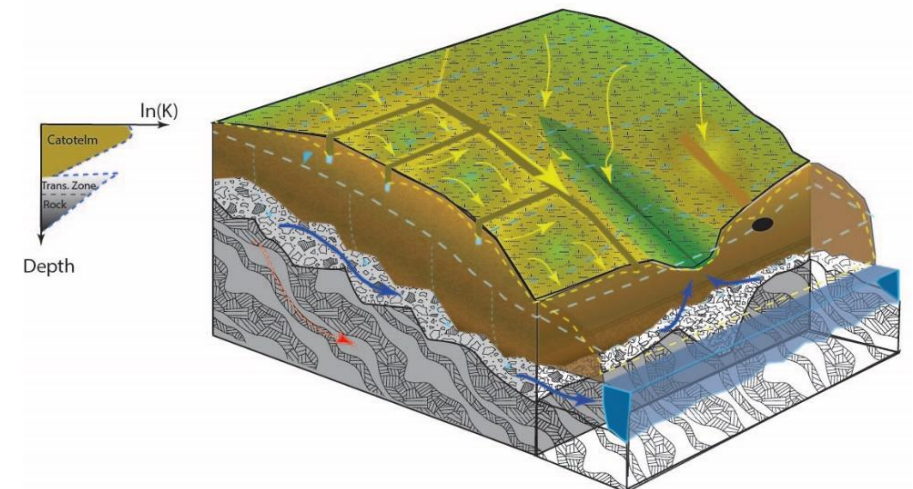
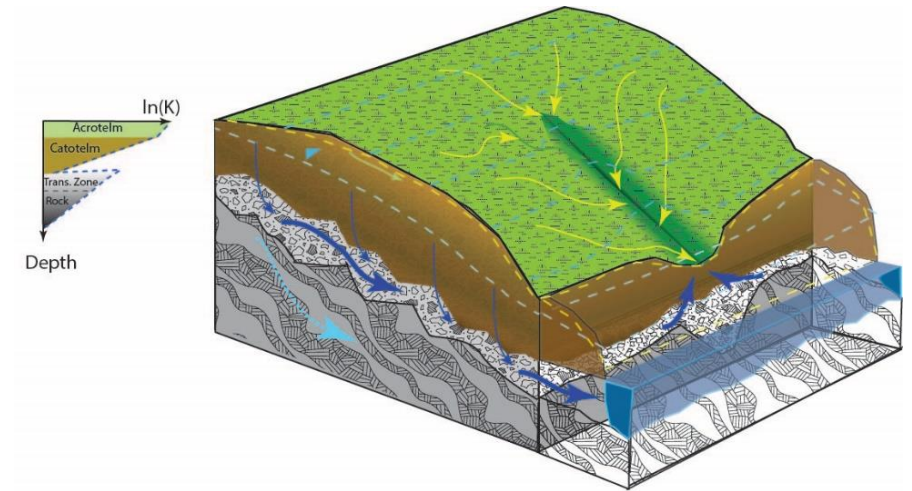


Figure 4 Cumulative removals and emissions of a Sitka spruce stand, YC 18 on blanket peatland forest over 3 successive rotations. C emissions are negative and removals are positive

Impacts of Forestry on Peat – Terrestrial Biodiversity.

- Drains remove water more quickly than naturally.
- Drainage alters natural flow paths and directions.
- Drain configuration / more rapid loss of water lowers water table.
- Additional impact from vascular plants (transpiration) and interception.
- This also applies to native “nature friendly” tree species.
- Persistence of drainage after felling prevents reestablishment of peat accumulating vegetation.



Impacts to Water

Drainage associated with planting

- Lowered water table increases oxidation of peat.
- Affects emissions ; increased loss of sequestered carbon via aqueous pathway –considered in modelling
- Yet also affects drinking water quality / security of water supply (Peatlands are an important source of drinking water in UK and Ireland)
- Cost of additional water treatment can exceed timber value ⁶.
- Presence of drains enhances delivery of water to channels, increasing flood peaks.

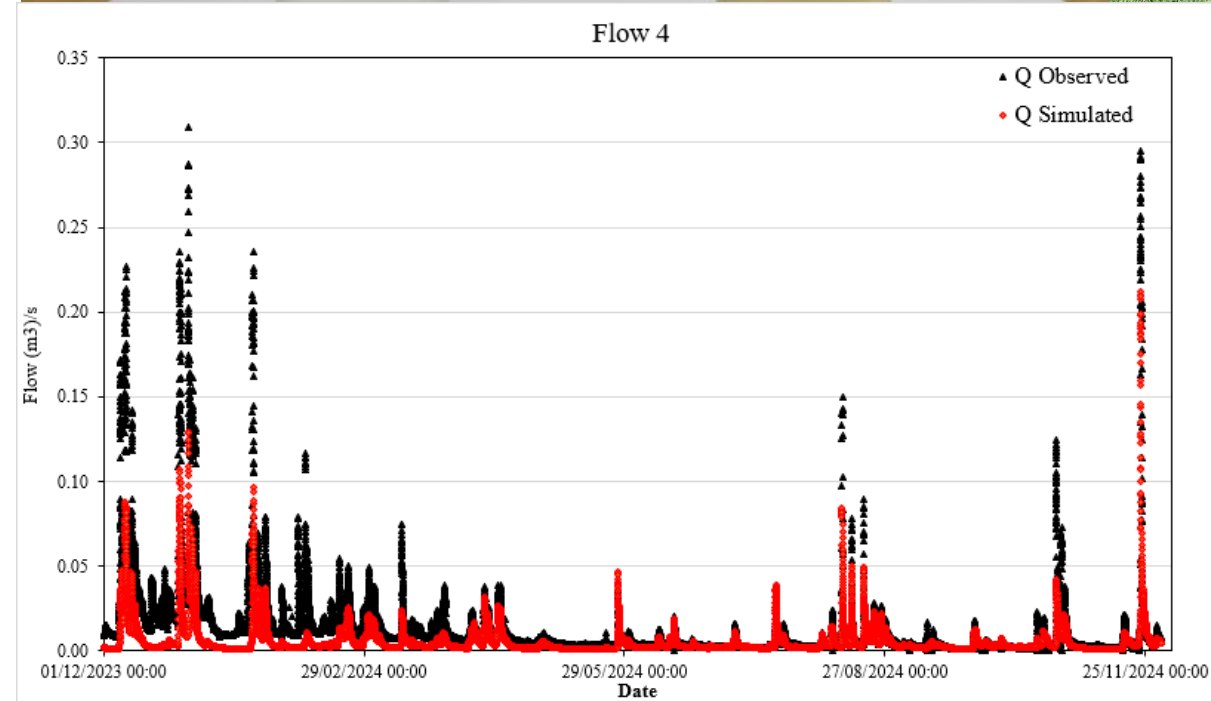
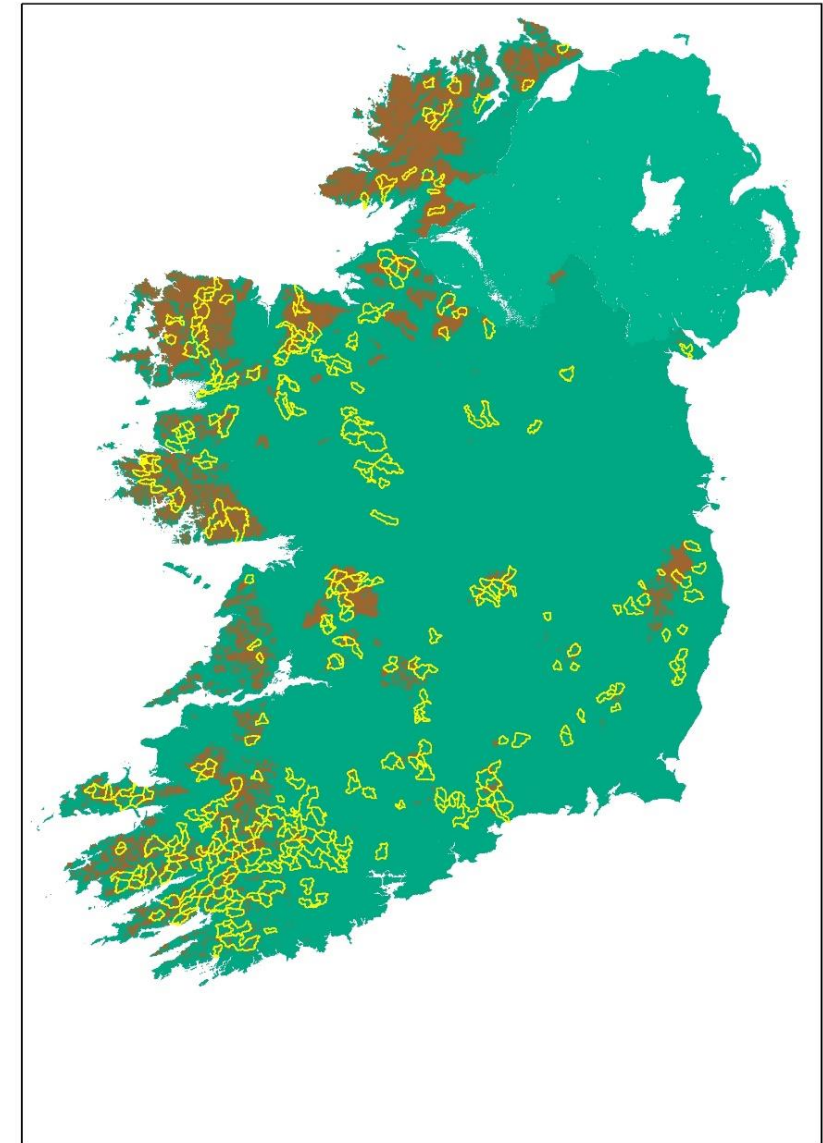
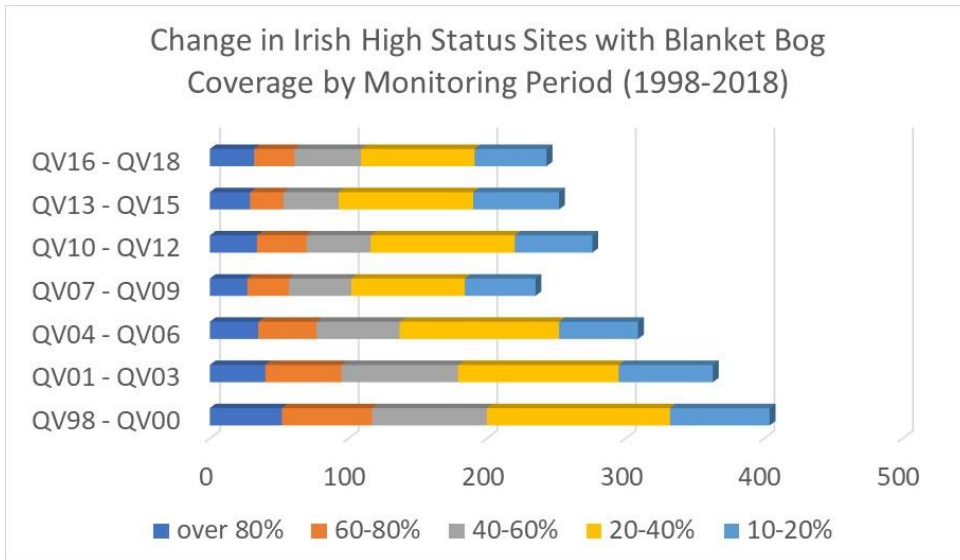


Image (below): Rainfall-runoff simulations in formerly afforested area.(Jehanzaib et al. (in review)

Impacts to Aquatic Biodiversity

- Comparison of stream water quality and flow rates indicate more variable conditions in peatlands affected by forestry⁸.
- This is linked to declines in WFD water body status, requiring restoration through programmes of measures⁹.
- Has potential implications for species downstream protected by Habitats Directive, e.g. Freshwater Pearl Mussel.



Above: Map of High Status water bodies and peatlands

8. Flynn, R., Mackin, F., McVeigh, C. and Renou-Wilson, F., 2022. Impacts of a mature forestry plantation on blanket peatland runoff regime and water quality. *Hydrological Processes*, 36(2), p.e14494.

9. Flynn, R., McConigley, C., O'Connell, G., Mackin, F. and Renou Wilson, F., 2021, April. Ecological Impact of Plantation Forestry on Blanket Bog on a Low Order Stream. In *EGU General Assembly Conference Abstracts* (pp. EGU21-2684).

How to deal with this?

Rewetting

- Deliberate action of raising the water table on drained soils to re-establish water saturated conditions.
- Coillte modelling considered rewetting as an option for low yield class forestry on peat.
- Modelling assumed restoration over a 50-year time frame.
- Time frame and technology (drain blockage) limited areas amenable to rewetting.
- Alternative rewetting techniques have been developed /more widely applied.
- These have had variable levels of success, with some displaying re-establishment of peatland communities in less than 5 years.
- Can be applied in areas formerly considered unsuitable for rewetting.



Above: Re-establishment of peatland plant communities at former conifer plantation on peatland, Tullycherry Bog, Co. Fermanagh. Photo **four years** post-works. Photo: K.Atcheson. Project; www.sourcetotap.eu

Rewetting: Employment / Community-based Restoration

- Peatland restoration /rewetting-a small but growing sector.
- Expertise developed across Ireland over the past 10 years at range of scales.
- Rewetting of peatlands affected by drainage/ mechanised peat extraction / forestry.
- Provides employment, e.g. Bord na Móna EDRSS. (<https://www.bnmpcas.ie/>)
- Provides community amenity, e.g. Abbeyleix, Co. Laois. (<https://www.abbeyleixbog.ie/conservation-and-community>)
- Requires further financial support (e.g. through payment ecosystem services) for wider application



Above: Cell bund outlet, Cloncrow Bog, March 2021,
Below: Cell bund outlet, June 2022. –completed by EU-funded Bord na Móna EDRSS scheme



Forestry on Peat and Rewetting

Issue	Forestry	Rewetting	Relevance
Climate	+ (Short Term)	+(Medium to long term)	Carbon Removals (EU/2024/3012).
Biodiversity (Aquatic and Terrestrial)	-	+	Nature Restoration Law, Habitats Directive (cf <i>Margaritifera sp.</i>), Water Framework Directive
Economics	+?	+?	Depends on value of timber / financial incentives for rewetting.
Soils	-	+	Soil Mission
Drinking Water	-	+	Drinking Water Directive
Flood Risk	-	+	Floods Directive

Conclusions – I

- Ireland's peatlands are **naturally treeless**. (If we need artificial drainage on peat for tree growth, then we naturally not have the trees there.)
- Over the longer-term modelling suggests that forestry on Irish peatlands will be a net carbon source.
- We also need to consider broader impacts of forestry
- Forestry on peatlands results in changes to its hydrology and the loss of peatland terrestrial biodiversity.
- Persistence of artificial drainage means degraded peatland ecosystems will not spontaneously restore.
- Legacy impacts of peatland forestry also affects aquatic biodiversity.
- Wider impacts include in
 - (a) Greater variations water quality – cf high water treatment costs
 - (b) Greater variation in flow regimes – available water resources and flood risk
 - (c) Loss of sequestered soil carbon.

These impacts have wider economic value that must be compared against the benefits of timber production.



Conclusions II –More Positive

- Considerable knowledge expertise of rewetting developed over the past 20 years.
- Growth of evidence base shows that efforts can be more effective than previously assumed, with revegetation occurring more rapidly ^{10,11}.
- Many areas currently considered “unrestorable” because of assumed long time frames for restoration and the infeasibility of previous technologies to impact challenging terrain.
- Combination of science and improved practice makes rewetting many of these areas now viable.
- Considerable scope to expand rewetting, providing community employment and amenity.
- Funding/financial mechanisms need to be developed and justified –more work needed.
- On-going work providing an economically- defensible basis for peatland restoration.
(<https://peatlandfinance.ie/>)



Above: Blockage of a peat pipe in a Co. Antrim blanket bog has resulted in increased water levels and rapid re-establishment of peat accumulating vegetation over a three-year period.

10 Swenson, M.M., Regan, S., Bremmers, D.T., Lawless, J., Saunders, M. and Gill, L.W., 2019. Carbon balance of a restored and cutover raised bog: implications for restoration and comparison to global trends. *Biogeosciences*, 16(3), pp.713-731.

11. D'Acunha, B., Lee, S.C. and Johnson, M.S., 2018. Ecohydrological responses to rewetting of a highly impacted raised bog ecosystem. *Ecohydrology*, 11(1), p.e1922.

Perspectives –Rewetting.

- There has been considerable peatland rewetting effort in Ireland in the last decades.
- Earlier work focused on engineering (doing), rather than science (measuring), and gave highly variable results.
- Combined science and practice provides an evidence base to address this issue and increase chances of success.
- Considerable scope exists for reducing time frames and carbon footprints of restoration efforts.
- New techniques have been piloted and successfully applied in areas previously considered unrestorable.
- Firmer funding mechanisms will encourage the expansion of the rewetting sector, while encouraging a more integrated research/application to dealing with Ireland's legacy of forestry on peatlands.
- This is anticipated to be adopted largely by Coillte and larger private forestry bodies, before application to smaller land owners.



Thank You for Your Attention

Acknowledgements: Findings from the Sensor Application to Peatland Hydrology in Remote Environments (SAPHIRE) project contributed to this presentation. SAPHIRE is supported by the USI 177 research grant from the Department for the Economy, Northern Ireland under the US-Ireland R&D Partnership Programme