

The effects of forest to bog restoration on water quality and implications for freshwater ecology

Nadeem W. Shah



Ecology



Atlantic salmon (Salmo salar)

Freshwater Pearl Mussel (*Margaritifera margaritifera*)

Threatened with extinction throughout its holarctic range. In Scotland viable populations still remain.

FWPM kills in Ireland



Photo: Berglund, J.

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Peatland distribution

Peatland cover (% national land area)



Peatlands store a huge amount of carbon – they cover only 3% of the world's land surface yet contain 30% of the total global soil carbon (Joosten 2011) Hydrologically and ecologically important.

Crown copyright



Peatland burning



Riau, Indonesia

Image credit: WWF

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Peatland drainage



Sumatra, Indonesia

Crown copyright



Peatland UK



An estimated 9.5% of the UK land area is covered by bog peatlands.

Scotland has about 60% of the UK's peatlands, and 4% of Europe's total peat carbon store.

Blanket bog – rare habitat with 15% of the global total in Scotland.



Peatland degradation



Peatland drainage and degradation - Sutherland, Scotland

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Drainage



Ploughing in deep blanket peat; Sutherland, Scotland, 1950

Crown copyright



Peatland afforestation



Deep peat and shallow peats drained, ploughed and planted with coniferous trees between the 1950s and 1980s

Photo: Norman Russell

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Flanders Moss drainage



Ploughing at the Flanders Moss raised bog with single furrow plough.

Photo by D.W. Henman, Jan 1965

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Peatland restoration

- The importance of peatland conservation, protection and restoration is well recognised; large-scale restoration underway at a number of sites in Scotland and around the world.
- Much of this is on the NFE and involves forest removal, but also drain blocking and ground smoothing.
- The impact of peatland forest clearance/restoration on soil and water has not been fully investigated.
- The scale of felling is an issue; management techniques (e.g. mulching).
- Potential impact on water quality and ecology; neglected somewhat thus far.
- Knowledge gap long term studies into peat bog restoration following felling to determine impacts on GHG, water and biodiversity (IUCN UK Committee Peatland Programme).



Study sites



Peatland restoration sites where water quality is being monitored.

own copyright



Flanders Moss





Peatland restoration





Phosphate



- Annual mean phosphate concentrations returned to prefelling levels 3-5 years after felling finished.
- Watercourses drain directly into large river systems (the River Forth and River Keltie).
- More concern where watercourses flowed from clearfelled peatland into small lochs or headwater streams with sensitive ecology.

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- DOC concentrations increased at two sites, mainly in the first year after felling.
- Mean annual concentrations still elevated at one site after 4 years; little increase in DOC was recorded with phased felling (Site 2).
- Colour levels increased and remain elevated at all sites relative to prefelling.

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Susp solids



- Very little sediment delivery during clearfelling operations.
- The highest SS peaks at Sites 1 and 2 occurred during dry summer periods in 2013 and 2014 when stream flows were low.
- Perhaps due to soil disturbance caused by:
- harvesting of forest residues from the extraction track network.
- or washout of soil exposed by a lowered water table (drought).
- vegetation removal exposing bare soil to weather events.

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In only one stream (Site 1), pH increased improving the WFD water body status from 'poor' to 'high' in the space of 3 years.

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- Our results show that forest clearance for peatland restoration can impact negatively upon water quality due to phosphate, DOC, colour and suspended sediment releases.
- The mechanisms by which the releases occur require further investigation but are thought to be driven by:
- nutrient leaching from forest residues,
- soil disturbance by machine trafficking and
- indirect effects of forest clearance, such as water table rise following cessation of forest water use.
- Applying the WFD water quality standard for reactive phosphate showed a deterioration of water status in all three studied watercourses, highlighting the need to be very cautious in ecologically sensitive water catchments.
- Research shows that concentrations are much reduced downstream.
- Climatic effects also play a significant role, particularly drying-rewetting cycles and periods of extended drought.
- To prevent negative impacts, phased felling and less intensive forest harvesting techniques should be employed.



Flanders Moss

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The effects of forest clearance for peatland restoration on water quality

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HIGHLIGHTS

GRAPHICAL ABSTRACT

Peatland restoration by forest clearance led to a release of PO₄-P to streams.

- Colour, DOC and SS concentrations increased but to a relatively limited degree.
- pH impacts varied; a 1.6 unit rise moved one site from poor to high WFD status.
- Climatic factors affect the timing and degree of water quality impacts.
 Phased felling and low impact harvest-
- ing can effectively control negative impacts.



Next stage at Flanders Moss – drain blocking and ground smoothing.

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ABSTRACT

Recognition of the importance of peatlands has led to increased efforts to protect and restore these environments but there are concerns about the impact of restoration on water quality, particularly in terms of sediment delivery, nutrient transport and carbon losses. In this study we present the results of almost 10 years of water quality monitoring in 3 catchments at a lowland raised bog that was afforested with confers in the 1960s and 1970s and cleared over the 2010s.

Phosphate concentrations increased after clearfelling with the main peaks seen in the summer after forest clearance; the use of low ground impact harvesting methods, removal of forest residues and especially phased felling tempered phosphate losses Annual mean phosphate concentrations returned to pre-felling levels 3–5 years after felling finished. Nitrate concentrations increased slightly from baseline levels during and after felling. DOC concentrations increased at two sites with mean annual concentrations still elevated at one site after 4 years; little increase in DOC was recorded with phased felling. Colour levels increased and remain levated at all lists relative to pre-felling, Icn only one stream, pH increased improving the WFD water body status from 'poor' to 'high' in the space of 3 years.

Our results show that forest clearance for peatand restoration can impact negatively upon water quality due to phosphate. DOC, colour and suspended sediment releases. The mechanisms by which the releases occur require further investigation but are thought to be driven by nutrient leaching from forest residues, soil disturbance by machine trafficking and indirect effects of forest clearance, such as water table rise following cessation of forest water use. Climatic effects alog play a significant role, particularly drying, rewetting cycles and periods of extended drought. To prevent negative impacts, phased felling and less intensive forest harvesting techniques should be employed.

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Photo: Larsen, B.M.

Juvenile mussels are ultrasensitive to habitat condition and require stable sediments; clean, welloxygenated sand and gravel; good water flow in hyporheic zone and high water quality.

Most serious problem is siltation, which effects interstitial waters and oxygen levels.

Nutrient and Ca excess is detrimental; nitrate levels should be < 1.0 mg l⁻¹; phosphates should be <0.03 mg l⁻¹ (Skinner et el., 2003)

Riparian shade is important to regulate stream temperature and algae growth.

Needs a viable host fish population.



Salmonids



Photo: Campbell, L.

Salmonids are vulnerable to suspended and deposited sediment, particularly during the incubation and larval phase.

Impacts of high nutrient levels.

Stream temperature is important (riparian shade).



Benmore





Forsinard Flows





Galloway



Investigating the effects of restoration on water quality.

Different phases/techniques of restoration: clearfelling, drain blocking and ground smoothing.

Partnership project with FR, FLS, SEPA and GFT.



Thank you

