Abstract No: A-092

MODELLING THE IMPACT OF MARGINAL CUTTING ON RAISED BOG TOPOGRAPHY AND CONSERVATION

Alister Best[1, 2] and Raymond Flynn[1]

[1] *School of Planning, Architecture and Civil Engineering, The Queen's University of Belfast, David Keir Building, Stranmillis Road, Belfast BT9 5AG.*
[2.] *RPS Group, Elmwood House, 74 Boucher Road, Belfast BT12 6RZ.*

**Corresponding author: abest04@qub.ac.uk*

SUMMARY

Irish peatland conservation programmes need to be implemented sustainably and in accordance with the law. Any approach needs to consider not only legal and technical issues, but also the social and financial elements of conservation and restoration strategies. Article 6.3 of the EU Habitats Directive provides a mechanism allowing on-going human activity within Natura 2000 areas, protecting priority habitats, provided these do not conflict with site conservation objectives (COs). Allowing continued localised peat cutting on SACs, containing active raised bog and degraded raised bog, requires a robust site characterisation strategy to predict changes in hydrological supporting conditions and their impact on site-specific COs. Profiling peat properties across uncut peatlands, when coupled with geotechnical and hydrogeological first principles, provides information necessary for predicting impacts of continued localised marginal turf cutting on raised bog topography and on the hydrological conditions needed to support active raised bog. Use of these data subsidence simulations, employing principles of conservation of organic and inorganic matter, combined with equations of groundwater flow and outputs from ground penetrating radar, permit bog profiles to be modelled, while taking natural subsurface variability into account. Application of this model to Clara Bog, Co. Offaly has simulated changes in bog topography, including the recent development of areas of standing water, while also generating changes in peat properties arising from turf cutting and marginal drainage. On-going field data collection and application of the approach will demonstrate its value for predicting impacts of localised cutting and drainage on raised bog hydrological supporting conditions and the confidence with which it may be applied for determining site suitability for continued cutting. Successful application has the potential to identify suitable sites for continued cutting and help address needs of local stakeholders, while also meeting Habitats Directive requirements

Keywords: *peatlands, modelling, subsidence, conservation*

INTRODUCTION

Western European peatlands have experienced significant ecological impacts over the past 100 years due to pressure from a growing population and an increasing demand for resources in the shape of farmland, fuel and horticulture, forestry and wind farm development (Joosten & Clarke 2002).

In Ireland the utilization of peatlands for human resource requirements has resulted in a dramatic loss of once widespread peatlands. For the example of raised bogs, once covering over 300,000 ha of Ireland, only 16% remain uncut, of which only 0.4% (1210 ha) of the original area is active (peat accumulating) raised bog (ARB) (Ryan 2007 & National Raised Bog SAC Management Plan 2014). These Irish sites, containing ARB, represent some of the last remnants of this habitat in the Atlantic region of the EU.

Recent research indicates that peatlands may play an important role in areas such as climate change, flood management, as well as acting as areas of special interest for flora and fauna (Schouten 2002). As remaining Irish bogs are sites of European and international importance (National Raised Bog SAC Management Plan 2014) there have been increased efforts to protect these peatlands over the last 20 years. As a consequence ARB, defined as the living, actively peat accumulating upper layer of a bog, has been identified as a priority Annex I habitat within the EU Habitats Directive (1992). Degraded Raised Bog (DRB), which is bog habitat no longer actively peat accumulating but is still capable of natural regeneration following restoration measures, is also protected. Across Ireland a network of special areas of conservation (SACs), now aim to conserve ARB and DRB (Habitats directive 1992 & National Raised Bog SAC Management Plan 2014).

Legislation protecting bog sites can generate wider social impacts. In Ireland the conservation of these habitats often causes discord with stakeholders whose turbary rights (rights to harvest peat for fuel) are affected, especially where alternative relocation peat cutting sites are not available. This can place peat cutters at odds with

legislators wishing to implement site specific conservation objectives (SCCOs) for SACs. The EU Habitats Directive provides legislation to resolve this issue through Article 6(3), which provides a mechanism allowing on-going human activity within protected (Natura 2000) areas, containing priority habitats, provided these do not impact on SSCOs.

Allowing continued localised peat cutting on sites, containing active and degraded raised bog, requires an appropriate assessment of the potential risks to these priority habitats. A robust site characterisation strategy is thus required to predict changes in hydrological supporting conditions and their impact on SSCOs. However, the hydrological and geotechnical properties of peatlands can be affected by drainage thereby complicating prediction of anticipated impacts to raised bog ecohydrology. The process is further hindered by a lack of understanding on how changes in peat properties impact the conservation status of protected sites.

This paper summarises work undertaken to evaluate the impact of marginal cutting and drainage on peat properties, using a combination of geophysical, geotechnical and hydrological investigation techniques.

THEORY

Previous research has aimed to model restoration potential in Irish raised bogs using hydrological and topographical data by employing point measurements, set out on a 100mx100m grid, to determine slope and flow path length as indicators of restorability (van der Schaaf 2002). LiDAR survey data provides higher resolution topographic data and can be used to refine existing models to more accurately predict restoration potential (National Raised Bog SAC Management Plan 2014, Mackin *et al.,* 2015). This approach thus permits estimation of the amount of active raised bog that could be restored (DRB). The approach has proven to work well in selected Irish raised bogs, which typically require a surface slope of between 0.2% and 0.6% for peat accumulating habitats to survive.

Kool *et al.* (2006) suggest that subsidence of peatlands is not necessarily detrimental to carbon storage. If the water table remains high during subsidence the peat can continue to accumulate under anaerobic conditions and carbon will not be lost to the atmosphere through oxidation. Evidence of this mechanism can be seen in subsidence hollows on raised bogs across Ireland, such as that shown in Figure 5 on Clara Bog, Co. Offaly. Although subsidence hollows can be regarded as potentially large and very healthy areas of a bog, they can also reflect/indicate the impact of drainage causing more widespread ecological problems. If subsidence can occur without significant loss of carbon, as indicated by Kool *et al.* (2006), organic matter content can be considered constant during subsidence and thus provide a tool to assess impacts of drainage on raised bog topography and ecohydrology. This constancy is described as the principal of Conservation of Organic Matter and may be expressed mathematically as follows:

Organic Matter % x Peat Depth (at location A) = Organic Matter % x Peat Depth (at location B)
Using this principle, mathematical models may be generated to predict impacts of peat subsidence on organic matter content due to drainage.

METHODS

Moneybeg Bog (Moneybeg) forms part of the Moneybeg Clareisland Bogs SAC that contains areas of ARB and DRB. Although extensive areas of Moneybeg have been impacted by subsidence due to marginal cutting, it also has areas proposed for consideration under Article 6(3) of the Habitats Directive thus required a thorough assessment of the impacts of proposed cutting on Annex I habitats. Investigations headed up by RPS consulting engineers on behalf of National Parks & Wildlife Service (NPWS) have included:

- A desk study, collating earlier reports and remote sensing data, provided a detailed overview of the condition of the site. Evaluation of groundwater vulnerability, subsoil, bedrock, ecotopes, existing drains and surface drainage flow paths provided an understanding of the regional hydrological and hydrogeological setting of the bog.
- An initial site investigation verified the information provided by remote sensing, while a hydrochemical survey of the drainage network surrounding the bog was completed.
- Existing geological maps provided no indication of peat thickness or substrate. Reconnaissance coring at 15 locations (2 at Clareisland and 13 at Moneybeg) provided an initial indication of spatial variation in peat thickness and substrate composition.
- Further focused coring was performed at 62 locations in six zones, five of which broadly corresponded to areas where continued peat cutting was proposed. Continuous samples were collected for the entire peat depth profile at each coring location using a 50mm diameter stainless steel Russian auger. The final depth

of peat was noted and, when possible, the substrate recovered and described. A total 1505 samples were analysed for water content. The coring locations on Moneybeg Bog are indicated in Figure 1.

- Ground penetrating radar (GPR) surveying was carried out along elected lines, broadly corresponding to coring transects, by Minerex Environmental Ltd., providing high resolution peat depth data across the entire relocation area and its immediate surroundings.

Following the collection of peat samples, the following analyses were carried out by Southern Scientific Services Ltd.:

- Dry matter analysis was carried out on the 1505 samples collected from Moneybeg Clareisland SAC. This has allowed the creation of 54 organic matter borehole profiles.
- 156 of the samples were also analysed for loss on ignition (LOI).

RESULTS

A 2D model has been produced to predict subsidence due to cutting, by combining principles of conservation of organic matter with peat thickness data. The relationship of intact organic matter profiles to those impacted by subsidence was combined with thicknesses of uncut peat to quantify subsidence at Moneybeg. This in turn has been used to predict changes in topography, linked to further cutting, by application of an equivalent trend in organic matter content over the full peat thickness, extending into uncut peat from the proposed cutting face. Sample organic matter profiles are displayed in Figure 2. The model was used to simulate 30m of cutting into Moneybeg Bog along the transect shown in Figure 3, the predicted subsided topographic profile output is shown in Figure 4. When the model is calibrated to the conditions present at Clara Bog Co. Offaly it can successfully predict the presence of subsidence hollows indicated at the site by large areas of standing water which have been expanding in recent years, Figure 5.

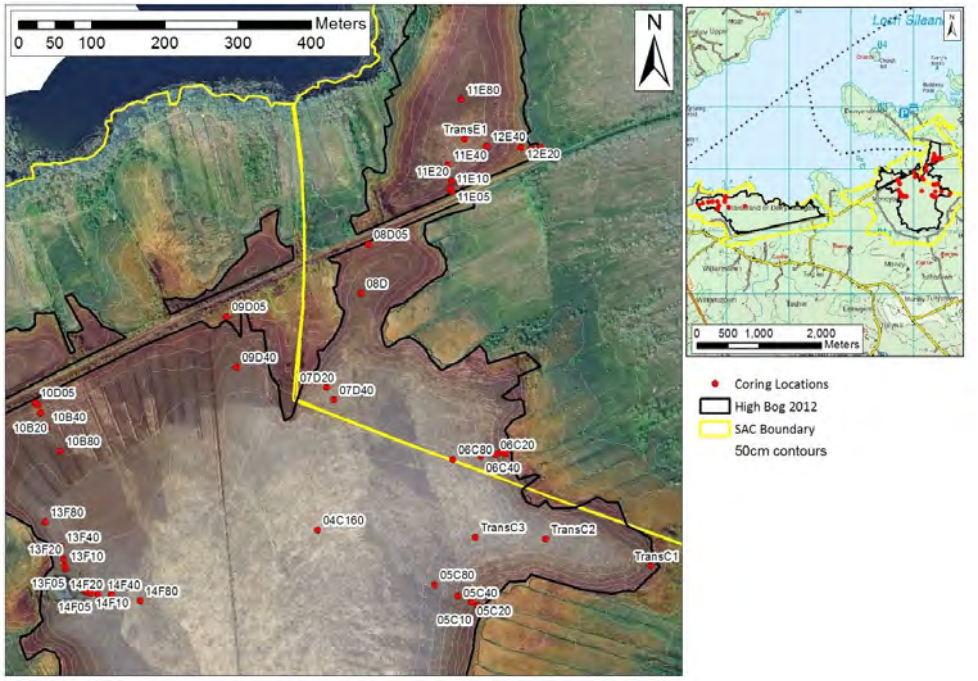

Figure 1: Map of Moneybeg Bog showing locations cored.

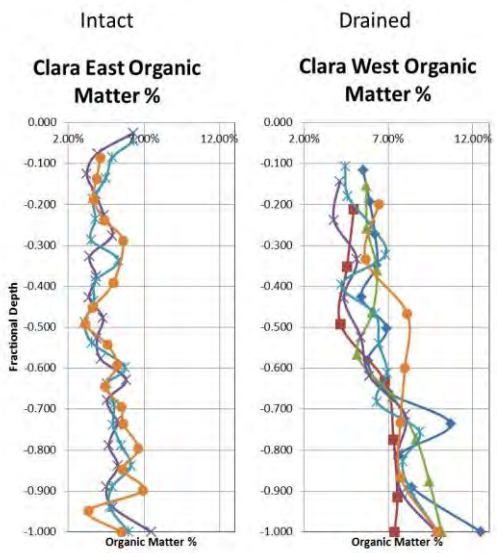

Figure 2: Organic matter profiles for intact and subsided bog.

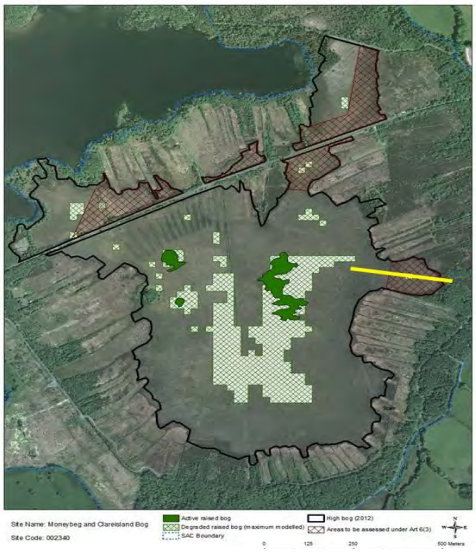

Figure 3: Moneybeg Bog, showing Annexed Habitats (Green), Article 6(3) areas (Red) and Transect modelled for 30m of cutting (Yellow).

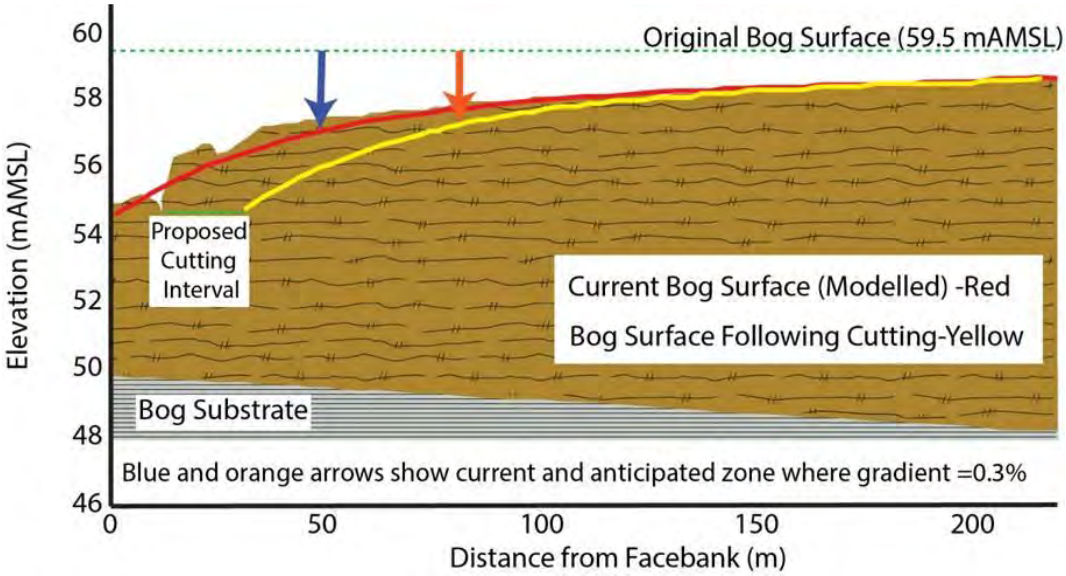

Figure 4: Model output showing predicted subsidence profile following simulated 30m of cutting into Moneybeg Bog along the transect shown in Figure 3.

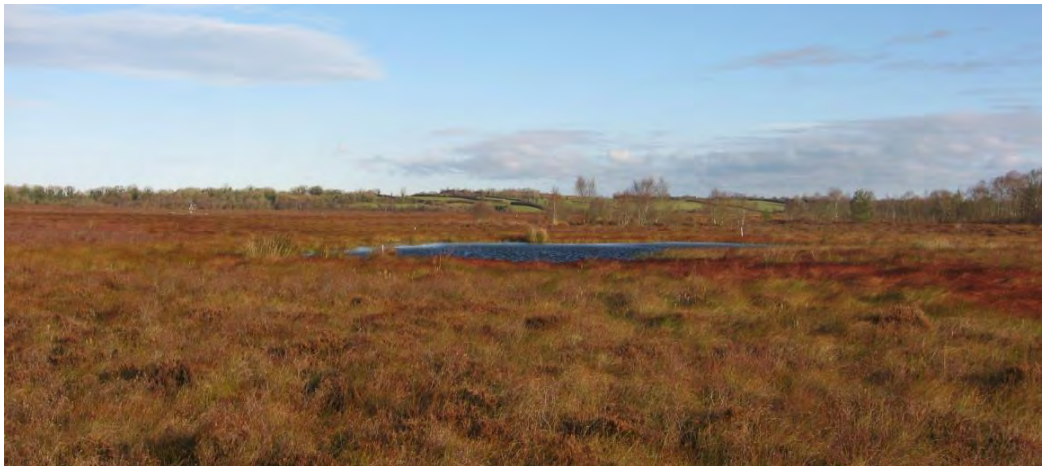

Figure 5: A subsidence hollow on Clara Bog, Co. Offaly

DISCUSSION

Using the principal of Conservation of Organic Matter a 2D mathematical model has been generated to quantify peat subsidence caused by marginal cutting and hence predict the impact on the conservation status of the bog.

Survey data including Organic Matter % profiles and peat depths taken at Moneybeg has been used to predict changes in topography, potentially caused if further cutting takes place. Calibration of the subsidence model to known features at Clara Bog, Co. Offaly, has permitted simulation of changes in bog topography, including the recent development of areas of standing water, while also generating changes in peat properties arising from turf cutting and marginal drainage. Successful application has the potential to identify suitable sites for continued cutting and help address needs of local stakeholders, while also meeting Habitats Directive requirements.

Currently the model is limited in its applications since it can only predict the final subsided profile of a bog and cannot give a timeframe for its occurrence.

Further development of the current model will create a 3D tool capable of predicting subsidence due to alterations in drainage of the bog. This will be achieved through;

- Adapting the model to accommodate variability in peat properties & structure,
- Development of a discretised model for higher resolution outputs,
- Refinement of empirical approach accounting for recharge in the system and flow rates through the peat,
- Introduction of permeable / semi-permeable substrates,
- Incorporating the effects of drains at varying depths, including increased under drainage from the bog, and
- Development of a time domain feature within the model to predict levels of subsidence at a given time after cutting.

REFERENCES

1. Habitats Directive (1992) 92/43/EEC the conservation of natural habitats and of wild fauna and flora, OJ L 206, 22.7.1992, p. 7–50
2. Joosten, H., & Clarke, D. (2002). *Wise use of mires and peatlands*. International mire conservation group.
3. Kool D. M. et al (2006). *Oxidation and compaction of a collapsed peat dome in Central Kalimantan.* Geoderma 137 (2006) 217–225
4. Mackin F. et al (2015). *The Role of Hydrology in Restoring Ireland's Raised Bogs: A Review of a Nationwide Study*. *National Hydrology Conference 2015*
5. National Raised Bog SAC Management Plan (2014) Management plan draft for consultation, Department of the Arts, Heritage and the Gaeltacht.
6. Ryan J (2007) Raised Bog Restoration in Ireland, National Parks and Wildlife Service Department of Environment, Heritage and Local Government
7. Schouten, M.G.C., Ryan, J.B., Streefkerk, J.C. (2002). *Introduction, pp 6-9. In: M.G.C. Schouten (ed.). Conservation and Restoration of Raised Bogs. Geological, hydrological and ecological studies. Dublin. Dúchas – The Heritage Service of the Department of the Environment and Local Government, Ireland; Staatsbosbeheer, The Netherlands; Geological Survey of Ireland.*
8. Van der Schaaf, S., (2002). *Bog Hydrology, pp 54-109. In: M.G.C. Schouten (ed.). Conservation and Restoration of Raised Bogs. Geological, hydrological and ecological studies. Dublin. Dúchas – The Heritage Service of the Department of the Environment and Local Government, Ireland; Staatsbosbeheer, The Netherlands; Geological Survey of Ireland.*