Blanket approach: Defra project on blanket bog management for biodiversity, carbon and water

***Dr Andreas Heinemeyer** has been a scientist at the Stockholm Environment Institute (SEI) at the University of York (which is part of the Environment Department) since 2002. His core research interests lie in terrestrial ecology and the carbon cycle. His work has focused on experimental and modelling the underpinning processes of how and how fast carbon cycles through terrestrial systems such as forests, grasslands and, more recently, upland peatlands. More recently, the work also included land management impacts on key ecosystem services such as water quality.*

We are now well over a year into our Defra funded project on assessing burning of heather dominated blanket bog *versus* alternatives and their respective impacts on key services that blanket bogs provide to us, namely carbon, water and biodiversity. Time for an update. This was the pre-treatment (i.e. background monitoring) year, so not much exciting happened apart from establishing a baseline and getting both burning and mowing done in what turned out to be a most challenging spring weather wise (i.e. rain, frost and snow). The project website https://sites.google.com/a/york.ac.uk/peatlandesuk/home provides a lot of background and up-to-date information in addition to the short update provided here.

So, how can we assess the potential issues of heather dominance in relation to burning and other management options? Are there issues? And, more importantly, are their ways of managing the system that will allow grouse shooting and grazing whilst also supporting increased benefits to other ecosystem services? The project provided a first literature review comparing burning *versus* potential alternatives (available on request); the potential impacts are certainly complex and remain largely untested.

Figure 1: The heat and chop is on: burning and large-scale mowing of equal areas in the Dales at the Mossdale site.

The overarching aim of this initially 5-year long study is to refine management techniques based on field experiments which compare 'control' to 'treatment' areas at three instrumented sites, two in collaboration with the Yorkshire Peat Partnership, Nidderdale and Mossdale, and another in the Forest of Bowland (United Utilities). At each site, two adjacent sub-catchments (each ~12 ha) have been set up. Within the '*treatment*' sub-catchments, catchment-level mowing and other plot-level alternatives replace the 'business as usual' burning, which is to be continued in the '*control*' sub-catchments on equal areas (**Fig. 1**). A workshop in February 2012 refined the five plot-level treatments: **mowing** at either short or long **rotation**, either with or without **brash removal** and with ***Sphagnum*** **addition** to one mowing regime; another recommendation was also to leave one treatment plot as a "**do nothing**" **comparison** to capture natural climatic and environmental variation (e.g. drought, pest) and long-term development of rank heather and to add another control with *Sphagnum* additions to burnt areas. The replicated 5 x 5 m monitoring plots ensure a rigorous statistical analysis of management effects on key ecosystem parameters: carbon stocks, CO_2 fluxes, methane emissions, peat pipes, vegetation dynamics, water balance and quality. Modelling will allow up-scaling of the findings in space and time.

The pre-treatment monitoring for carbon and water (**Fig. 2**) revealed comparable peat depths and carbon stocks and similar steadily recovering water tables during a wet summer, but with considerable ranges between sub-catchments and sites after the dry spring of 2012. All sites show a similar abundance of peat pipes.

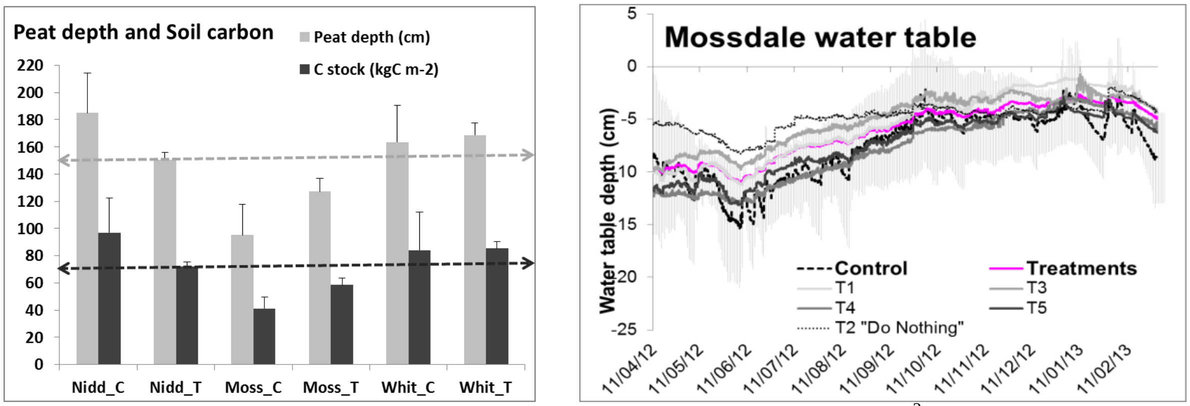

Figure 2: Average peat depths (148 cm) and corresponding soil carbon stocks (73 kg C m^{-2}) across all sub-catchments (C = control; T = treatment) and daily water table depths (cm below surface) at the Mossdale site for control and treatment plots (note: ranges of water tables across replicated plots (n = 4) are indicated for the control plots only).

All sites were characterised by relatively tall heather with notably low plant diversity (~14 species per 5 x 5m) (**Fig. 3**). The dense *Calluna* (~60%) further contained mostly ~10% fractions of sedges (*Eriophorum* spp.), *Sphagnum* moss and other mosses. All relatively typical for heather dominated grouse moor.

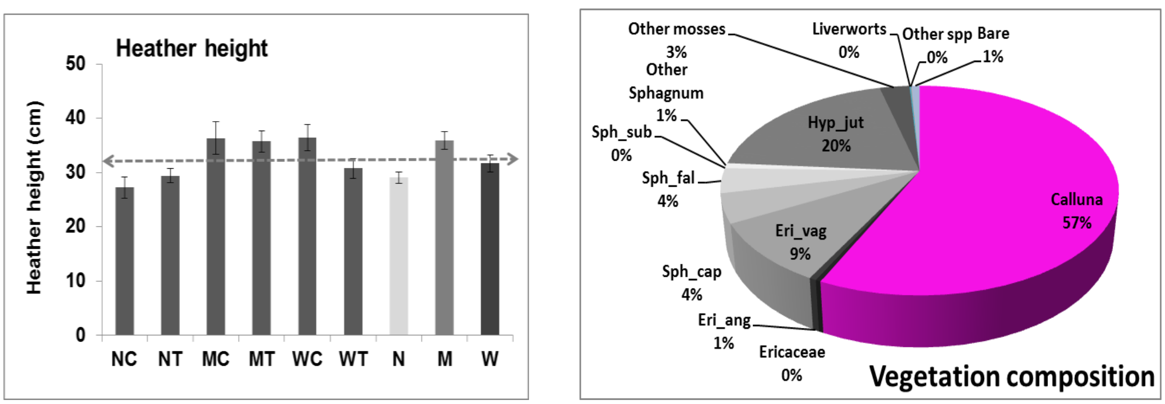

Figure 3: Average heather height (32 cm) across the three sites (N, M, W) and all sub-catchments (control = C and treatment = T catchments) and average vegetation cover within the 5 x 5 m plots across all sites showing *Calluna* dominance.

The bog's C balance is partly driven by light enabling photosynthesis, but mainly by the water table regulating decomposition of organic matter; high water tables prevent decomposition, thus forming layers of peat. Comparing management impacts on water budgets is therefore key to long-term changes in C storage. Pre-treatment water budgets also showed very similar behaviour between sites and sub-catchments and initially during the dry spring only 40% of the rainfall left the catchments via the stream outflow, whereas this was about 80% during the wet summer with about 10% estimated as being lost through transpiration from plants and soil, the rest raising the water table. These peatlands sequester about 20 g C m^{-2} per year (small amounts, but over ~6,000 years resulting in about 8,500 t C per catchment) and any changes in stream dissolved organic carbon (DOC), vegetation growth and net C uptake (i.e. photosynthesis – respiration) can impact on this C storage. For example, the DOC in peat pore water (~40 mg/L) was much higher than stream export rates (~10 mg/L), both within commonly reported ranges; the latter relating to an estimated annual catchment DOC export via stream water (~144 million litres) of about 1,500 kg C, equal to about 60% of annual catchment net C sequestration.

Overall, the starting conditions for a sound comparison are good (i.e. similar between control and treatment catchments and sites). It will be interesting to see if there are any short and long-term changes in response to management changes with impacts on key ecosystem services such as C-storage, water flow and quality. We will monitor C and greenhouse gas fluxes in relation to vegetation dynamics with chamber technology (**Fig. 4**); it takes surprisingly much light (about 1/3rd of the average daytime peak) to turn a bog from a net C source (net respiration) into a net C sink. Moreover, we will specifically look at C export from slopes and in streams in relation to management (with much appreciated HT funding).

Figure 4: Field deployment of clear Perspex chambers for measuring net ecosystem CO_2 exchange (NEE: sum of carbon uptake and release) and light response curves (i.e. shading) and cover boxes for measuring net CH_4 and N_2O emissions.

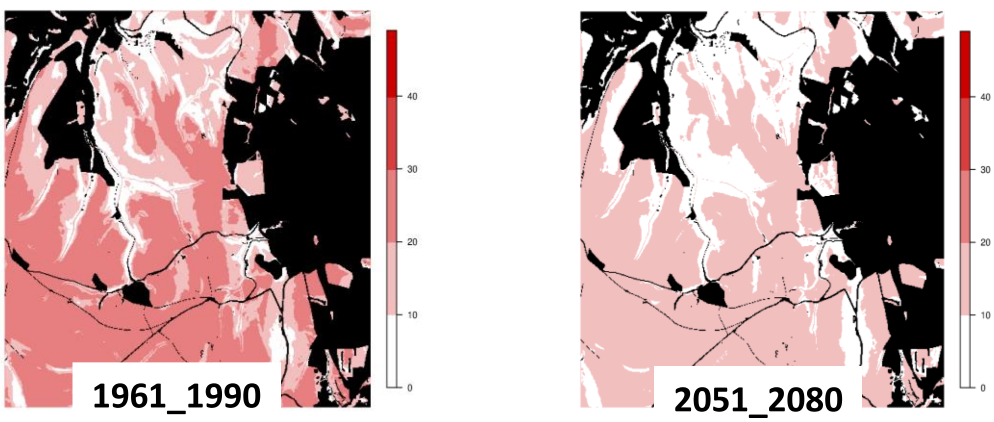

Figure 5: Model predicted crane fly abundance across 5 x 5 km during recent actual (left: 1961-1990) and future (right: 2051-2080) climate predictions. Estimated abundance (dark grey = high; white = low; black excluded) is based on MILLENNIA peatland model predicted water table and subsequent calculated soil moisture changes relating to observed crane fly abundance. Data are taken from the PhD thesis by Dr. M. Carroll. Note the disappearance of the high abundance areas.

Finally, why does this all matter? Take, for example, red grouse (or many other upland birds). The chicks depend considerably on cranefly larvae and adults for their initial growth and survival, which in turn depend on moist peat. Therefore, whereas high water tables benefit craneflies and consequently the birds that eat them, as climate changes, lower spring and summer water tables are predicted, with the potential for large scale negative impacts on these important upland bird species (see **Fig. 5**).

Finding the best way forward for managing these important areas relies on robust evidence, a shared understanding of the problems and a willingness to engage with other points of view and search for solutions. I am certainly delighted in the constructive engagement so far with key stakeholder groups involved in the active and policy related management of these beautiful places. I am hopeful to provide some clear evidence on key management impacts, pivotal to inform both, policies and stakeholders.