The fine-scale spatial distribution of surface moisture content in Canadian and Irish peatlands

Nuria Prat-Guitart [a*], Dan Thompson [b], Guillermo Rein [c], Claire Belcher [d], Rory Hadden [e], Merritt Turetsky [f], Jon Yearsley [a]

[a] University College Dublin, [b] Canadian Forest Service, [c] Imperial College London, [d] University of Exeter, [e] University of Edinburgh, [f] University of Guelph

*nuria.prat-guitart@ucdconnect.ie

http://www.ucd.ie/ecomodel/peat_smouldering.html

EUROPEAN REGIONAL DEVELOPMENT FUND

Summary

In pristine peatlands, a mosaic of peat-forming *Sphagnum* mosses covers the surface developing a hummock-hollow microtopography[1]. *Sphagnum* facilitate vertical water circulation raising moisture from the water-table to the surface[1]. On degraded peatlands *Sphagnum* is less dominant and the prevalent vegetation (e.g. feather mosses, grasses, heather, shrub) do not have the same ability to transport water.

During drought periods the risk of fires increases. Peat ignites when its volumetric moisture content is below ~20% (volume of water per unit soil volume)[2,3].

Post-fire studies in peatlands[4] reported peat being consumed in irregular patches (figure 1): *Sphagnum* hummocks remained unburned due to their high water retention whereas the surrounding areas were burnt.

We have studied the spatial distribution of volumetric moisture content and bulk density of superficial peat to analyse the existing variation of volumetric moisture content in a fine-scale.

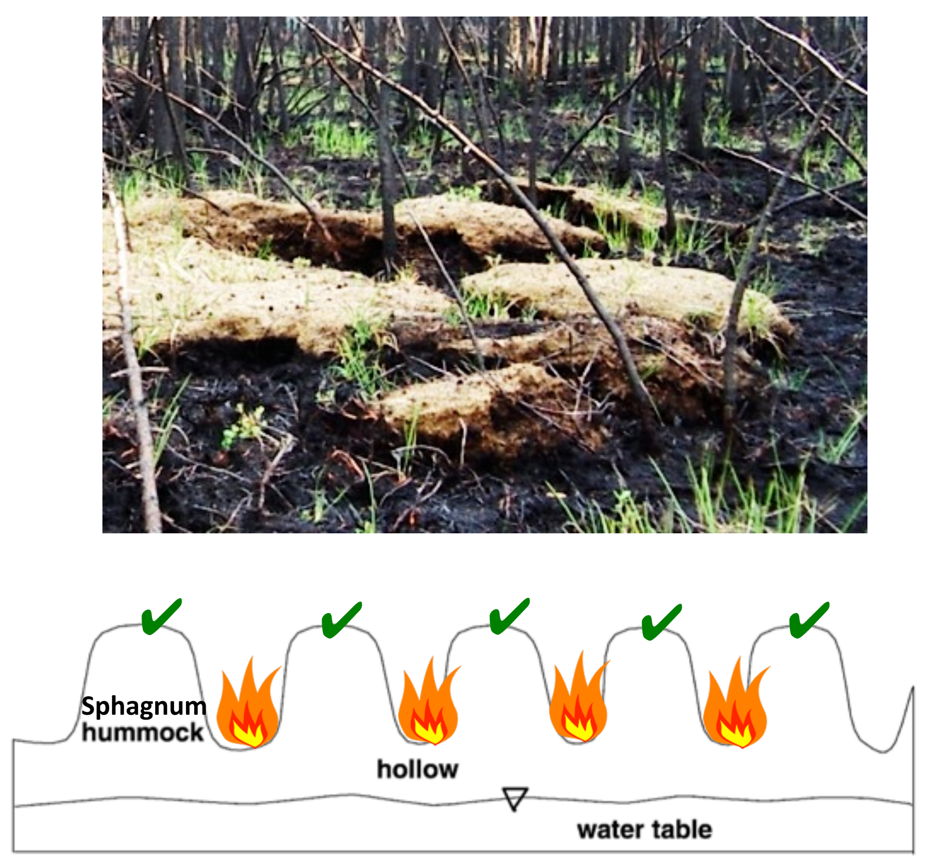


Figure 1. Heterogeneous distribution of burned patches after a smouldering fire. Photo: Turetsky's Lab, Alberta, diagram adapted from Nungesser, 2003[5].

Data collection

Figure 2. Quadrat in Ireland, September 2013.

Two sets of samples were taken in 2013 from an old undisturbed black spruce raised bog in Burned Crow Century, Alberta (Canada) during July and a drained cutover bog in the Wicklow Mountains National Park (Ireland) in September.

One quadrat (150x150cm) was randomly placed within flat, treeless areas of each peatland (figure 2). Vegetation was cut away to reveal the surface of the moss layer and the microtopography. One hundred peat cores (8cm diameter, 5cm length) were randomly taken from a regular grid. From each core we measured: volumetric moisture content, bulk density and vegetation category.

[1] McCarter, C. P. R., and J. S. Price. 2014. "Ecohydrology of Sphagnum Moss Hummocks: Mechanisms of Capitula Water Supply and Simulated Effects of Evaporation." Ecohydrology 7(1):33–44.

[2] Frandsen, W. H. 1997. "Ignition Probability of Organic Soils." Canadian Journal of Forest Research 27(9):1471–77.

[3] Rein, G., N. Cleaver, C. Ashton, P. Pironi, and JL Torero. 2008. "The Severity of Smouldering Peat Fires and Damage to the Forest Soil." Catena 74(3): 304–9

[4] Shetler, G., M. R. Turetsky, E. S. Kane, and E. S. Kasischke. 2008. "Sphagnum Mosses Limit Total Carbon Consumption during Fire in Alaskan Black Spruce Forests." Canadian Journal of Forest Research 38(8):2328–36.

[5] Nungesser, M. K. 2003. "Modelling Microtopography in Boreal Peatlands: Hummocks and Hollows." Ecological Modelling 165(2-3):175–207.

Spatial Analysis

In Canada the average volumetric moisture content was 9.8% and 35% in Ireland (figure 3). Using Moran's I significant spatial autocorrelation was found out to a spatial separation of 50 cm for volumetric moisture content and bulk density in both peatlands.

Bulk density was 0.03±0.01g cm^{-3} in Canada and in Ireland 0.07±0.03g cm^{-3}. In both Canada and Ireland, the samples with >91% *Sphagnum* had the lowest bulk density.

Figure 3. Mean and standard deviation for volumetric moisture content for different vegetation categories. Standard deviations are corrected for spatial autocorrelation. Letters indicate vegetation categories with significant differences. Red dashed line is at 20% VMC (this equates to a 50% peat ignition probability).

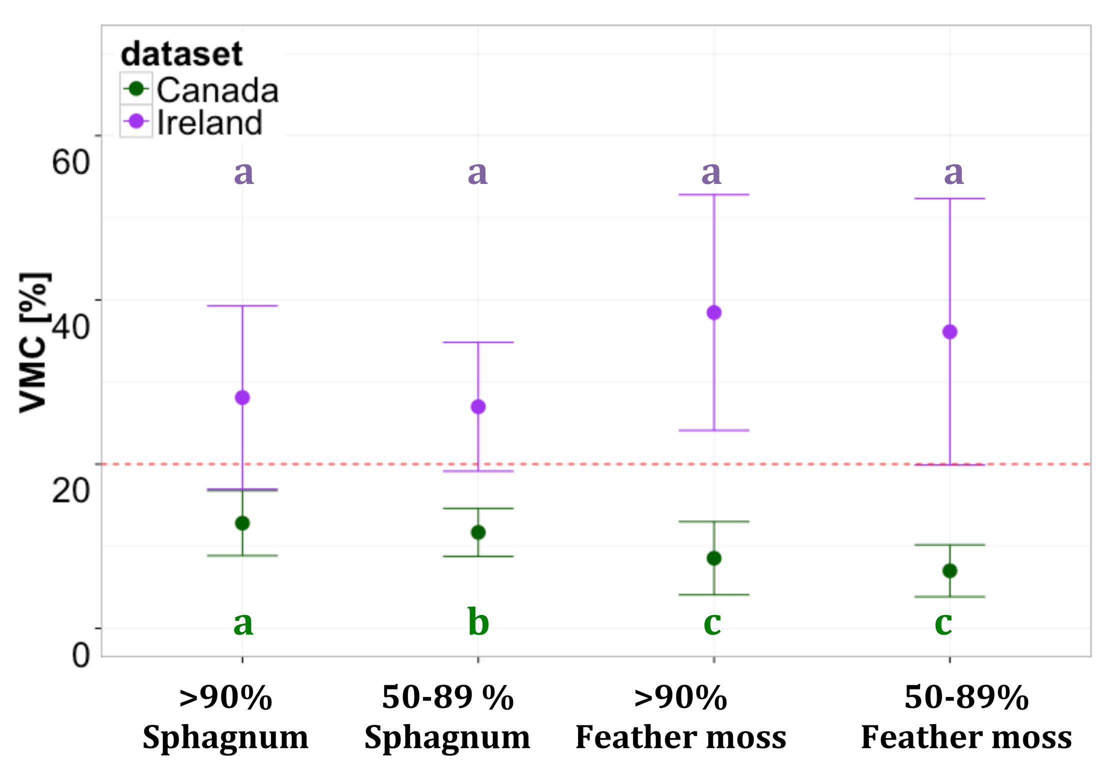
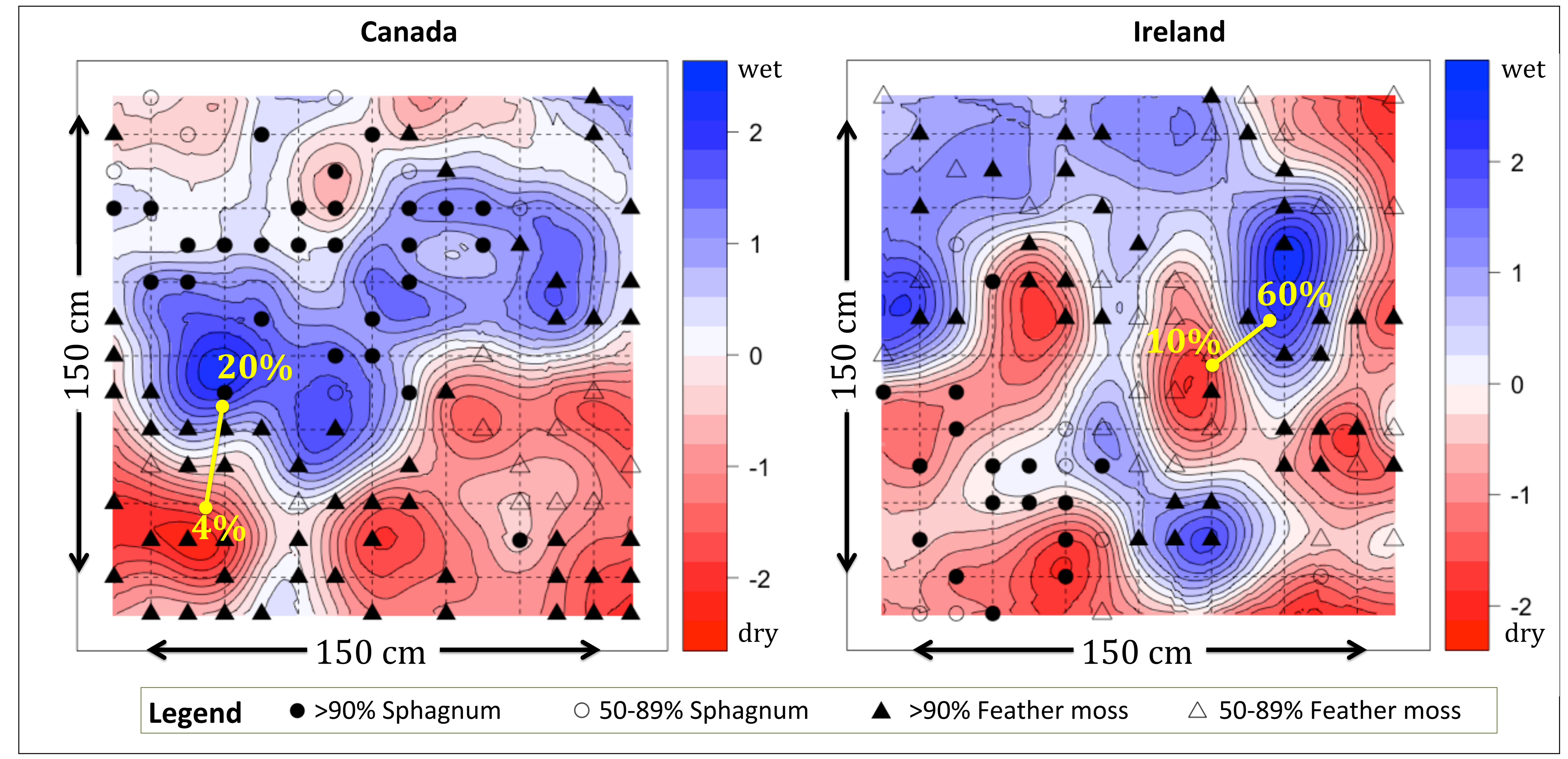


Figure 4. Interpolation maps of volumetric moisture content. Data are scaled and centred to the mean of each quadrat. Blue indicates wetter areas and red drier areas. Yellow: estimated volumetric moisture contents. Symbols represent vegetation category at each sampling location (see legend). Gridlines: 20cm.



	Canada	Ireland
Semivariogram	Gaussian range = 20cm, nugget=0.2	Exponential range =9cm, nugget =0
Number of data points	99	94
Intercept	0.5 ± 0.8	-1.4 ±1.2
Bulk Density	2.7 ± 0.4***	12.5 ±1.0***
Vegetation	-3.6 ± 0.5***	-1.1 ±1.3
Bulk Density × Vegetation	-0.6 ± 0.4	2.6 ±1.1*
Residual Standard Error	3.7	8.1

Table 1. Correlates of moisture content. Modelling was done with generalised least squares. Semivariograms were used to account for spatial structure of the data. Table shows parameter estimates ± standard error. Significance code: <0.001 (***), <0.05 (*).

Interpolation maps of volumetric moisture content were estimated with universal kriging, using bulk density and vegetation as external drift variables (Canada R^2 = 0.69, Ireland R^2 = 0.67). Peaks and troughs of volumetric moisture content were typically separated by 20-40cm (figure 4). Peat bulk density and vegetation were significant predictors of volumetric moisture content. Nevertheless, the vegetation category is more strongly associated to the volumetric moisture content in Canada than in Ireland (table 1).

Conclusions

Even though the two datasets are from very different peatland ecosystems. We found that the scale of spatial variation in moisture content consistently had a fine-scale of 20 to 50 cm. The volumetric moisture content of superficial peat in Canada was found to be dry (below 20%) in all the samples, whereas for Ireland it was higher and more variable.

In both quadrats there are areas of peat that could ignite during a vegetation fire and start smouldering. The spatial scale of moisture content variation can influence the propagation and the area consumed by smouldering fires.

Moisture content variation at a fine–scale can also be considered to study the impacts of peatland conservation, vegetation diversity and carbon storage function of peatlands.

Acknowledgements:

We thank: Andrew Kohlenberg and Rebecca Kutzner for field assistance. Wicklow Mountains National Park for access permission. The collaboration of Northern Forestry Centre in Edmonton (Natural Resources Canada).

This study is funded by the Higher Education Authority (HEA) through the Programme for Research at Third Level Institutions, Cycle 5 (PRTLI-5) and is co-funded by the European Regional Development Fund (ERDF).