CHAPTER 1

INTRODUCTION
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The principal aim of this project is to provide a critical analysis of the factors controlling the rate of physical and chemical degradation of organic and organo-mineral soils in Scotland and Northern Ireland and to relate these factors to impacts of erosion on habitats and freshwater quality. It review the findings of empirical studies and evaluate predictive models of erosion of organic and organo-mineral soils.

To meet this overall aim, the project team addressed to complete the following objectives:

1. Review evidence-based and quantitative information on the factors, natural and human-induced (including but not limited to soil properties, management practices, land use, grazing, habitats, climate factors), known to influence erosion dynamics in peat and organo-mineral soils in Scotland and Northern Ireland.

2. Review data on evidence of accelerated soil loss (including DOC and impacts on terrestrial habitats) and analyse and correlate data and factors reviewed in objective 1 to determine trends and primary driving factors both in Scotland and Northern Ireland.

3. Using an agreed selection of existing erosion model(s) (1) assess the robustness and sensitivity of erosion driver and factor responses to changes; and (2) evaluate the ability of selected erosion model(s) to inform on potential risk and its regional variability in Scotland and Northern Ireland for both loss of soil and evidence of soil loss such as DOC or habitat changes.

4. Identify means of assessing and quantifying the response of peat and organo-mineral soils under different climate change scenarios (e.g. land use change and change in climatic factors; temperature, precipitation and storm frequency).

5. Evaluate options for land management practices and mitigation techniques which will reduce the risk of erosion, habitat loss and DOC leaching in high risk situations.

Soil erosion is a natural process but it can be exacerbated by inappropriate soil management or extreme weather events. On cultivated mineral soils, erosion can often be easily rectified. On uncultivated organic or organo-mineral soils in the uplands,
restoration is much more difficult. The degradation of organic soils is the result of many natural and anthropogenic factors, often with complex interactions between them and operating over long time periods. These factors are reviewed in detail in Chapter 2. Erosion of soils with organic surface horizons has a direct impact on soil quality in terms of its capacity to deliver a number of functions including the storage of organic carbon. Off-site effects, including elevated Dissolved Organic Carbon (DOC) and Particulate Organic Carbon (POC) concentrations in streams, increased Green House Gas (GHG) emissions to the atmosphere and reductions in above-ground biodiversity, are also impacts related to peat erosion. Nevertheless, some severely eroded sites have been designated as Sites of Special Scientific Interest (SSSI) in their own right because of the geomorphological interest and the pool systems that have developed, for example the Knockfin Heights on the Caithness/Sutherland border in Northern Scotland.

Because of their diverse geomorphology and climate, Scotland and Northern Ireland possess a wide variety of different soil types. The diverse topography gives rise to further local-scale variation, and mapping units shown on the 1:50 000 or 1:250 000 soil maps encompass a range of soil types with varying properties linked to local variations in slope and landform (Soil Survey of Scotland Staff (1970-1987); Soil Survey of Scotland Staff (1981); Soil Survey of Scotland Staff (1954-1986); Cruickshank, 1997).

The distribution of the principal soil groups in Scotland and Northern Ireland is shown in Figures 1.1 and 1.2, respectively. Because of the strongly maritime climate, with cool temperatures and rocks which are generally resistant to weathering and base cation deficient, Scottish soils are in general more organic, more leached and wetter than those of most other European countries. Scotland contains greater proportions of podzols (23.7% of the land area), peat (histosols, 22.5%) and gleys (20.6%) than Europe as a whole. Many of these features are also observed in Northern Ireland where gleyed soils predominate. The proportions of podzols, peats and gleys in Northern Ireland as a percentage of land area are 4.1%, 14% and 62%, respectively.

Figure 1.1 also reveals the contrast between soil types in the Midland Valley and those in the Highlands and Southern Uplands of Scotland. The Midland Valley is dominated by mineral soils, whereas the Highlands and Southern Uplands are dominated by peaty soils (peat, peaty gleys and peaty podzols) especially in the west. Similarly, the central lowlands of Northern Ireland (Figure 1.2) are dominated by mineral gleys, while the peripheral uplands are predominantly covered with peaty soils.
This diversity of soil types underlies the wide range of functions associated with soils in Scotland and Northern Ireland. Although almost all soils produce above-ground biomass, the area of semi-natural communities and their underlying soils in both countries provides an indication of the importance of soils for wider environmental functions such as carbon storage, biodiversity or water filtration, rather than agricultural crops or forestry production. Many of these habitats of high conservation value are unique to Scotland and Northern Ireland and the soils that underpin them are rare in a UK, European and, on occasion, a global context.

Compared with many other soil properties, the current status of soil organic carbon can be quantified relatively well, although there are significant limitations due to heterogeneity of soils and lack of measurements of bulk density needed to calculate absolute stocks of carbon (C) in the soil. Soil organic carbon is an attribute common to soil databases held by the Macaulay Institute (MI) and Agri-Food & Biosciences Institute (AFBI) and can be used to give a broad picture of the soil organic carbon status of Scottish and Northern Ireland soils (Figures 1.3 and 1.4). Figure 1.5 illustrates the frequency distribution of soil organic carbon concentrations in the uppermost horizon of the 10 km National Soil Inventory of Scotland (NSIS) data points, and Figure 1.6 illustrates the frequency distribution of soil organic carbon concentrations in the A horizon for 5 km data points in Northern Ireland. The frequency distributions are very similar, with a bimodal distribution in both cases. The peak at around 5% organic carbon represents the bulk of the agricultural soils in Scotland and Northern Ireland, whilst the peak at around 55% represents peat and other organo-mineral soils such as peaty podzols and peaty gleys.
Figure 1.1  Distribution of soil types in Scotland (source Macaulay Institute)

Coastline based upon 1:50 000 Scale Maps © Crown copyright. All rights reserved.
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Figure 1.2  Distribution of soil types in Northern Ireland (from AFBI, 2006)

Based upon Ordnance Survey of Northern Ireland’s data with the permission of the Controller of HMSO © Crown copyright and database rights NIMA ES&LA201.3 (for Northern Ireland).
Figure 1.3  Topsoil organic carbon in Scotland, expressed as % total organic carbon of the most extensive soil in each 1km grid square of the 1:250000 soil map.
Figure 1.4  Topsoil organic carbon in Northern Ireland (% total organic carbon for each 1:50,000 soil map unit)
Figure 1.5  Frequency distribution of carbon (mass (wt) %) in the upper horizon of soils at NSIS sites (source Macaulay Institute)

Figure 1.6  Frequency distribution of carbon (mass %) in the upper horizon of soils at NI 5km sample sites (2005) (source AFBI).
High levels of soil organic carbon concentrations exist in the Highlands and Southern Uplands of Scotland, and in upland areas in the north-east and west of Northern Ireland, where the cooler and wetter climate inhibits the decomposition of organic matter in plant material deposited on the soil surface. In such areas, the accumulation of organic carbon is often more rapid than decomposition and an organic surface horizon forms. On level or gently sloping sites, the total accumulation can be as much as 7-8 m.

Although the quality of data on the C concentration in Scottish and Northern Ireland soils is relatively good, it must be remembered that carbon concentrations cannot be translated directly into carbon stock. The bulk density of each soil horizon is also required in order to calculate carbon stocks. Bradley et al. (2005) have reported on the development of a database of soil carbon storage and land use. Organic and organo-mineral soils in Scotland and Northern Ireland account for a total carbon storage to a depth of 1 m of almost 1800 Tg C, 40% of the UK’s total soil carbon store (Bradley et al., 2005). Estimates of C stocks below 100 cm depth have been determined as part of the ECOSSE project (Scottish Executive, 2007b) and this has added a further 485 Tg C to the Scottish total. In the case of Northern Ireland, estimates of C stocks below 100 cm are computed from the difference between the total soil C stock estimated by Cruickshank et al. (1998), (386 Tg C), and soil C stock to 1m given by Bradley et al. (2005), (296 Tg C), equating to 90 Tg C.