Continued relevance of Scottish soil maps in addressing current land management and land uses

Introduction

Soil maps in Scotland can be up to 70 years old (Lilly et al. 2015), however, they remain as relevant today as they did when the soils were first mapped. This is primarily due to the way soils are classified in Scotland. The Scottish soil classification is a field-based system that relies on the identification of specific types of soil horizons (layers) that indicate the main soil forming processes that have led to the development of the soil. Measurements are only required in a few cases to properly classify some soils. For example, very shallow soils and Peat require a measurement of thickness for classification and while magnesian and calcareous soils may require verification following chemical analyses, they can still be readily recognised in the field based on the type of rocks they have developed from.

This reliance of classification on how the soil has formed over thousands of years means that, while relatively recent changes such as the addition of soil nutrients may change some soil properties, they do not fundamentally change the soil type. With soil type not changing, the maps remain a significant and relevant source of information to address current land management and land use issues.

How Scottish soils developed

Soils in Scotland are relatively young in comparison to soils found in other parts of the world as they only began to develop at the end of the last ice-age around 12,000 years ago (Figure 1). The retreating ice left a variety of materials such as till, moraine, sands and gravels. Some of these deposits have been reworked to an extent giving rise to more recent materials such as river, loch and estuarine alluvial deposits, wind-blown sands and thick deposits of peat. Soils have developed from these materials - known as 'parent materials'. The combination of a range of soil forming processes acting on these parent materials determines the types of soils we find in Scotland today (Hollis and Lilly, 2022).

Following the end of the ice-age, the climate has fluctuated between warm and cold, wet and dry before settling into our current, temperate climate around 6,000 years ago. Since then, the dominant soil forming processes in Scotland have been **leaching**[1] (removal of base cations such as calcium and magnesium) and **gleying**[2] when the soils are waterlogged either where the parent material restricts the downward movement of rainfall or where there is a fluctuating groundwater table. Intermittent waterlogging results in changing oxygen levels in the soil which determines the form of iron present and thus the colour of the soil. This can cause a distinctly 'mottled' appearance or, in some cases distinctly bluish or very pale soil colours.

An extreme form of leaching is called **podzolisation**[3] which is more prevalent in the uplands or where the parent materials are derived from the more acid rock types found in Scotland (e.g., granite) and involves the removal of iron, aluminium, and often carbon, from the upper parts of the soil and redepositing them in the lower parts. This results in a very distinctive banding of pale, black and bright orangey, iron-rich layers.

Finally, **chemical weathering**[4] and the downward movement of clay particles also occur to an extent resulting in clay skins in the subsoils and alteration of the colour of the underlying parent material to a more brown or reddish-brown colour. The degree to which all these soil-forming processes operate over the thousands of years since the ice-age ended varies with factors such

as altitude, topography, porosity of the parent material and rainfall leading to the wide diversity of soil types with distinctive characteristics found in Scotland.

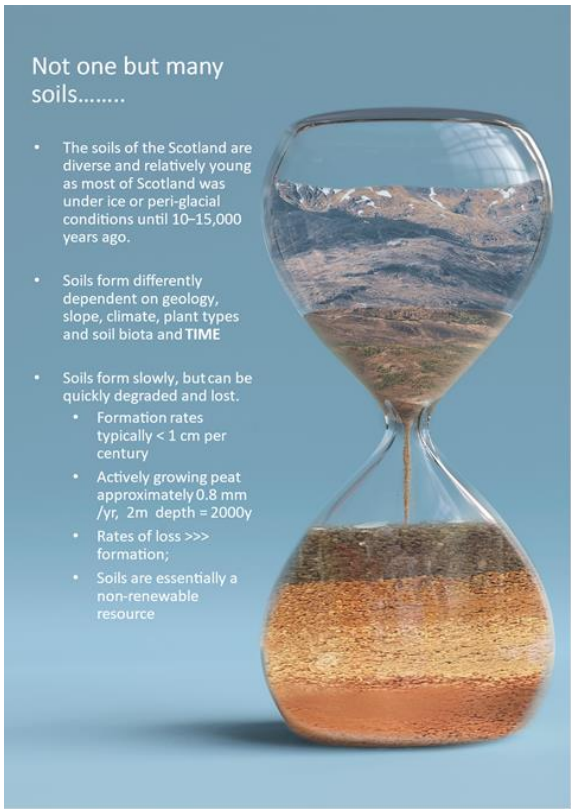

Figure 1: Impact of time of soil development

While most of the soil-forming processes are more evident in the subsoil, the development of topsoils are strongly influenced by the plants and animals that live in the soil as well as the climate. Following the retreat of the ice, Scotland was left with only bare ground which was colonised firstly by mosses and lichens, then by grasses, flowering plants and legumes to reach a point where much of the country was covered in woodland. Around 6,000 years ago a change to cooler, wetter conditions saw the development of soils with organic surface layers in the uplands. This split between lowland brownish, mineral topsoils with a mix of mineral and organic matter and the upland, organic-rich, peaty topsoils persists today.

Impact of people on soil development

In comparison to the thousands of years over which soils in Scotland have developed and to the characteristics inherited from the parent material, the human impact on the type of soil found in an area is relatively limited except where soil has been removed and transported elsewhere. Replacing nutrients lost through leaching allows crops to grow but doesn't alter the underlying soil leaching process. Similarly, installing drains can reduce the period of waterlogging in some soils but rarely completely prevents waterlogging, meaning that process of gleying still continues.

Soil classification and mapping

Mapping soils helps structure, organise and make sense of the complex nature of the distribution of different soil types while classifying soils allows us to predict their behaviour and make assumptions about how they will respond to different forms of management. The Soil Survey of Scotland used the understanding of soil forming processes outlined above and the resultant distinctive soil characteristics to classify and map Scotland's soils. The soil forming processes result in the development of distinctive layers in the soil that can be readily identified in the field without the need for complex chemical analyses. These layers form the basis of the Survey's 'genetic' rather than 'diagnostic' approach to classifying Scottish soils. Only in a few instances are measurements required to properly classify some soils, for example, the classification of very shallow soils (10cm or less to rock) and Peat (organic surface layers at least 50cm thick) are the only soils that require a measurement of thickness for classification while soils with high levels of magnesium or calcium (Magnesian and calcareous soils respectively) may require verification following chemical analyses, they can still be readily recognised in the field.

Conclusion

Short-term changes (relative to the time taken for the soil to develop) such as the addition of nutrients to improve soil fertility, or lime to alter the acidity of the soil, or ploughing to increase the thickness of topsoils, do not fundamentally change the soil forming processes outlined above and are not considered part of the classification system used in Scotland. Thus, soils that were mapped in the early days of the Soil Survey in the 1950s may now have more phosphorous or a thicker topsoil or less waterlogging, but their underlying characteristics, layering and processes stay the same and therefore, they remain as originally classified and mapped.

References

Hollis, J.M. and Lilly, A. 2022. The Fragile skin: Soil Landscapes of the UK. British Society of Soil Science. ISBN: 9781399922753.

Lilly, A.; Miller, D.R.; Towers, W.; Donnelly, D.; Poggio, L.; Carnegie, P., (2015) Mapping of Scotland's natural resources., Bulletin of the Society of Cartographers, 48, 35-46.

Glossary:

Leaching[1]: The loss of water-soluble base cations such as calcium, potassium and magnesium from the soil mainly by rainwater filtering through the soil.

Gleying[2]: The process where iron and manganese are either removed from or redistributed within the soil due to waterlogged conditions to give pale, greyish or bluish colours or a rusty-coloured, mottled appearance**.**

Podzolisation[3]: Acidic soils that are often nutrient-poor and strongly leached due to infiltration of rainwater which removes iron, aluminium and carbon from the upper layers and redeposits them deeper in the soil forming pale, grey upper layers and bright, orangy and/or black subsoil layers.

Chemical weathering[4]: The weathering of clay minerals under warm, humid conditions often leads to the release of iron-rich minerals in the soil leading to the development of brownish or reddish colours in the soil typical of Brown earth soils.

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