DPLUS083 – SUSTAINABLE LONG-TERM SOIL MONITORING PROGRAMME

REPORT SEPTEMBER 2020 – JIM MCADAM, ANNE D. JUNGBLUT, STEFANIE CARTER

The DarwinPLUS083 Soil Mapping Project (2018 - 2020) created a national soil map for the Falkland Islands, delivered tools to landowners that can be utilised for sustainable land management, created a baseline for peat extent, carbon stock, erosion extent and assessed soil microbial diversity and abundance. Climate change is predicted to alter soil properties in the future. In particular, an increase in temperature combined with stronger winds will likely dry out soil and lead to carbon loss (Upson et. al., 2016). In turn, this could have knock-on effects for soil physical, chemical and microbial properties. To assess changes in soil properties over time, a long-term monitoring programme needs to be in place so that the appropriate soil properties are measured at relevant locations, which can be compared to the baselines established by the Soil Mapping Project. Here we discuss how soil health in the Falkland Islands can best be determined and monitored on a long-term basis and at the end of the report we provide a brief summary with monitoring recommendations.

1. SOIL HEALTH

There has been no clear definition of soil health in the Falkland Islands to date. We have attempted to define the parameters for soil health in the context of this project – i.e. how can we best describe and monitor soil health as a measure of climate resilience and the soil's ability to sequester and retain carbon. For this Soil Mapping Project soil health included chemical properties, soil organic carbon (SOC) and soil microbiology. These plus one additional indicator are discussed below.

Following standard advice (mainly from the Agricultural and Horticultural Development Board (AHDB) Soil Health project https://ahdb.org.uk/GREATsoils), we recommend sampling from a network of representative sites chosen based on a stratified sampling procedure from the Soil Mapping Project. This should include a subset of original survey points representing a range of conditions and properties.

1.1. MONITORING SOIL HEALTH

1.1.1. Soil shrinkage

Local stakeholders (mainly farmers) often comment about soil shrinkage as a visible sign of drying out, sometimes as a result of management practices exacerbated by climate change. As a simple, user-friendly measure which would engage farmers, it is proposed that graduated metal stakes are driven into the ground at points indicative of a range of soil types, depths and land management practices. Farmers could be encouraged to monitor the soil level on these and this would engender awareness of climate change and soil resilience issues.

1.1.2. Chemical properties

Several soil chemical features mapped are indicative of basal geology and will not change over time. Those that were mapped and might change as a result of management practices and climate change are pH, nitrate-nitrogen, phosphorous, potassium and magnesium. It is recommended that these parameters be sampled on a 5-year basis. The tests for these soil chemical properties are currently available at relatively low cost at the Department of Agriculture.

1.1.3. Soil organic carbon

Soil organic carbon is a component of organic matter. In general, it is assumed that 58% of organic matter is SOC but this ratio can vary with soil type. Sequestering carbon from the atmosphere as SOC – which can either be an on-going natural process or can be encouraged through soil health management – can be an effective way of mitigating climate change. Likewise, climate change and land management can lead to SOC loss, which may exacerbate climate change. It is therefore important to monitor SOC in order to understand long-term trends. The FAO recommend that SOC is monitored on a 5-year basis as an indicator of soil health (Clara et. al., 2017). The Soil Mapping Project determined soil organic matter through loss of ignition, from which SOC can be derived.

1.1.4. Biological and microbiological diversity

Methods for biological testing for soil health are relatively new in the Falklands Islands. Belowground biodiversity of soils is comprised of a wide range of organisms ranging from earthworms, nematodes, microarthropods, protists, fungi, bacteria and archaea, and many of these organisms consume oxygen and produce CO_2. There is limited information on soil fauna such as earthworms to establish reliable baselines in the Falklands so these might not be appropriate indicators of soil health (as they are in other temperate regions).

Microorganisms such as bacteria and fungi are of particular importance for carbon and nutrient cycling in soil environments. These processes performed by microorganisms include decomposition of organic biomass and, together with earthworms, the generation of bioavailable nitrogen by bacterial nitrogen fixation, and release of nutrients by fungi from soil minerals. Microorganisms therefore form the basis of food-webs in soils. The richness and relative abundance of microbial communities can be affected by physical and chemical characteristics of soils, vegetation and geographic location. Plants also interact with microbes, which can effect plant growth, health, and adaptation to stressful environments. The rhizosphere comprises microorganism and soils that are directly in contact with plant roots. It is a selective environment with microbial communities varying between plant species likely due to excretion of compounds including antimicrobials and organic acids.

Due to the close interaction between microorganisms and plants, the microbial diversity and activity of the rhizosphere can be important for plant fitness and changes in plant-microbe interactions may also have implications for plant growth. There are therefore an increasing number of studies worldwide that not only document microbial diversity and interactions in soils using DNA sequencing technology in combination with other methodologies, but also evaluate findings in context of monitoring soil parameters and soil health. While it is possible to use DNA sequencing to identify specific pathogens, the understanding of the contribution by specific microbial species to carbon and nutrient cycling is too limited to use as indicator species for soil management. However, prior to this project, there has not been any comprehensive DNA sequencing soil microbiology from the Falklands. A DNA sequencing assessment of microbial communities from selected sites across the Falklands has enabled the creation of the first baseline information on soil microbiology, and assessment of environmental and geographic drivers of community composition and correlations with vegetation cover. DNA-based techniques are an emerging tool for monitoring and the baseline data from the project will help to evaluate if such techniques could be suitable for the Falkland Islands in the future.

Whilst DNA-based techniques can be expensive and time-consuming, they are a very useful tool to assess microbiological functions of the soil. It is recommended to assess microbiological communities through DNA-sequencing for a subset of the soil survey sites, which should include a representative sample of the different habitats present in the Falkland Islands. This should take place alongside the aforementioned monitoring every 5 years.

Summary

A sustainable and long term manageable monitoring programme for assessing soil health in the Falklands should be based on samples taken from a series of permanent sample points selected on a stratified sampling basis (by soil type) analysed for pH, N, P, K, Mg, SOC and microbiological communities on a five-year basis. The level of soil shrinkage should be monitored using permanent stakes at several representative sites.

References

AHDB (2018) Soil assessment methods. Agriculture and Horticulture Development Board. Factsheet.

Clara et al (2017) Soil Organic Carbon-the hidden potential. Food and Agricultural Organisation of the United Nations.

Upson, R., McAdam, J., & Clubbe, C. (2016). *Climate change risk assessment for plants and soils of the Falkland Islands and the services they provide*. Royal Botanic Gardens Kew and UK Falkland Islands Trust.

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