COMPREHENSIVE AND EFFECTIVE RECORDING OF EDAPHIC CHARACTERISTICS OF DUNE ECOSYSTEMS AS APPLIED IN THE MONITORING PROJECT OF THE FLEMISH COASTAL DUNES

C. AMPE and R. LANGOHR
Soil Science Unit, University of Ghent, Belgium

Introduction

A project was set up in 1996 to monitor management regimes (shrub removal, grazing and mowing) implemented in different nature reserves along the west Belgian coast. The project integrates botanical, zoological, hydrological and pedological research at several levels (Bonte et al., 1997). The soil study aims to produce a comprehensive and effective system of soil description, and in this paper we propose the methodology used for recording soil characteristics at the most detailed research level. The initial period of the monitoring project runs for 3 years.

Methodology

Soils are described on the basis of both field and laboratory characteristics.

Field description

Two levels of detail are used.

1. Soils in 80 permanent quadrats (3 × 4m) situated in (approximately) 50 × 50m plots representing 16 management regimes (including the controls) and spread over six sites, situated in the Westhoek Nature Reserve and the Flemish Nature Reserve of Houtsaegerduinen, were investigated in great detail. Mini-soil profiles, 50 × 40cm and approximately 50cm deep, were dug for which vertical and horizontal sections were studied.
2. At a number of other sites in the Westhoek Nature Reserve, Dune Marchand, Ter Yde, Oostvoorduinen and Schuddebeurze soil profiles were investigated in less detail by observations of profiles produced by using a hand auger.

First a more *general description of the soil profile* was recorded. This description partly followed the Food and Agriculture Organisation (FAO) guidelines (1990), but this standard technique for soil profile description provides insufficient data for an understanding of the ecosystem dynamics. Based on literature, mainly from The Netherlands, and personal experience we added a number of parameters to be described.

Dune soils are often shallow for root penetration and the *humus form* will play a very important role in increasing the available nutrients and moisture for plant growth. The terminology according to Green et al. (1993) was employed for the description of the humus form. The parameters considered were horizon designation and depth, moisture status, colour, fabric including structure, texture and character, roots, soil flora and fauna.

The *thickness of the biological active layer ('bi' horizon)*, the sum of the horizons where the majority of the roots are concentrated, is often limited in sandy dune soils. Former research along a topo-chronosequence in the Westhoek Nature Reserve has shown that in hollows the thickness of the biological active layer was often limited to about 20cm. This biological active layer was underlain by a more *compact ('d') horizon* with almost no more roots. Bulk density measurements resulted in the following values: 1.35 ($n = 49$), 1.50 ($n = 121$) and 1.56 ($n = 436$) g per cm^3 for the Abi, Bbi and Cd horizons respectively. On the micro-ridges the biological active layer became thicker, often due to bioturbation caused, for example, by rabbits, and rooting was more developed in the resultant air spaces (Ampe and Langohr, 1993). The thickness of the biological layer was measured from the vertical section or determined with a penetration rod of surface area $1 cm^2$.

The limited thickness of the biologically active layer has important consequences for water and nutrient supply. Firstly, the water available to plants in dune soils amounts to only a few per cent of the total amount of water present and is only higher in those surface horizons with somewhat greater organic matter (OM) content. Secondly, if the groundwater table is at a greater depth than the sum of the thicknesses of the biological active layer and the capillary rise, plants encounter great problems in water uptake. Due to a limited thickness of the biological active layer, the system is very sensitive to disturbances.

In this study particular attention was paid to *rooting characteristics.* Size (diameter), abundance, orientation and species are determined on the vertical as well as on the horizontal section. In some profiles live roots were observed growing in old humified root galleries. It can be deduced that on the one hand we have plants which grow with the accreting dune such as *Ammophila arenaria* and *Salix repens*, and on the other hand there are plant species which make use of the presence of these old humified root galleries in later successional stages. If these old root galleries are missing, further colonization of the dune will be very slow.

Specific rooting characteristics of different plant species have also been investigated as these may explain why some plant species are more competitive than others in their struggle for water and nutrient supply.

Extent of decalcification is determined with HCl (2N). Decalcification can vary within the profile due to:

- the presence of buried decalcified humic horizons;
- the active process of deposition whereby the soil is regularly showered with fresh calcareous sand;
- lateral supply with calcareous seepage water;
- turbation activity by animals (rabbits, moles, mice) or people (forest management, thinning).

The pattern of decalcification can also be very irregular over short distances in space, resulting in a mosaic of calcicole and calcifuge vegetation.

The soil is tested for *water repellency* under field conditions and also on air-dry samples in the laboratory. Soils which are water repellent show a certain resistance to water penetration, a common characteristic of dune soils (Dekker and Jungerius, 1990). The model of homogeneous wetting fronts cannot be applied in such soils. Preferential flows develop in tongues or fingers along roots, in microdepressions or less repellent areas, or follow buried horizons. Along these preferential flow routes water can reach the groundwater table much faster than would normally be expected. In the field, patches of moist soil surrounded by completely dry patches can be observed. Water repellency is therefore another factor causing dune soils to be drier than expected.

Oxidation-reduction features were described. Abundance, size, contrast, boundary, colour, the activity status and the related distribution of the mottling were recorded. Active mottling can be represented by the presence of a rusty rim especially along *Carex* roots. On the horizontal section, sharp concentric rust-coloured mottling surrounding a live root can be seen; on the vertical section this kind of mottling forms rusty vertical streaks along the root. U-shaped mottles can very clearly be seen on horizontal sections, their morphology consisting of a dark, sometimes black nucleus – a dead root channel – surrounded by the U-shaped rusty colouring. Indeed, due to lateral water flow the original concentric mottle becomes U-shaped with the closed end showing the direction from where the water flow comes. Apart from these very striking types of mottling, a rust-coloured soil matrix can be observed in some horizons.

Other special features can be observed on the vertical and horizontal sections. Plough layers or thin bands that are probably buried algal bands are examples of such features.

Sampling strategy

Siting of the *mini-profile* and sampling took place on one of the four sides of the permanent quadrat with a preference for the southern. In the mini-profile bulk samples were taken for each horizon. For some representative horizons undisturbed samples (5 replicates of cores of 100cm^3) were taken on the horizontal section for bulk density determination.

For the *surface mineral horizon* between 0–5 and 0–10cm, a composite sample was taken consisting of 5 subsamples. Because of persisting dry conditions of the soil or the presence of thick roots (*Salix repens*) or rhizomes (*Iris pseudacorus*), neither the gouge auger nor the grass plot sampler (a small auger designed for grass-covered terrain, pressed into the soil by stepping on the container which subsequently collects the sample) proved to be practical. Therefore rings with a height of 5 and 10cm were used to sample the soil.

The *humus profile* was sampled at some selected sites. For this a stainless steel cylinder with a diameter of 25cm and a height of 20cm was hammered into the soil. The L, F, H and A horizons were taken off separately and placed in bags. For each permanent quadrat this sampling was repeated three times.

Laboratory analysis

The following analyses are provisionally being considered as appropriate.

Main horizons: colour, water repellency, bulk density, pH H_2O, pH KCl, $CaCO_3$, organic carbon.

Samples between 0–5 and 0–10cm depth based on mixed sampling: water repellency, pH H_2O, pH KCl, $CaCO_3$, organic carbon, N, Cation Exchange Capacity.

Samples of the humus profile: air dry weight, pH H_2O, pH KCl, organic carbon and N.

Acknowledgments

This research is co-financed by the LIFE nature project ICCI.

References

Ampe, C. and Langohr, R. (1993), 'Distribution and dynamics of shrub roots in recent coastal dune valley ecosystems of Belgium', *Geoderma*, **56**, 37–55.

Bonte, D., Ampe, C., Hoffmann, M., Langohr, R., Provoost, S. and Herrier, J.L. (1997), 'Monitoring research in the Flemish dunes: from a descriptive to an integrated approach', in C.H. Ovesen (ed.), *Coastal Dunes – Management, Protection and Research*, report from a European seminar, Skagen, Denmark, August 1997. National Forest and Nature Agency, Geological Survey of Denmark and Greenland.

Dekker, L.W. and Jungerius, P.D. (1990), 'Water repellency in the dunes with special reference to The Netherlands', *Catena Supplement*, **18**, 173–83.

Food and Agriculture Organisation (1990), *Guidelines for Profile Description*, 3rd edn, Food and Agriculture Organisation, Rome.

Green, R.N., Trowbridge, R.L. and Klinka, K. (1993), *Towards a Taxonomic Classification of Humus Forms, Forest Science*, Monograph 29, Society of American Foresters, Bethesda, MD.