Scientific registration n° : 97
Symposium n° : 45
Presentation : poster

Care and neglect of soils: human impact on the soil resource in Europe
Soin et négligence envers les sols: l'impact de l'homme sur les sols d'Europe

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Introduction

The concept of soil care has developed throughout history alongside the growth of agricultural knowledge. This paper attempts to assemble pedological and archaeological information to demonstrate how care and neglect are features of the European soil resource throughout the ages. Archaeological evidence points to the early hominids living in hunter-gatherer societies and occupying open country on the borders of the tropical regions. These early inhabitants may have dug-up roots for food, but they were not cultivators and their impact upon the soil was minimal. With the development of settled agriculture and use of water for irrigation of crops, as occurred in the Middle East, human impact upon soils became greater. The use of the ard, and subsequently the invention of the wheeled plough pulled by oxen in the Iron Age, introduced mechanization. By the middle of the 20th century, mechanical equipment was available which could disrupt soils to more than a metre depth, even completely overturn them, mixing the horizons and destroying the natural profile.

The impact of human actions upon soils has been referred to as "metapedogenesis" (Yaalon & Yaron, 1966) and the results may be considered to be either beneficial or detrimental in their effect upon soils (Bidwell & Hole, 1965). Beneficial activities include deep cultivation, intensive fertilizer applications, sedimentary additions during irrigation, drainage, embankment of forelands, checking soil erosion, additions of organic materials and creation of poor drainage for irrigated cultivation of rice. Although these activities have modified soils drastically, in general they have enhanced soil productivity. Detrimental practices include removal of plant nutrients in crops without replacing them, the addition of toxic materials, accelerating erosion, burning organic layers, reducing organic matter content, destruction of soil structure, compaction by farm machinery and acidification. These activities have had the effect of lowering soil fertility, causing soil degradation and in the worst cases, complete loss of the soil resource has occurred. Reviews of these beneficial and detrimental practices are given in Bridges (1978, 1997a).

Early history

The use of soil for food production has a long history and no attempt will be made here to consider all periods of human development, but reference will be made to the findings of archaeologists and anthropologists. Ford (1948) traces the origins of wheat and barley cultivation back to Egypt and Mesopotamia as early as 3000 BC: ....*the use of draught animals and levelling fields, broadcast sowing, the reaping sickle and the use of beasts for treading out the grain were all part of the technology....* of food production which became widespread throughout Europe from the Neolithic to the Medieval period. In discussing the path of human development (Childe, 1936) stated *the first revolution that transformed human economy gave man control over his food supply*. With this Neolithic revolution came the realization that soil care was necessary as part of food production: soils required cultivating for a seedbed and crops needed to be weeded, tended and eventually harvested.

A consensus of opinion accepts that after developing in the countries of the Near East, Neolithic farming methods spread through Turkey and Greece into Eastern Europe. At first, in gardens based on alluvial soils, but on reaching the Hungarian Plain, a change was made to extensive cultivation on soils with loessial parent materials. Spreading further west and north into cooler climates, archaeological studies in Bohemia suggest a form of shifting cultivation had developed. In southern Britain, many chalk hillsides are scarred by prehistoric cultivation benches, called lynchets, which were abandoned towards the end of the Bronze Age (Fowler and Evans, 1967). Cultivation has influenced the nature of the soil profile developed. At the foot of chalk slopes, soils are much deepened with colluvial material, such that a separate soil (Gore series) has been mapped on footslopes leaving rendzinas on upper slopes. ^{14}C dating of alluvial sedimentary sequences at three sites in the Avon-Severn valley of central England indicate a sudden increase in red silty clay sediment in the late Bronze Age attributed to erosion following woodland clearance and cultivation (Limbrey & Evans, 1978).

In the earliest times, digging sticks (like crowbars) were used to break the ground. Subsequently, paddle-shaped spades were made and the use of these spread to Ukraine and as far as Norway and Finland. The earliest hand-operated plough to be found in northern Europe - an ard from 1500 BC - was unearthed at a site in Jutland, Denmark. However, traces of plough marks, claimed to be some 2000 years earlier, have been identified in Polish soils. In Scotland, and at many other places in western Britain, cultivation took place in small fields (Celtic Fields) as long ago as the late Neolithic-Bronze Age. Evidence of this activity remains in the form of spade and ard-marks at the base of the plough layer. Some sites in Wales and Cornwall were overwhelmed by sand dunes which have preserved the celtic field boundaries and evidence of manuring and cultivation in the Bronze Age, Iron Age and Medieval times. In Ireland, growth of peat in the Sub-Atlantic period has covered fields cultivated during the Bronze Age.

There is circumstantial evidence that the Mesolithic and Neolithic settlers had the ability to identify the most advantageous soils upon which to locate their cultivations and settlements (Crampton & Webley 1964; Limbrey & Evans, 1978). Unfortunately, forest clearance by Neolithic people in Europe interrupted the circulation of plant nutrients and led to acidification, reduction of fertility and erosion. In sandy soils podzolization was initiated and in loamy and clayey soils leaching of bases reduced the soil structural stability,
providing conditions favourable for clay illuviation, leaving a corse-textured topsoil and a slowly draining subsoil. Bowen (1978) describes areas of the English counties of Dorset, Hampshire and Wiltshire which suggest the pre-historic landscape was not 'wild' but had a highly organized arrangement of settlements an blocks of 'celtic' fields and more extensive 'ranches'. An outstanding example of late prehistoric soil erosion occurs in Ireland on the

limestone plateau of the Burren. Formerly covered with woodland, the area was cleared and farmed in the Bronze Age. The Bronze Age field pattern is now situated on a limestone pavement with no soil except in the deep joints of the rock (Roberts 1989).

Greco-Roman times

Archaeological and palynological evidence indicates that Greece was well-forested in Bronze Age times with forests growing where little soil exists at the present time. Subsequent erosion completely transformed the nature of the soil geographyof many Mediterranean countries. In central Europe, Bronze Age valley floor sites became buried by as much as 1 or 2 m of loessial soil wash (Davidson, 1982). Many of the soils of floodplains, now mapped as Fluvisols had their origin in soil erosion of prehistoric times.

Homer, in the Odyssey, refers to manuring of vineyards around 800 BC, a practice also recommended by Theophrastus c 300 BC, using animal wastes. Theophrastus also noted the value of residues from leguminous crops and suggested mixing different soils to remedy defects and add heart to the soil (Quoted by Tisdale *et al,* 1993). Liming of soils is recorded on the island of Aegina, Greece, a practice adopted by the Romans and recommended by both Pliny and Columella. The use of lime had already spread to the British Isles by the time of the Roman invasion. Saltpetre (potassium nitrate) was recognised as a useful soil amendment, subsequently claimed by Glauber in 17th century Germany as the principle food of plants.

White (1970) assembled evidence of the loss of fertility of soils in Roman times. As soils were exhausted, farms became impoverished. With debts and poverty it became impossible for soil fertility to be maintained and amalgamation of land into larger estates took place. At the same time grain was sought further and further afield, for example from Sicily and North Africa. In the immediate area around Rome, land use changed to the production of olive oil, fruits and grapes for wine. Land was also put down to pasture. Not all classical writers agreed that soil exhaustion was to blame. Columella argued against the idea stating that soil was conferred with perpetual fecundity, as it had already been observed that if land is abandoned to natural vegetation, fertility gradually returns and productivity would not diminish if soils were properly cared for and manured. Unfortunately, In a recurring problem throught history, Roman animal farming methods did not produce enough manure to maintain soil fertility.

Methods used to care for soils

Soil care methods may be traced back into antiquity showing human appreciation of the need to conserve soil. Some of the earliest methods include stone clearance, terracing and marling the soils of cultivated areas. Stone clearance was associated with easier cultivation and the stones could be used for boundary markers and in terrace construction. Terracing

was mainly associated with the southern European countries, but extended into central Europe on steep valley sides, usually associated with viticulture. Terraces provided level ground upon which water and erosion were controlled. Levelling on gently sloping land achieved similar purpose, but often brought to the surface infertile subsoil material. Deep cultivation gives a greater volume of soil for roots to exploit and it can be used for textural modification of soils where suitable conditions exist. Drainage of soils also provides a greater soil depth, and allows soils to warm more quickly and be cultivated earlier in spring. The practice of adding calcareous materials (marl and lime) is necessary in all humid climates to counteract acidity. As Europe became industralised, techniques were developed to increase the productivity of many farming operations. Mechanization enabled seed to be sown in lines and mechanical hoes kept weed infestations under control. Cultivation of root crops instead of a fallow increased the amount of organic manure which could be returned to the soil from over-wintering stock. The use of natural phosphatic and potassic rock materials as fertilizers followed in the 19th century, and in the 20th century the extension of the use of chemical fertilizers greatly increased the fertility status of soils.

Current degradation of soils

The findings of the GLASOD survey (Oldeman *et al*, 1991) give a general picture of the degradation of European soils, but a better understanding of the current degradation affecting soils is necessary. Work on a compilation of data from countries in eastern and central Europe is currently in progress (Batjes and Bridges, 1997). Erosion by water continues to be the most significant factor in soil degradation (114.5 million ha). Locally losses of 20-40 t/ha once every 2 or 3 years occur and in extreme events over 100 t/ha can be lost; such losses are not sustainable over a long period. Agriculture, over-grazing and deforestation are the major triggers for water erosion in western Europe and deforestation is the cause in eastern Europe. Wind erosion (42.2 million ha) in western Europe is localised, but is widespread in southeastern Europe, especially in southeastern Europe where cultivation and a dry climate leaves the soils on loess vulnerable to wind action.

Chemical degradation in Europe (25.8 million ha) may be categorised broadly as dispersed pollution or arising from localised sources. Acid deposition from industrial and traffic emissions have particularly affected the Scandiavian countries where soils are shallow, acid and with low cation exchange capacities. Nuclides from weapons testing worldwide, and the accident at the Chernobyl nuclear power plant has affected Belarus in particular and countries as far away as the United Kingdom. Scattered point sources exist across the whole of the European landmass associated with industrial complexes. Certain pesticide residues are also widespread throughout Europe. Military activities in former states of Yugoslavia have left unexploded bombs, grenades, mines and other munitions which present a hazard to users of the land. Military installations in UK, Germany, the Baltic Republics and many other countries are sites with badly contaminated soils.

Physical degradation of soils in Europe amounts to 36.4 million ha. Compaction is widespread where heavy machinery has been used frequently, often in less than suitable conditions. Increased bulk density at depth reduces the rate of percolation downwards and causes waterlogging. Waterlogging is stated to be a problem in northern Russia, the Black Sea coast of Ukraine and in the Danube valley. Lowering the water table can also result in

problems of lack of soil moisture and wastage of organic soils. Peat shrinkage has occurred in Belarus, the Netherlands and parts of eastern England

Conclusions

This paper has attempted to assemble some of the European experience of care or neglect of soils thoughout the pre-historic and historical period with brief comment upon the present situation. The impact of human actions on soils has been described as *metapedogenesis* and involves the benefits of cultivation, manuring and fertilizer applications, drainage, checking erosion, and the adverse effects of nutrient depletion, accelerating erosion, depletion of organic matter, destruction of soil structure, compaction and addition of toxic elements.

Recognition and measurement of soil degradation is not straightforward, but the problem may be approached by considering the percentage of topsoil eroded, and with it the amount of plant nutrients lost. Loss of organic-rich topsoil also results in a reduction of the water-holding capacity of soils, limiting the moisture available for crops. This loss is accompanied also by a reduction in the ability of the soil to provide nutrients for the plant, and to resist further chemical degradation. Throughout history, mankind has striven to manipulate the soil so that it would provide food on a sustained basis. However, not all soils are sufficiently resilient and may undergo irreversible changes. Soil resilience is defined as *the ability of a soil to restore its life-support systems after disturbance* (Lal, 1994).

Soils which have been profoundly modified from their original natural condition are referred to as Anthrosols. Many of these soils are capable of producing satisfactory crops and have done so for many generations. The changes are such that these soils may be considered to be artefacts, the result of human workmanship, in a similar way as pottery, metal or wooden items are made into useful things (Bridges, 1997b). Looking to the future, Anthrosols are probably the soils which can be relied upon to continue to produce high yields. With world population set to increase during the next 25 years, the inevitable conclusion is that further intensification of food production will take place and more soils will become profoundly modified to become Anthrosols. Every effort therefore must be made to ensure that these soils are properly cared for and zealously conserved for future generations.

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Key words: human impact, soil care, soil degradation, Anthrosols, Europe
Mots clés: l'impact humaine, Le soin des sols, la négligence des sols, Anthrosols, Europe