8.1 Introduction

Soils, together with air and water, are fundamental resources on which all life depends. Soils are part of a wider ecosystem where soils, plants, animals and humans all interact with each other and the natural processes of climate, geology etc. The quality and depth of soils will vary from place to place, and over time, in response to natural processes and the influence of human use.

Under the Resource Management Amendment Act 2003, soil conservation has been defined to mean

"avoiding, remedying, or mitigating soil erosion and maintaining the physical, chemical and biological qualities of the soil".

Section 5 (Purpose) of the Resource Management Act 1991 (RMA) applies a long-term perspective to this definition requiring that the key qualities of soils need to be maintained for future generations. The concept of reversibility is central to the sustainable use of natural resources. It ensures that land use activities do not foreclose the options for future generations to manage the land for a range of production or conservation purposes.

Sustaining the potential of soils for future generations, and safeguarding the life-supporting capacity of the soil and ecosystems requires the protection of both the quality and the quantity of the soil, and the processes sustaining those soils. In this chapter the focus is on the prevention of soil erosion that is induced or accelerated by the activities of people and/or the animals they have introduced.

8.1.1 Progress in soil conservation management

In management terms, soil conservation is about managing land in a way that maintains the life-supporting capacity, productivity, versatility and integrity of the soils and their ecosystems for present and future generations, and protects the cultural, scientific and amenity values associated with those resources.

Human use of the land has the potential to cause significant changes in the biological, chemical and physical characteristics of the soil over very short time periods. Some land uses have resulted in improved soil quality, while others have led to a decline in soil quality that may take many generations to recover. Since the soil conservation movement began in the 1940s there has been a progressive improvement in the level of awareness of soil conservation, and, more recently, in the development of good land management practices. Catchment Boards actively pursued on-the-ground measures to deal with erosion, for example destocking, fencing, windbreak planting and hill country erosion plantings. More recently, reduced levels of burning and improved stock management have contributed, in many areas, to a reduced risk of erosion resulting from human land use in the non-arable hill and high country lands.

The intensification of land use on the arable soils of the plains and downlands, and the loss of soil through wind and water erosion, has highlighted the need for more sustainable management of the soil system. For example, the use of fertilisers, irrigation and pasture phases in mixed cropping regimes has improved soil structure through the build-up of organic material. Increased use of no-tillage and minimum tillage techniques for arable farming have reduced exposure of the soil to wind and water erosion, as well as building up the soil organic matter and soil fauna, leading to improved soil structure and soil processes.

This chapter builds on past experience and promotes practices that have been successful in improving the management of the soil and its environment. The co-operation, knowledge and awareness of landholders is central to addressing soil conservation issues. The establishment of resource care groups, focusing on specific local issues, provides an effective network of support and experience. Environment Canterbury is keen to continue its participation with these groups, and promote and assist the formation of new groups. A comprehensive monitoring programme to track progress with soil quality will show how successful this approach has been to improve the management of soils.

A regional plan has a maximum life of 10 years before it has to be reviewed. Some of the outcomes sought through the objectives and policies in this chapter will require much longer periods of time for their achievement and will only be achieved in part within the first 10 years. Where appropriate, specific short-term targets have been identified that will contribute towards the achievement of these long-term outcomes.

This chapter also recognises that there are still gaps in the understanding of the sustainable management of the soils. Long-term outcomes provide time for further investigations and data collection and, with the accumulation of new information, time to identify and adopt more effective management approaches and techniques. No one group in the community holds all the knowledge about the sustainable management of soils. There needs to be a combining of ideas and expertise within the community, to explore new ways to achieve sustainable management of the land and to enhance the wellbeing of people and communities that comes from the land.

8.1.2 Purpose of the Soil conservation chapter

The purpose of this chapter is to:

(a) assist Environment Canterbury to implement its functions under the RMA to achieve the integrated management of natural and physical resources, and to manage the use of land for the purpose of soil conservation;

(b) achieve the objectives and implement the policies for soil conservation outlined in the Canterbury Regional Policy statement;

(c) identify and build on past experience and improvements in land management; and

(d) provide guidance to the community on the sustainable management of soil resources in the region.

8.2 Background

8.2.1 Why is it important to conserve our soils?

(a) soils and vegetation depend on each other - the condition of one ultimately determines the condition of the other. Vegetation provides organic matter and nutrients for recycling and provides protection from extremes of climate, and erosion by wind or water. Soil fertility is important to maintain vegetation vigour, productivity and resilience to natural and human induced stresses. A healthy and intact vegetation cover is the single most important factor in reducing the risk of erosion;

(b) in human time frames, soil is essentially a non-renewable resource. Lost organic content may take decades to recover. The inorganic component of the soil, including sand, silt and clays, formed by the weathering of the parent rock, if lost,can take thousands of years to reform;

(c) soil erosion will reduce soil depth and fertility, depriving future generations of a potential resource. Dust storms and land slips can cause damage to property and endanger human health and safety. Increased sediment levels in streams, resulting from erosion, can affect water quality, threaten instream habitats, increase the risk of flooding and adversely affect mahinga kai values;

(d) contamination of the soil by substances that are persistent and toxic will limit the availability of soils for production for many generations;

(e) soils contribute to the natural, physical and cultural values of the land, including its biodiversity, mauri and landscape values. Maintaining soil quality is important to protect these values;

(f) for Ngāi Tahu, protection of the mauri, or life-force, of the land is inextricably linked to protection of the life-supporting capacity of the soil; and

(g) the protection of soils is not just a conservation issue. For the Canterbury region, where agriculture is vital to the region's economy, soil conservation is basic to maintaining a healthy and sustainable economy.

8.2.2 Soils in the Canterbury region

Large areas of Canterbury were directly or indirectly affected by past glaciations. Therefore soils in most areas of Canterbury are likely be less than 20,000 years old. Most Canterbury soils are formed on parent material derived from greywacke rock. The distribution of soil parent material such as loess, alluvium, colluvium or raw greywacke combined with climatic and topographic influences and the age of the landform explains much of the broad pattern of soils in Canterbury. Other local geological influences such as the Banks Peninsula basalts and andesites, Mt Somers andesites and rhyolites, the tertiary mudstones, sandstones and limestones in parts of the hill country and hill country margins override the general pattern.

Landform components are the recognisable basic units of any landscape. These components include ridges, hill slopes, valley floors, fans and plains. Particular groupings of components produce distinctive landforms. The landforms and their location help determine some of the key soil properties due to the influence of soil parent material, soil age, climate, slope and original vegetation on soil processes and soil development.

At a broad level, Canterbury has four major landforms: the flat to undulating plains including the lowland basins[1]; rolling to strongly rolling downs generally below 500m altitude; the inland basins modified by the last glaciation; and the hill and mountain ranges. Within these major landforms, different levels of detailed landforms can be described, for example moraines and terraces within the inland basins.

8.2.2.1 Soils of the plains

The plains' soils are mostly formed from a layer of alluvium and/or loess over gravels. The depth and degree of stoniness of the fine material (mostly silt loams or stony silt loams to fine sandy loams or stony fine sandy loams) are two of the main factors influencing the pattern of soils on the plains. This can vary over very short distances and even within a paddock. Other influencing factors superimposed on the parent material include soil age and rainfall gradients. The high terraces of the plains are approximately 20,000 years old, intermediate terraces are 3,000 to 10,000 years old and low terraces and floodplains younger than this. The rainfall gradient gradually increases from the coast (c.600 mm mean annual rainfall) to the hills (c.1,000 mm mean annual rainfall).

The high terraces are found mostly on the western side of the plains so receive higher rainfall than soils further east. The soils on the high terraces are mostly shallow and stony, although deeper, recent loess derived soils are found in narrow strips on the south side of the major rivers. These deeper soils are some of Canterbury's most versatile soils: those that can produce the greatest output for the least input (Land Use Capability Class I and II). Patterns of shallow and stony, deep, and gleyed soils are found on the intermediate and low terraces and floodplains. Most plains' soils are free draining apart from the finer textured or gleyed soils found nearer the coast, where ground water levels approach or intrude into the soil profile.

According to the New Zealand Land Resource Inventory, approximately 25 percent of the plains' soils have little to slight limitations for arable use (LUC Class I and II), 40 percent have moderate limitations for arable use (LUC Class III), 30 percent have severe limitations for arable use (LUC Class IV) and five percent of the plains are regarded as unsuited for arable use (LUC Class V to VIII).

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[1] Includes Hakataramea, Amuri and Fairlie basins.

Soil structure of the drier plains' soils tends to be moderately developed friable crumb. These soils generally have low to moderate levels of organic matter. The combination of friability, moderate structure development, stony silt loam to stony fine sandy loam texture, free drainage, low organic matter levels and relatively low rainfall means that soil aggregate stability is vulnerable to decline with cultivation, resulting in smaller soil aggregate size and increased risk of wind erosion.

This same combination of soil properties means that soil compaction is not likely to be an extensive problem unless there is excessive weight loading when the soils are wet.

8.2.2.2 Soils of the downs

Soils on the downs are on a landform that is mostly gently rolling to moderately steep (8-25 degrees). A major feature of these soils is that they are mostly formed from loess deposited on the landscape during and soon after the last glaciation. Downs soils are mostly found near the coast between the Conway and Waipara Rivers in North Canterbury and between Timaru and Waimate in South Canterbury. Some areas of North Canterbury downs soils are formed from tertiary sediments as well as loess.

There is a distinct rainfall gradient from the coast to the foothills on the South Canterbury downlands. The drier coastal downland soils have a distinctive, compacted fragipan layer at approximately 50cm depth. As the rainfall increases inland this fragipan become less distinct and the soils become more friable, with more developed structures, yellowish-brown subsoils and lower nutrient content (Molloy, 1998). The topsoil structure of these soils is mostly weakly to moderately developed, especially on the drier eastern soils. These soils can be structurally unstable and are prone to wind and rill erosion when cultivated, especially if organic matter levels are low. Some loess is easily dispersed when wet resulting in tunnel gully erosion, especially if the surface is bared or cracked.

8.2.2.3 Soils of the inland basins

The inland basins as typified by the Ashburton and Mackenzie basins are infilled with sedimentary and glacial deposits dating from the Pleistocene (2 million years ago) to the last glaciation (15,000 years ago)[2]. The results of ice advances and recessions have developed four distinct landforms of moraines, terraces and floodplains, fans and wetlands. These are most strongly developed in the Mackenzie basin, but are found to varying degrees in the other inland basins. The moraines are mantled with loess of variable thickness. Older terraces also have a mantle of loess, whereas the intermediate terraces, which comprise the most extensive area of flat land in the Mackenzie basin, are formed from gravels with varying depths of sandy alluvium. Most soils on this surface are shallow and stony. The young terraces and wetlands mostly occur as narrow strips in the major valleys and can have a complex pattern of deep to stony soils and varying from excessively drained to poorly drained. Fans occur around parts of the basins and have similar patterns of soil parent material to the terrace soils with which they are associated.

The inland basins have a sub-continental climate, especially away from the western ranges. For example, the Mackenzie basin is dry in the south and east and moist in the north and west, with warm to hot summers and cold winters, and a high probability of strong westerly winds, especially during the equinox. The soil pattern is related mainly to climatic zonation and landforms in the Mackenzie basin, and these factors will have similar influences in the other smaller, inland basins.

The soils of the inland basins, therefore, have a wide range of properties resulting in a wide range of land-use production potentials and limitations to use. The perception of the Mackenzie basin as a degraded landscape is mainly applicable to some soils on

[2] Webb, T.H. 1992. *Soils of the Upper Waitaki Basin, South Island, New Zealand*. DSIR Land Resources Scientific Report No.3, 1992.

intermediate terraces (about 50 percent of the upper Waitaki basin according to Webb, 1992). These soils, which are shallow, infertile and suffer moisture deficits, consequently, have weak plant cover and are prone to wind erosion and rabbit infestation. However, about 25 percent of the upper Waitaki basin has moderately deep and fertile soils which are suitable for more intensive development, particularly with irrigation (Webb, 1992), and have much lower susceptibility to erosion, degradation and rabbit infestation.

8.2.2.4 Soils of the hill and high country

The one common factor about the soils of the hill and high country is that they are developed on slopes normally greater than 20 degrees. Forty percent of the Canterbury region is hill and high country and is associated with the numerous ranges found throughout the region. Hill country tends to be lower and less steep than high country..

As with soils in the other landforms, the actual soil pattern is governed by the five soil forming factors of climate (especially precipitation and temperature), soil parent material, original vegetation, soil age as well as topography. The end result is a complex myriad of soils in this landform.

Potential for plant growth, and consequently associated ground cover, tends to increase with increasing rainfall and increasing temperature. Ground cover is more likely to be incomplete on soils receiving less than 600-800 mm annual rainfall or at altitudes greater than 900 metres. Lack of ground cover creates a risk of surface soil erosion, especially on steeper slopes.

Natural soil fertility (particularly plant available phosphorus) tends to decline with increasing rainfall while sulphur and nitrogen are generally at low natural levels over all this landform. Fertiliser inputs will be required on pastoral and multi-rotational plantation land to maintain a healthy and productive vegetation cover.

Unconsolidated soil parent material and underlying regolith, especially when deep and fine, is prone to mass movement slope failure following heavy rain when soil pore water pressure reduces the strength of the parent material or the regolith. Deep-rooted vegetation increases regolith stability compared to shallow rooted vegetation but slope failure can still occur naturally with prolonged or intense rainfall.

8.2.3 An integrated approach to soil conservation

Soils cannot be managed in isolation from the rest of their environment. Their life-supporting capacity is dependent on soil quality, which in turn is dependent on the health of the plants, animals and other biota associated with the soil. An integrated approach to soil conservation takes these elements into account by promoting land management practices that reflect the physical and ecological capabilities of their environment.

The Canterbury region can be divided into groups of environments that share a particular combination of climate and landforms, where soils and vegetation are likely to respond in a similar way to natural stresses and human disturbances. Within each of these groups it is recognised that there will still be local variations in climate, geology and vegetation that may influence the specific management requirements for soil conservation.

Eight soil environment groups have been defined for the Canterbury region:

High country – moist mountain ranges	Hard rock hill country
High country – dry mountain ranges	Kaikoura coastal zone
Inland basins and major river valleys	Banks Peninsula
Soft rock hill country	Canterbury plains

Figures SCN1.1 and SCN1.2 show the distribution of these groups within the Canterbury region.

Figure SCN1.1 Distribution of soil environment groups in Canterbury – northern region

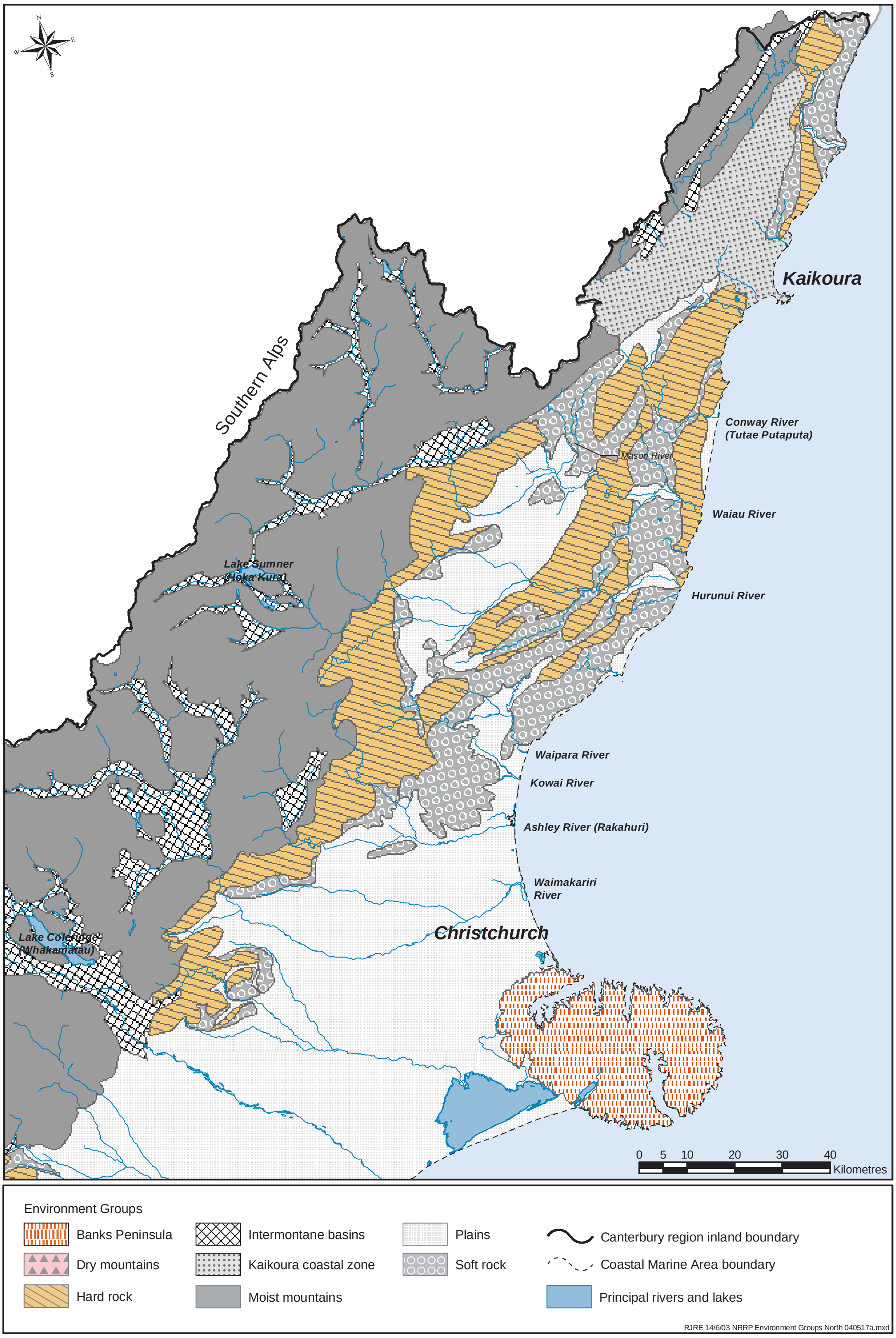

Figure SCN1.2 Distribution of soil environment groups in Canterbury – southern region