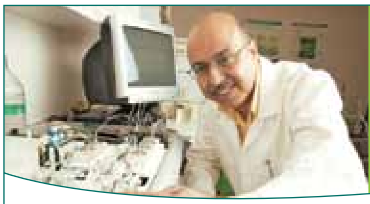

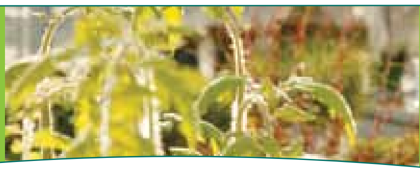



# THE SCIENCE OF SOILS
# Managing our soils in a changing climate

*This fact sheet discusses the potential impact of a changing climate on New Zealand's soils under agricultural production.*

### CLIMATE PROJECTIONS FOR NEW ZEALAND

- By the end of this century the whole of New Zealand is predicted to be warmer by around 2°C.
- Rainfall patterns are projected to become drier in the east and wetter in the west.
- The country will experience more variability in weather events such as severe storms, flooding and droughts.
- More easterly winds are expected in summer, except for Otago and Southland, and also more westerly winds in winter, except in Northland.

### HANDY HINTS FOR MANAGING SOILS

- Where possible, use minimum or conservation tillage practices.
- Look at ways to improve soil organic matter and soil carbon.
- Reduce wind erosion by planting shelter, avoid overworking soil, maintain a vegetative cover and consider strip cropping techniques.
- Update soil conservation and land management plans to accommodate greater variability in weather events such as severe storms, flooding and droughts.
- Be aware of areas susceptible to flooding and have a plan in place to deal with these events.
- Keep drains cleaned and if soils do become wet, have a plan to remove livestock and keep machinery off to avoid damage.

## HOW MIGHT CLIMATE CHANGE AFFECT OUR SOILS?

Soils serve as a medium to physically anchor plants, support livestock, provide a source of water and nutrients, and regulate emissions to air and water. Soils support an extensive biological system that is involved in aerating the soil and cycling nutrients and organic matter.

Erosion from wind and rain is likely to reduce the natural capital of our soils by removing topsoil (along with its nutrients and organic matter) and exposing subsoils. Typically, subsoils are a much poorer environment for plants to grow in and may be even more susceptible to wind and water erosion than topsoils. Areas that receive the eroded materials will suffer down-stream effects such as crop spoilage, coverage and sealing of topsoils, and pollution of surface waterways.

In dry areas or regions experiencing severe droughts, soil structure and productivity may fall as soils dry, crack and become hard to re-wet. In areas where high or extreme rainfall is projected, soils will come under greater risk from erosion. Soils may suffer from surface flooding and water logging, more frequent drainage and leaching events, and become damaged from compaction due to livestock or machinery use.

Soil biological activity is also sensitive to changes in soil moisture levels. Warmer temperatures could mean greater mineralization and mobility of nutrients like N, P and S. In extreme situations this may lessen the amounts stored in soil organic matter but in other cases, may be compensated for by greater plant productivity from the increased nutrient cycling within the soil.

## SOIL ORGANIC MATTER AND CARBON SEQUESTRATION

There is a strong link between soil organic matter and soil carbon.

At present, knowledge about the effect of climate change on soil organic matter is uncertain, and may well vary in different parts of the world (Lal 2004). The key to understanding what long-term changes will occur as a consequence of climate change will be through knowledge of the changes in balance between inputs and outputs from systems.

Soils are both a source and store of carbon. Much of the carbon in soils is within soil aggregates and protected from breakdown.

By increasing the amount of organic matter and carbon in the soil, land managers can benefit from:

- Increased water holding capacity and infiltration rates.
- Improved water quality in run-off and leaching.
- Improved soil structure and less erosion.
- Greater ability to cope with compaction.
- Improved nutrient cycling and cation exchange rates.
- More soil micro flora and fauna.
- Greater pesticide degradation capacity.

Some of the management practices available for increasing organic matter and soil carbon include:

- Reducing tillage.
- Increasing plant productivity and the amount of plant residues, composts and manures added to the soil.
- Increasing the amount and duration of crop cover.
- Improving grassland management.
- Restoring degraded lands.
- Planting trees.
- Appropriate fertilizer and lime inputs to lift plant production.
- Improving water management and irrigation efficiency.
- Using appropriate animal and plant species.

## ADAPTING SOIL MANAGEMENT ON-FARM

### 1. MINIMUM TILLAGE

Minimum or conservation tillage helps to maintain a protective cover of organic material on the soil surface and to minimise disruption to the soil's pore architecture. These changes help to maximise infiltration and retention of rainfall. In turn, these benefits reduce the risk of overland flow, sedimentation and can improve surface water quality and biodiversity.

In some methods of tillage only one trip across the field is required to plant a crop, resulting in significant savings of time, labour, machine wear and fuel. Studies have found large increases in soil organic carbon using conservation tillage techniques in soils with depleted soil carbon levels. Generally, carbon increases are most noticeable in less well developed soils that have little organic matter to start with. The same applies for carbon losses when old grassland or minimally tilled soils are cultivated for cropping – light textured soils lose their carbon faster than heavy textured soils like clays.

Strip tillage.

Cloddy surface at work.

### 2. REDUCING WIND EROSION THROUGH SHELTER

Projected wind changes for New Zealand indicate that mean westerly flows in winter are likely to increase in all regions except Northland. This may create the potential for greater wind erosion during cultivation prior to spring crop sowing. If minimum tillage is not a feasible option and traditional cultivation methods are used, then fine cultivation should be left until it is absolutely necessary and other management practices considered.

Once wind reaches a critical speed, called the threshold velocity, erosion begins. This speed is not necessarily high and for many soils, the critical wind speed is only about 20–25km/hr. Above this threshold velocity, a doubling of wind speed causes eight times more soil movement.

Because of the effect that wind has on soil erosion, any reduction made in wind speed can have a dramatic effect. Shelterbelts can give protection for horizontal distance about ten times their height. Therefore a five-metre-high shelterbelt protects about 50 metres of ground. Shelterbelts should be continuous and not too dense – about 50 percent permeability is best. A solid barrier will cause wind to eddy and may actually increase local wind speeds and erosion downwind.

### 3. CONTROLLING SOIL CONDITIONS

Try and leave a rubbly surface when working a soil and avoid overworking, as a reduction in the average aggregate size increases the risk of soil movement. A rubbly surface increases the threshold speed for wind erosion, protects and traps smaller particles and reduces saltation. Saltation is the movement of fine soil particles, usually caused by wind, where the soil particles "bounce" and collide with one another.

*"Strip cropping can be especially effective if strips of fast growing crops like maize or oats can be established in fields of more sensitive crops like asparagus or squash." Jeff Reid, Plant & Food Research, Hastings*

Increasing surface roughness by ridging also slows wind speed at the surface and can therefore reduce erosion. Aim to create ridges of soil 50–100mm high, if possible at right angles to the prevailing wind direction. Don't have these ridges higher than 100mm as this exposes them and can actually increase erosion.

Growers sometimes irrigate during a wind erosion event, hoping this will control the erosion. This is ineffective for two main reasons:

- Once the wind is fast enough to initiate erosion it is generally impossible to apply sufficient water to settle the soils.
- Water droplets can destroy dry soil aggregates triggering saltation and then wind erosion.

While moist soils blow less easily than dry, water must be applied while the soil is still moist. Even so, wind will rapidly dry the soil surface. Moisture management alone is insufficient to control wind erosion.

### 4. MAINTAINING VEGETATIVE COVER

Vegetative cover (either alive or dead) is one of the best methods for effectively controlling erosion. Update soil conservation and land management plans to accommodate greater variability in weather events such as severe storms, flooding and droughts.

Vegetation protects the soil surface and holds soil together increasing the threshold wind speed, and trapping moving particles. It needs to be well attached to the soil and a minimum of 20 percent cover is required to be effective.

The greater the amount of vegetation, the greater the protection. However, plant residue may reduce germination of seeds and create problems with pests such as slugs. These can be controlled with baits or stock treading.

Table 1 shows how the required width of cultivated soil strips for wind erosion control varies with soil type. The table highlights the vulnerability of light and coarse textured soils. Because soil movement accumulates across a field, losses increase as field width increases. Typical paddock widths in New Zealand are in the 200–400 metre range. Creating narrow "isolated" fields with shelterbelts and/or grass borders will help control saltation and hence minimise erosion.

Strip cropping, strip cultivating or using "trap strips" of stiff upright vegetation to reduce local wind speeds and catch and hold saltating particles are other techniques to minimise erosion.

## Key points

1. **New Zealand soils are likely to be affected by warmer temperatures, changes in seasonal rainfall and wind, and more severe events such as floods and droughts.**
2. **Minimum or reduced tillage is a good soil management practice to maintain or improve soil health.**
3. **Reducing the risk from wind erosion will become increasingly important as some regions will be drier and windier.**
4. **A range of management practices such as shelter, controlling soil condition, vegetative cover and trap strips can be used to reduce the risk of wind erosion.**
5. **Higher rainfall in some areas, coupled with high energy storms, will increase the risk of soil erosion and droughts will increase the danger of loss of vegetative cover.**
6. **Artificial drainage, investment in flood protection, keeping livestock and machinery off wet soils, and provision of loafing areas for cattle are possible management strategies to minimise damage to wet soils.**

**TABLE 1: MAXIMUM WIDTH OF CULTIVATED SOILS FOR WINDS OVER 65 KM/HR (FROM THE HAWKE'S BAY REGIONAL COUNCIL'S *ENVIRONMENT TOPICS FACT SHEET* ON WIND EROSION AND CONTROL)**

| SOIL TEXTURE CLASS | MAX STRIP WIDTH (m) |
|---|---|
| Sand | 6 |
| Loamy sand | 8 |
| Sandy loam | 30 |
| Silty clay | 50 |
| Loam | 75 |
| Clay loam | 100 |

## FOR MORE INFORMATION

- For more information on climate change projections for New Zealand visit the NIWA website: **www.niwa.co.nz/our-science/climate**
- For more information on soils read the Hawke's Bay Regional Council's *Environment Topics Fact Sheets* – a range of topics relating to soil management such as flood protection, wind erosion, minimum tillage to shelter planting and more: **www.hbrc.govt.nz**

*Erosion from wind and rain is likely to reduce the quality of our soils by removing topsoil (along with its nutrients and organic matter) and exposing subsoils.*

**5. REDUCE THE RISK FROM FLOODING**

Floodwaters can deposit large volumes of material onto fertile soils. Flood wash containing subsoil deposits material with little or no organic matter and very low in plant nutrients. Transported topsoil can cover and seal the soil surface, in addition to spoiling forages and crops. Furthermore, transported topsoil and subsoil can be major polluters of surface waterways.

Reducing the impact of major rainfall and flood events is going to be very important in the future. Farmers can also adjust their management practices to minimise the risk of local sources of flooding by reducing compact areas within their fields, often the source of surface run-off.

Research by Paul Johnstone of Plant & Food Research suggests that local run-off and sedimentation can be greatly reduced by the creation of simple furrow dykes. An added advantage of minimising local run-off is that it reduces the chances of substantial patches of pastures and crops being waterlogged and losing yield.

Some other maintenance ideas to consider are:

- Maintenance of drainage systems to make sure they are clear of any debris that may cause blockages and lead to flooding.
- Catchment management for soil conservation so that soil is not exposed and able to erode.
- Flood control design systems which allow for future adaptation to deal with changes.
- Increase the infiltration rates so that local sources of run-off are minimised. Avoid keeping the soil surface bare or in a badly compacted or pugged condition. This can include tractor tracks or furrows on sloping land.
- Installing drainage may be a worthwhile investment in areas that are prone to surface flooding.
- Keep livestock and machinery off wet soils to avoid compaction and soil damage. On farms, provision of loafing areas for stock may prevent soil damage, and the ability to store dairy effluent may relieve the need to irrigate already wet soils and risk leaching of nutrients.

Retention of vegetative cover (either alive or dead) is one of the best methods for effectively controlling erosion.

**THIS IS ONE IN A SERIES OF FACT SHEETS CALLED *ADAPTING TO A CHANGING CLIMATE* FOUND AT WWW.MAF.GOVT.NZ/CLIMATECHANGE**

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