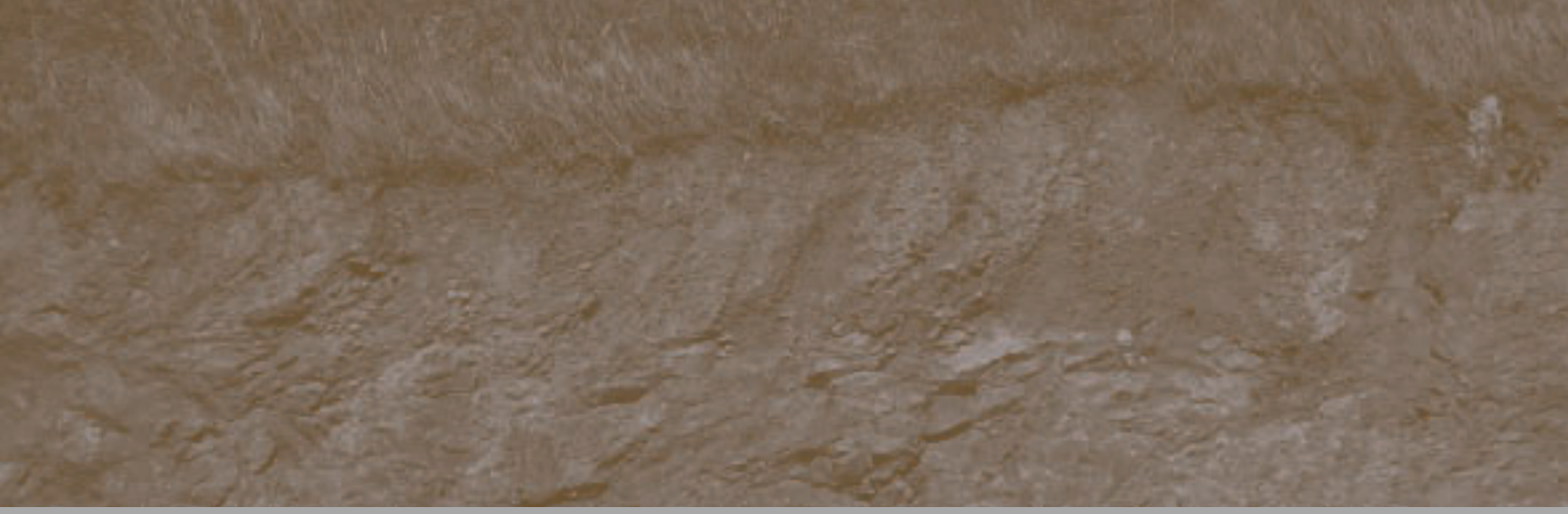
Soils



Objectives

1. The soils in the Wellington region maintain those desirable physical, chemical, and biological characteristics, which enable them to retain their life supporting capacity and to sustain plant growth.

2. Land degradation is limited to that for which there is no feasible remedy.

Doing well

- About one third of the soil sites tested in the region have good soil quality.
- Over 98 per cent of the region's soil is 'intact' – meaning it is not currently eroding.
- Background levels of heavy metals in soils are within the range expected for uncontaminated soil.

Must improve

- Sixty per cent of erosion-prone land (140,000 hectares) has no woody vegetation.

Earthly wealth

Soils are crucial to life on Earth. Without them, most of the world's plants could not have evolved. They are the foundation of all terrestrial food chains and ecosystem health and are a more complex phenomenon than people might first realise. A healthy soil is more than just dirt or mud – it contains air, water and organic matter, formed over eons by climate and geology.

The region's soils are vital to our economic wealth, so Greater Wellington aims to conserve and protect soils by controlling the way we treat them. In this chapter, we look at if, and how, we are meeting those objectives.

Soil quality

Anyone with a veggie patch knows the value of good soil, which rewards good management with years of healthy harvests. Greater Wellington aims to mimic that notion on a regional scale, preserving soils so they go on sustaining the plant growth and animal productivity we need to live.

Soil quality is a relative notion and we can say that, at best, it describes how well a particular soil stacks-up with an intended land use. Growing grapes for example, doesn't require soils of high quality – some of the region's best wine is grown on soils that would be described as having moderate to low quality.

Only about one per cent of the region's soil might be regarded as high quality – mostly found in and around Otaki. Between one and four per cent of the Wellington region is made up of soils of moderate quality – meaning they need some fertiliser to maintain productivity – while the remainder is quite poor.

This is a typical soil-profile found in many western parts of the region – greywacke rock overlain by yellow-brown (loess) siltstone with pasture. The greywacke is highly fractured and broken. The loess – a clayey silt blown in during last Ice Age – sits on top. The break between the two represents a geological time gap of some 200 million years. The loess has moderate to low quality.

Where we are now

Soil quality monitoring

In the last *Measuring up* in 1999, we said that Greater Wellington lacked up-to-date information on soil quality in the region. Since then, we have started surveying our soils. The first foray into soil monitoring was when Greater Wellington joined the *500 Soils Project* – a Ministry for the Environment, Landcare Research, and Crop and Food Research, led initiative. This nationwide project has now finished, but Greater Wellington has continued doing soil tests using the same monitoring criteria developed by the project. Under *500 Soils* Greater Wellington monitored 50 soil sites, and since the project finished in 2001, has added another 67 monitoring sites.

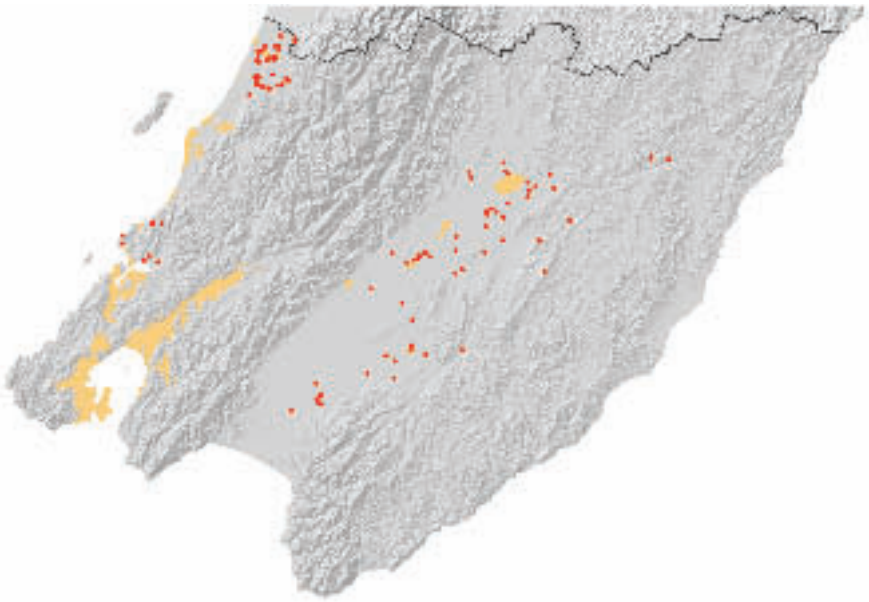


Figure 3.1:
These are the sites where we have checked soil quality. But 117 soil sampling sites in a region of 8,136 square kilometres (or 813,600 ha) only gives us pinpoints of information about soil quality. The sampling programme assesses how different soil types are coping under different land uses.

We tested for soil quality against three main criteria: physical, chemical and biological properties. The physical criteria measure – structure, density and porosity. The chemical criteria measure – pH (is the measure of a soils acidity or alkalinity), carbon and nitrogen contents. And finally biological criteria measure the organic content of a soil. Data were sorted according to land use and soil type, and soil quality indicators were compared against a standard target scale. Analysis gave a comparison of soil quality in the Wellington region with the rest of the country.

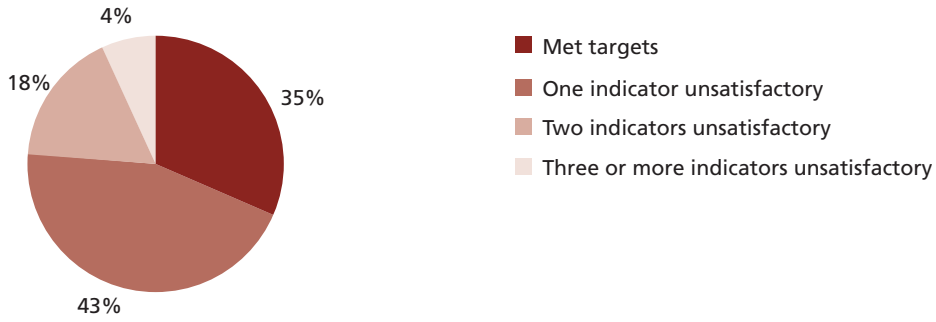


Figure 3.2:
Thirty-five per cent (40 sampling sites) met all soil quality targets. A further forty three per cent (50 sampling sites) had one indicator that failed to meet the target range. Eighteen per cent (21 sampling sites) failed on two indicators, while just four per cent (four sampling sites) failed on more than two indicators.

A closer look at the soil quality target indicators is shown in Figure 3.3. Soil compaction (the compressing of soil particles by heavy machinery or heavy hoofed stock) was the most common reason for a site not meeting its soil quality target (41 per cent of sites sampled). Higher fertility measured by Olsen-P (means the soil has excessive plant available phosphate) occurred on 24 per cent of the sites samples. The fertility levels on these pastures were well in excess of the amounts needed for maximum agronomic benefit.

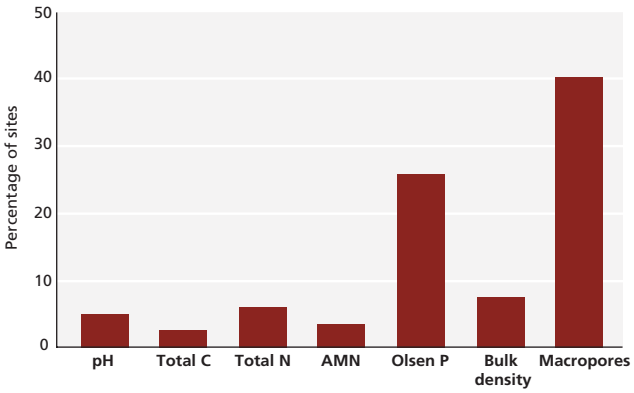


Figure 3.3: Proportion of sites not meeting target ranges for seven key soil quality indicators.

Sampling sites on cropping land showed low levels of aggregate stability, high Olsen–P, and low bulk density. This suggests the soil is over-cultivated with high rates of fertiliser application. The soil may be subject to further wind erosion if left fallow at different windy times of the year.

The proportion of sites that met soil quality targets in the region (35 per cent) was slightly greater compared with the proportion in other parts of New Zealand (32 per cent). This proportion is affected by the sites that are chosen for sampling. If other regions sampled more 'at risk' sites (these are sites known to be under stress from different land uses) then it is likely that a greater proportion would not meet the soil quality targets.

Weaknesses found in the Wellington region were reflected elsewhere, suggesting most regions are experiencing similar problems. The most common concern, soil compaction, afflicted 41 per cent of Wellington sites. Soil compaction is a problem because it reduces the air spaces (termed macroporosity) in a soil and so inhibits water (and nutrients) getting into the lower soil profile. As a consequence, overland flow can increase and there is less recharge of shallow groundwater. Soil compaction can be caused by continuous tracking of heavy machinery or from heavy hoofed stock standing in one

area for long periods. Research has found that if macroporosities get below 10 per cent, pasture production is hindered. Pastoralism is the largest single land use in the region, so any loss of pastoral soil quality has major implications.

Soil compaction was often coupled with very high fertility – well above optimum production levels. By putting so much fertiliser on the soil, farmers can eventually harm the water quality of shallow groundwater aquifers, while rain washes excess nutrients into streams where they exacerbate weed growth (see **Freshwater**).

Figures 3.4, 3.5, and 3.6 show the soil quality data for the three major land uses in the region; pastures, plantation forestry, cropping and horticulture. The seven soil quality indicators are shown for each land class.

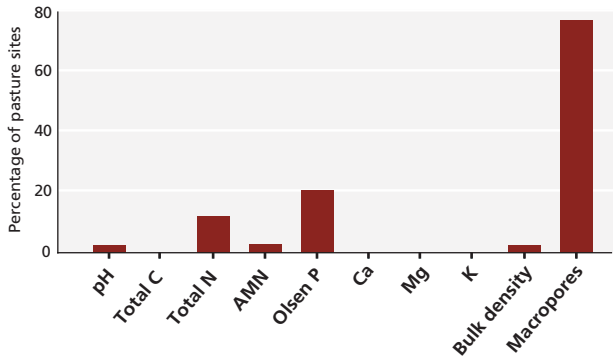


Figure 3.4:
Compaction (lack of macropores) is the biggest problem in pasture sites sampled. Over 70 per cent of sites showed moderate levels of compaction.

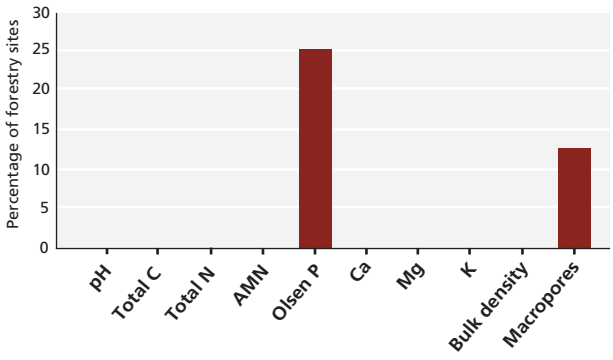


Figure 3.5:
Under plantation forests we found higher than usual levels of Olsen-P. We are not entirely sure why this should be, but it could be due to the previous land use – pasture.

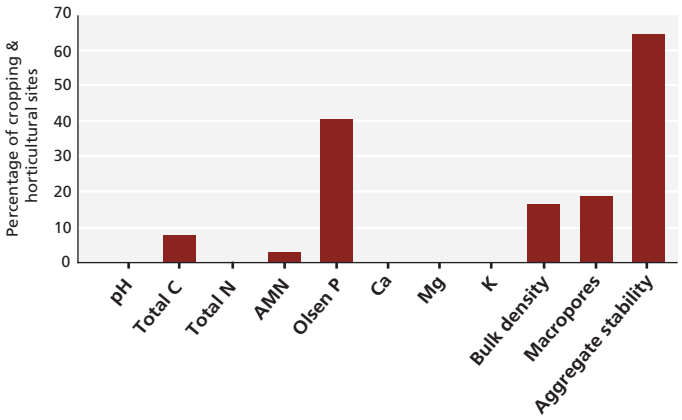


Figure 3.6:
High Olsen-P, low levels of bulk density, and very high aggregate stability (means the soil is too friable and won't hold together), were all issues for soils under cropping and horticulture.

Heavy metals in our soils

Heavy metals are found naturally in soils. Normally they occur at such low concentrations that they pose no threat to human health, but there are a few exceptions. Upper North Island volcanic soils are high in heavy metals – in the Auckland isthmus, nickel is present at levels that exceed current Australia and New Zealand Environment Conservation Council (ANZECC) guidelines.

There is some evidence that past intensive land use in parts of the Hutt Valley and Wellington city may have left them abnormally high in heavy metals. Copper, for example, was used extensively in orchard sprays, and this might be still present in Hutt Valley soils.

Greater Wellington checked heavy metal concentrations in the region's main soil groups in 2003. We found background concentrations of heavy metals in all five groups were very low compared with others around New Zealand, and all met health guidelines.

High levels of cadmium were found in dairy pasture, with slightly lower concentrations in drystock soils – probably from phosphate fertilisers – but these were still within human health guidelines.

Pressures on soil quality

Urban expansion and inappropriate land use are the main pressures on soil quality in the region. Urban development in particular has an irreversible effect, because it removes soil and locks up the land under buildings, roads, and other hard surfaces.

Sealed off this way, the soil is denied vital rainwater and cannot function as it should. The Hutt Valley was once very fertile and nourished a thriving patchwork of market gardens, but those rich soils have vanished beneath the urban landscape we see today.

Also under threat are the high quality soils around Otaki, Te Horo, Masterton and Carterton. These are the last naturally fertile soils in the region, but urban expansion could see them lost (see the Built Environment chapter for more information on the pressures from subdivision).

Poor farming practices can sap the soil quality of good productive land. Left unchecked, over-stocking and over-cultivation can damage soil structure, lowering crop yields and pasture growth and aggravating erosion.

Most of us assume that planting trees helps to stabilise soils and protects them from erosion. This is true to a certain extent, but trees – especially pine plantations – can alter the nitrogen and phosphorous levels in soils, and logging brings a greater risk of erosion, sometimes cancelling out the benefits from planting in the first place. Unless logging is done with care, silt can run into watercourses (see the Freshwater chapter for more information about freshwater streams in the region).

What's being done

Greater Wellington is not doing any soil quality protection work in the region, but will keep monitoring soil quality. Re-sampling is needed at least three – and preferably five – times for long-term detection and prediction of soil trends. This sampling will be extended to soils under scrub – an important land cover in our region.

Soil conservation

Soil conservation is all about managing land use to prevent erosion and soil loss. Erosion happens for all sorts of reasons; there are natural causes like heavy rain and flooding leading to slips, and there are human ones like over-grazing and poorly managed earthworks.

Earthworks can produce vast amounts of sediment. If allowed to run into waterways, this sediment robs fish and invertebrates of a vital habitat. Sediments eventually settle out into low-energy environments like lakes, wetlands and coastal estuaries, smothering habitat for fish and other marine life (see **Freshwater**). Objective two aims to protect land from further erosion.

Where we are now

Figure 3.7 summarises the results of a Greater Wellington study into soil impacts from different land uses and natural events. On stable land (see first circle of Figure 3.7) about 45 per cent (366,120 ha) of the region has 'intact', soils – meaning the soil has a cover – pasture or bush. Of these intact soils, 7 per cent (56,950 ha) has been disturbed in some way or another – cultivation and harvesting, grazing pressure, logging, roads, drainage and pond excavations. The actual percentage of bare soil on stable land is only 0.6 per cent (4,880 ha) of the region's area.

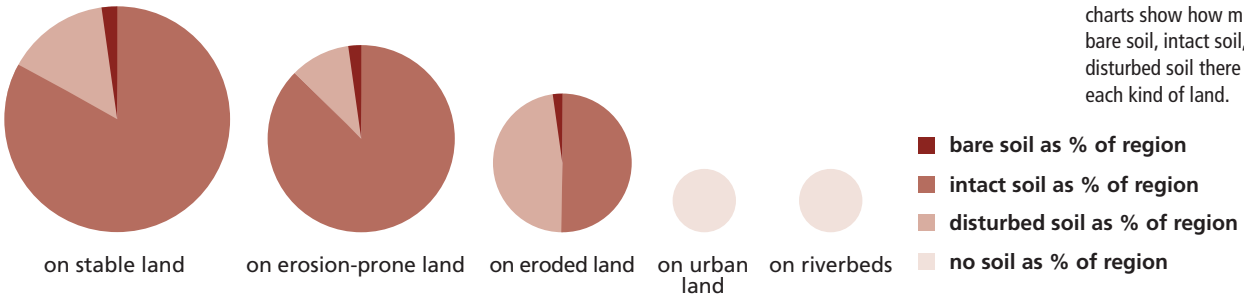


Figure 3.7:
These proportional pie charts show how much bare soil, intact soil, and disturbed soil there is on each kind of land.

We can say about 31 per cent (252,200 ha) of the region has erosion-prone land and that is currently stable. Of the 31 per cent, about 27 per cent (219,600 ha) contains intact soils, and only 4 per cent (32,500 ha) contains soil disturbed by land uses. The actual percentage of exposed soil is 0.4 per cent (3,250) of the region.

About 18 per cent of the region is eroded land that bears landslides, scouring of streambanks, sand blowouts in coastal areas, rockfalls, and recent scree slopes. We can see that about 9 per cent (73,000 ha) of it is now recovering, which means erosion scars have started to revegetate. The other 9 per cent (73,000 ha) has fresh scars interspersed with natural or modified plant cover. Only 0.4 per cent (3,250 ha) of eroded land is actually bare soil.

So what do these figures tell us about the state of the intactness of our land? About 1.4 per cent (11,390 ha) of the region's soil is currently bare enough to be in need soil conservation measures. Of this percentage, 0.4 per cent (7,300 ha) has been caused by poor management, and the remaining 0.4 per cent (3,250 ha) is caused by exposure to natural forces.

Pressures on soil conservation

Greater Wellington uses indicators to estimate how much bare land – under various land uses – is susceptible to erosion and soil loss, thus allowing for future comparisons. We can say the larger the area of exposed ground, the greater the risk of erosion.

Figure 3.8 shows the proportion of bare land under different land covers. To see whether any pressures can be influenced or controlled, it's helpful to split survey results into land under conservation use (natural cover), and land under rural use (mostly human development). Within each, there are estimates of the proportion of bare soil from natural and human influences.

Figure 3.8 shows, that 37 per cent (310,000 ha) of the region is under natural cover – forest, scrub and mountain vegetation – or semi-natural cover such as exotic scrub, coastal vegetation or wetland. Almost all of this land is considered intact. Just 0.1 per cent (800 ha) has been bared by human activities such as scrub clearance or roading, while a further 0.2 per cent (1600 ha) has been exposed by natural erosion processes like slips.

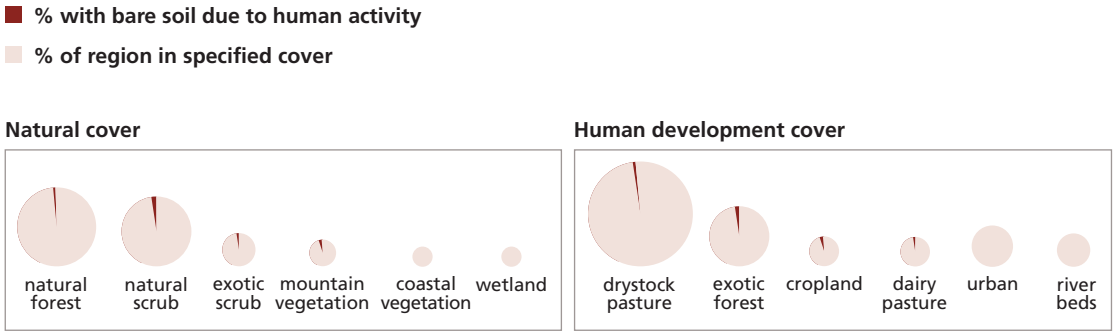


Figure 3.8: Proportions of bare soil under different land covers in the region.

Fifty seven per cent (463,750 ha) of the region is under some form of human-made land cover, mostly cropland, dairy and drystock pasture, and exotic forest. Of this, 0.8 per cent (6,500 ha) has been exposed to weathering effects by human activities, such as cultivation, livestock grazing, roads and tracks. Nearly three quarters of bare ground comes from just one land use - drystock pasture. Natural erosion bares another 0.2 per cent, again mostly in drystock pasture. The remaining 6 per cent of the region is covered by urban areas, river beds, and roads.

What do these figures tell us about the pressures on our land? Human activity currently exposes about 0.9 per cent (7,300 ha) of the region's land. Only 0.1 per cent of this occurs in natural covered land, where control is unnecessary or difficult – the remaining 0.8 per cent is on modified land where damage can be reversed by changes in management. Natural erosion exposes 0.4 per cent of our region's land – half of it in mountainous areas where control is not needed. The remainder occurs on farmland and forest plantations, where land management controls are necessary to remedy any erosion.

What's being done

We can let degraded soils heal naturally by leaving hillsides to revegetate, or we can use better pasture management and tree plantings. Responses differ from one land use to the next. The best remedy in dairy pastures, for instance, could be better cultivation and grazing practices – on drystock pasture, there might be some return to natural cover and changes to grazing management. Within the region, the most common strategy, however, is to plant trees with assistance from Greater Wellington.

Conservation planting programmes have been under way for some years now, targeting erosion-prone farm land in consultation with landowners. Figure 3.9 shows the extent of conservation cover on stable land – that is, vegetation dense enough to protect soil from exposure by land use. Cover is generally dense (lighter in the pie graphs below) in dairy and drystock pasture. One area of concern is the amount of sparse cover – freshly cultivated fields and emerging crops (darker in the pie graphs below) – on cropping and horticultural land. Another is the sparse cover in exotic forest plantations – harvest sites and recent plantings with no closed canopy. In native forest, scrub and tussock, sparse cover isn't a concern.

Figure 3.9:
The density of vegetative cover on stable land in the region.

Despite high soil exposure, there is little risk of erosion on cropping land as most of the land is low-lying and soil is only exposed for short periods. If left for any longer, however, high wind will increase that risk. A 1984 survey found that roughly 88,532 hectares of Wairarapa plains land was at risk from wind erosion. To counter this, Greater Wellington began a shelterbelt scheme to protect arable land. A total of 217.6 kilometres of shelterbelt shelter has so far been planted on 110 farms, protecting 15,028 hectares, or 17 per cent, of vulnerable soils.

Figure 3.10 shows the extent of conservation cover on unstable land. Unstable drystock farming and plantation forestry land covers 29 per cent of the region (235,940 ha). Grass does little to stabilise soil against erosion in these areas, whereas the deeper roots of woody vegetation hold soil longer.

By measuring the proportion of woody vegetation on different land uses, we can see where planting is needed. Forty per cent of drystock pasture on unstable land contains woody vegetation – half of it from natural regeneration. The other half comes from Greater Wellington conservation plantings. Eighty per cent of plantation forestry has woody vegetation on unstable land. Most are private plantings, though Greater Wellington funds about 4,000 ha of conservation woodlots or conservation forests. The remainder shows sparse natural reversion in canopy gaps, or young tree plantations that haven't yet closed over.

Dairying and cropping have woody conservation cover on half or less of their unstable land, which makes up 0.6 per cent of the region. Native forest, scrub and tussock on unstable land are a much larger part of the region – 37 per cent. Fortunately, more than three-quarters of it is covered in woody vegetation offering good protection from erosion.

Figure 3.10: The density of vegetative cover on unstable land in the region.

In summary, natural regeneration and private - and Greater Wellington-funded tree planting have adequately covered two-fifths of unstable land in drystock pasture, and about four-fifths of unstable land in plantation forest. Nevertheless more plantings are needed, particularly on drystock pasture.

Prospects for soil conservation

A typical erosion scene in the Wairarapa hill country – removal of the original cover has allowed water penetration into the lower soil layers accelerating the production of shallow slip movements like this one. The topsoil has been transported to the base of the slip and left as a humpy deposit. The slip scar will eventually heal, but will take many decades. Slips and scars reduce the production potential of the land, and result in loss of income for the land owner.

Human-induced erosion can be avoided by ensuring appropriate, compatible land use, but there will always be some natural erosion no matter how much cover the land has. Through policies and methods in the Regional Policy Statement, earthworks and vegetation clearance consents, farm conservation plans and assisted tree-planting, retirement fencing and pest control, we are gradually meeting objective two. There is still scope, however, for much more conservation cover on drystock pasture in the region's hill country.

One perceived problem with restoring land to its former state – or at least to a state acceptable to land users – is the time it takes. Recent work by Greater Wellington highlighted the issue of short-term views and reporting intervals that rarely fit comfortably with nature's more expansive timetable.

Greater Wellington needs to persevere with soil objectives over the long term. There is still work to do if we're to ensure that land management practices are sustainable across all uses.

More information

Denton, Paul, 2005. *Soils and minerals – background report*. Greater Wellington.