Case Study 16: The Upper Kaituna Catchment Control Scheme: has riparian retirement been successful?

The Upper Kaituna Catchment Control Scheme was developed in the late 1970s to arrest the deteriorating water quality of Lakes Rotorua and Rotoiti, and to do it in part by controlling and preventing soil erosion, sedimentation and nutrient runoff from the surrounding catchment. The other part of the scheme was to reduce the sewage load from Rotorua City entering the lake.

Understanding the problem

Over the 50 years leading up to 1990 there was an increase in sewage volumes discharged to Lake Rotorua and an increase in catchment area developed to pastoral agriculture. Both the sewage and the catchment made significant contributions to the nitrogen and phosphorus budgets of the lake. The increased supply of nutrients affected the lake in several ways:[1]

- increased growth of algae decreased the clarity of the water
- surface scums of unsightly and potentially toxic blue-green algae occurred
- bottom waters had an increased tendency to become depleted of oxygen.

Some of these features were also observed in Lake Rotoiti, which receives outflow water from Lake Rotorua.

This continued deterioration in the water quality of both lakes was of concern to the local community, especially given the regional and national importance of the lakes to tourism, fisheries and conservation values. Out of this concern the Upper Kaituna Catchment Control Scheme arose.

Managing the problem

The soil conservation component of the scheme was implemented through the 1980s, and included tree plantings on the erosion-prone hillsides, preservation of wetlands and lake margins, and retirement and planting of stream riparian zones. These works were undertaken in the belief that they would reduce upslope entrainment of sediment and nutrients into surface runoff and bring about the entrapment of runoff contaminants within the retired riparian zone. Riparian plantings were also expected to reduce sediment and nutrient inputs to the lakes by stabilising stream banks against erosion and preventing stock access to the stream. While these expectations appeared to be reasonable at the time that the scheme was developed there was no hard scientific evidence available to support the expected outcomes.

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[1] Cooper AB, Williamson RB and Smith CM. 1990. *Assessment of soil conservation work in the Ngongataha catchment and the implication to Lake Rotorua*. Water Quality Centre DSIR, Consultancy Report No. 7061.

Consequently, as the soil conservation works drew to a close towards the end of the 1980s, the decision was made to investigate the degree of success of the scheme. The information in following sections outlines the findings.

The catchment of the Ngongataha Stream was chosen to carry out the investigation. In the early 1970s, before the soil conservation works began, the 7330 ha catchment consisted of 46 percent native bush, 6 percent exotic forestry, and 48 percent pasture. By 1990, 407 ha or 5 percent of the catchment had been retired. The retired areas included stretches along the banks of the Ngongataha (along 17.6 km or 90 percent of its total stream length), Umurua and Otamaroa streams, ephemeral waterways, headwater streams and swamps, and erosion sensitive hill slopes planted in conservation forestry or previously in native bush but accessible to stock. Eighty-seven percent of the works undertaken between 1980 and 1992 were subsidised by grants.

The strips of retired stream bank vary in width from 2 m to 100 m, although they are usually less than 40 m wide.

Species planted

Retired areas have been planted at a rate of 1200 stems per hectare. Native trees are now preferred as they are generally maintenance free and easily established; however, when the scheme began natives were not available in the quantities required and consequently a greater proportion of exotic species were planted than preferred.

Erosion prone hill slopes and gullies were predominantly planted with production forestry species *Pinus radiata* and Tasmanian blackwoods. Blackwoods were preferred because of their higher timber value and their slower growth rate, which would mean the retired areas would be disturbed less often. Douglas fir were also planted in production woodlots for the same reasons.

Subsequent experience is showing that blackwoods require considerable silviculture (form pruning) from an early age to produce a harvestable log; poorly formed trees can make up a considerable proportion of the stand especially in narrow riparian strips where a large proportion are exposed to exposed stand margins. Landowners have the responsibility of carrying out silviculture and maintenance works in the retired zones, but many of the blackwood stands have not received the required pruning necessary to produce a high value log.

Eucalypts (*Eucalyptus regnans*, *E. delegatensis* and *E. cordata*) were often planted in the initial stages of the scheme as they were readily available. Their propensity to be windblown has reduced their use in more recent times. Other exotics such as oak and walnut were also planted in the initial stages.

The stream banks and low-lying areas have been predominantly planted in native species, although a few shrubby willows have been planted along the Ngongataha Stream edge to reduce streambank erosion, and to serve as fillers in swampy tributary headwaters. Flax has been most used because of its hardiness and low cost. Other native species include karamu, kohuhu, lemonwood, akeake, kanuka, manuka, wineberry, cabbage tree, koromiko, kahikatea, ribbonwood, and rimu.

Monitoring the changes

The Ngongataha Stream was chosen for the study because the water quality and quantity databases from prior to the commencement of the soil conservation were more comprehensive than from other Lake Rotorua sub-catchments. The major part of the study, carried out in 1990, was to compare water quality before and after soil conservation measures were implemented. The study was carried out by the Water Quality Centre of the DSIR (now NIWA) and its main findings are summarised below.[2]

Sediment and nutrient loads

The prime aim of the study was to quantify the impacts that the catchment management scheme has had on loads of sediment, phosphorus and nitrogen to Lake Rotorua.

Sediment

Sediment exports from the Ngongataha catchment fell by 85 percent from pre-catchment works to the period following the works. This substantial reduction was thought to be due to a reduction in streambank erosion and a reduction in sediment contained in surface runoff.

Phosphorus

Total phosphorus yields were 24 percent lower when the soil conservation measures were in place compared to pre-catchment works. Retirement was associated with both reduced particulate and dissolved phosphorus exports, and this was reflected in substantially reduced exports in stormflow (34 percent) and slightly reduced in baseflow (4 percent).

Interestingly, in both pre-and post-retirement periods most of the dissolved phosphorus was transported during baseflow, and most of the particulate phosphorus was exported during flood flows.

Phosphorus concentrations (as opposed to load) generally fell following retirement.

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[2] Cooper AB, Williamson RB and Smith CM. 1990. *Assessment of soil conservation work in the Ngongataha catchment and the implication to Lake Rotorua*. Water Quality Centre DSIR, Consultancy Report No. 7061.

Nitrogen

Total nitrogen exports were very similar under retired and non-retired conditions. However, there was an important difference in the partitioning of the nitrogen. Nitrogen was primarily exported as organic (particulate) nitrogen (70 percent) when the stream bank was not retired, whereas nitrate was the predominant form (54 percent) after retirement. Nitrate exports in stormflow did not differ between retired and non-retired conditions, but baseflow exports did. Estimated annual exports were 39–56 percent higher after the conservation measures had been implemented. The change from predominantly organic to nitrate export may be of real significance, as nitrate is mainly exported during baseflow and as such is a continuous source of immediately plant-available nitrogen to Lake Rotorua.

In addition to the nitrate load increases, nitrate concentrations also increased between the mid-seventies and late eighties. There are two possible reasons for these increases.

These increasing nitrate concentrations and loads may be unrelated to the soil conservation measures and could instead reflect increasing groundwater nitrate levels in the Rotorua region because of the large scale changes in land use over the last 50 or more years. Much of the flow in Rotorua streams (and other areas with pumice substrates) is derived from springs and rapid subsurface runoff, and the proportion of surface runoff contribution to stream flow is small compared to streams on other substrates. It is for this reason that any increase in nitrate concentrations in groundwater will have a significant impact on stream water concentrations.

Average groundwater residence times can reach 50–100 years, which would coincide with the major period of conversion from native vegetation to pastoral land use. Because of the time delay, the effects of this historical land use conversion would only now become apparent as the groundwater emerges at springs to feed the stream. Average nitrate concentrations in the Ngongataha increased from 300 mg/m^3 in 1968–1970 to 531 mg/m^3 in 1975–1978 and 610 mg/m^3 in 1987–1989. This would support the argument that the nitrate increases have little to do with the conservation works. But it does raise the question as to whether we are yet to see the worst of nitrate levels nationwide, especially if we are having to wait 50 years or more before the original contaminated groundwaters re-emerge.

The other possible explanation for the nitrate increase could be that there is a decrease in the capacity of the riparian zone and/or the stream channel to remove nitrate following retirement. The denitrifying capacity of the riparian zone and the stream channel may have been reduced by the heavy plant cover established as part of the retirement process. Shade created by overhanging tree and shrub vegetation may have shaded out the macrophyte and periphyton populations in the channel thereby reducing denitrifying activity, and/or the new riparian vegetation may have drained the previously wet riparian soils also reducing the amount of denitrification able to occur.

There is no evidence from the Ngongataha to say which of the two theories is the most plausible explanation. However, information gained from the Whangamata Stream near Taupo (see *Case Study 4*) showed clearly that streambank shading dramatically reduced the capacity of the stream to strip the water of nutrients, because of the exclusion of semi-aquatic streambank vegetation. That stream is also predominantly spring-fed. Unlike the Ngongataha Stream, its spring water has shown no sign, in the period 1991–1998, of increasing or decreasing concentrations of nitrate (or phosphorus), which could be because that part of the Taupo region was not developed for intensive agriculture until the late 1950s. However, the nitrate concentrations in the Whangamata appear to be nearly twice as high as those in the Ngongataha. Clearly, there is more we need to discover before adequate predictions of cause and effect can be made.

Streambank erosion

Active streambank erosion was found to be occurring on 3.7 percent of a 14.3 km reach of the Ngongataha Stream in a post-retirement survey, compared to 30 percent pre-retirement. In addition, the average size of each erosion site was substantially reduced in the later survey.

The most likely reason for this change is because of the removal of stock and the planting of vegetation that has re-stabilised the banks. An alternative view is that the stream channel has reached a state of equilibrium following the removal of the original stream bank vegetation and its conversion to pastureland, and as a consequence bank erosion is no longer as substantial as it once was.

Photograph 66: Most of the Ngongataha Stream margins have been retired as part of the Upper Kaituna Catchment Control Scheme. Much of the stream's margins looked like this small unfenced portion prior to the commencement of the scheme. Note the straight stream channel and the unstable steep banks. Compare this to Photograph 63, a reach of the same stream not more than 100 metres away that has been fenced for many years.

Photograph 67: 100 metres along the stream from Photograph 66. Note the wider stream bed and the meandering water channel.

Vegetation changes

A survey of vegetation within 5 metres of the stream channel undertaken in 1989 revealed that blackberry made up over 30 percent of the plant material growing there. This compares to an area that was predominantly grazed grass pre-retirement. Eighteen percent of the vegetation remained in exotic pasture grasses and 12 percent consisted of conservation plantings (these were under represented in the survey because vegetation was only measured within 5 metres of the stream). The rest of the plant material consisted of willows and other exotic shrubs. Semi-aquatic monkey musk (a species capable of stripping nutrients from stream water – see *Case Study 4*) made up 5 percent of the vegetation.

There was also a significant amount of vegetation overhanging the stream which was obviously not present when the banks were in pasture. This overhang provides important shade to the stream and may also supply terrestrial invertebrates (food) for fish.

Estimation of riparian margin nutrient and sediment stripping capacity

An evaluation of the effectiveness of the retired riparian margins in stripping nutrients from overland flow was carried out on the main channel of the Ngongataha Stream.

The field survey involved mapping the surface runoff source areas, identifying likely surface runoff paths (where channelisation obviously occurred), and classifying the intervening retired strip on its ability to remove nutrients.

Effective buffer strips were judged to be:

- where the stream is bounded by low gradient land which generates little surface runoff
- on steeper banks, where there is a wide buffer strip with a good thick sward of grass ground cover.

Poor nutrient stripping was judged to occur in the following situations:

- where the vegetation canopy had shaded out ground cover on steeper slopes
- where retired vegetation (grasses) becomes submerged by surface runoff in heavy rain
- where surface runoff enters an incised permanently flowing channel without previously passing through a buffer strip
- where the grassy buffer strip is too narrow to cope with the volume of runoff it receives.

The assessment judged that retired strips along about 55 percent of the main Ngongataha Stream removed most of the sediment-bound pollutants in surface runoff, but that strips along other reaches often had insufficient close ground cover to be effective. Blackberry and other weeds have proliferated within the retired strips, and the former appears to be preventing the establishment of a close ground cover, and therefore reducing the nutrient and sediment interception capacity of the strip.

What difference have the retired and planted Ngongataha Stream riparian margins made 10 years after retirement?

What has happened?

- Sediment loads have decreased substantially.
- Phosphorus loads and concentrations have decreased.
- Nitrate loads and concentrations have increased.
- Particulate nitrogen loads have fallen.
- Streambank erosion has decreased considerably.
- Weeds, especially blackberry, have invaded some riparian areas.

Why have these changes happened?

- Sediment and phosphorus reductions have probably occurred because of the effective filtering of surface runoff passing through the grasses in the retired riparian margin.
- Sediment levels would also seem to have been reduced by effective stabilisation of stream banks by planted vegetation, reducing bank erosion.
- Particulate nitrogen levels appear to have been reduced because of the filtering actions of the riparian margin.

- Nitrate levels have risen because of increased nitrate levels in emerging groundwater, and also because most nitrate does not pass through the riparian zone in surface water to any great extent.

Future recommendations and expectations

- In pumice substrate streams where a high proportion of water supply comes from groundwater, management of the spring heads and associated riparian wetlands may be the best (and possibly the only) way to extract nitrate before it enters the water body and becomes unmanageable.
- Substantial effort should be focused on reducing the production and leaching of nitrate at the source – on the farmland.
- What will happen to the nutrient and sediment trapping potential of the riparian margins when woody shrubs and trees begin to dominate? We may be faced with managing artificial grass strips in addition to riparian habitat to serve two separate functions.

Attitudes and opinions

Farmers in the Ngongataha were questioned as to their observations of changes resulting from the retirement works and their opinions of the value of the works. The findings were as follows:

- Most thought the retirement scheme had reduced soil erosion and nutrient runoff.
- Most thought the exclusion of stock, especially cattle, had been the most positive effect; followed by the stabilisation of stream banks by planted vegetation.
- Weeds, especially blackberry, were considered to be the biggest practical problem in retired areas. Several farmers stated that they resented being obliged to control the noxious weeds in the retired areas.
- Seven out of 17 farmers reported they had done nothing to control weeds in the retired areas (despite their obligation to do so); two had no problem and eight had undertaken some weed control.
- Farmers reported that retirement has had only minor effects on day-to-day management. Some reported stock mustering was easier because of the retirement fencing and some reported reduced stock losses in the stream.
- Seven of 17 considered their property value had probably been affected by the retirement works; five of those felt it had declined because the retired areas were a mess to look at or they had lost significant grazing areas to retirement, while two thought their property values would increase because the retirement trees are or will be attractive.
- Some were unsatisfied with funding arrangements for maintenance works in the retired areas.
- The majority were satisfied with the way the regional council staff had dealt with them.

Several key issues arose out of these findings. Some of them are positive:

- Farmers were generally concerned about the condition of Lake Rotorua and Ngongataha Stream, and were willing to cooperate in an endeavour to protect them.
- Many of the established farmers felt closely involved in the scheme because council staff had gone to considerable efforts to work in a cooperative manner when designing the farm retirement and planting plan. They appreciated being able to participate in species selection and placement of fences, etc.

There were also some negative issues identified:

- Most of the farmers lack any sense of responsibility for the retired areas. While most had retained title to the land, it was viewed as unproductive and consequently an unwarranted drain on resources. This attitude was especially noticeable amongst those who had purchased the properties after the works were completed.
- Several recent purchasers of property appeared unaware that they were responsible for maintaining the retired areas.
- There was a general level of discontent with funding arrangements for maintenance works and an unwillingness to make substantial efforts to control the weeds that are proliferating along stretches of the stream bank.
- There was concern about the lack of funding and arrangements for replanting where initial plantings have been unsuccessful.
- There has been reinforcement that the original preference for native plants over exotic species should be adhered to along riparian margins now that native plants are readily available.

Riparian management today in the Bay of Plenty

The Bay of Plenty Regional Council has learned a lot from the experiences of the 1980s and has adapted its riparian and soil conservation procedures accordingly.

Farm plans

The Regional Council (Environment BOP) remains one of the few regional councils who continues to offer farm plans supported by a grant rate funding system. It offers a two-tiered free farm plan service to farmers:

1. Soil Conservation Plans, which focus on on-farm erosion issues and remedial or preventative works.
2. Environmental Plans, which have a broader focus and allow grant funding to be used in support of works including bush and wetland retirements and soil erosion control. These plans cover issues such as:
   - runoff control
   - erosion control
   - protection of natural areas (wetlands and bush areas)
   - waste disposal
   - fertiliser use
   - plant and animal pest control.

Funding assistance

The Council provides grant rate assistance of 50 percent for works with a high off-site benefit, including retirement fencing, retirement planting and erosion control structures. Twenty-five percent assistance is provided for works with moderate off-site benefits such as alternative water supplies, woodlots and spaced planting.

Assistance has been reduced from the 87 percent-plus-compensation high of the 1980s for several reasons:

- *affordability*: making the ratepayer dollar go further
- *equity*: a 50:50 split symbolises a balanced partnership
- *ownership of responsibility*: past experience has shown that high grant rates do not create commitment, motivation or any sense of ownership
- *incentive:* having a grant rate of any sort encourages more environmental protection work to be done than would regulation or recommendation alone.

Landowners who receive grant assistance for retirements or major works are required to accept a Land Improvement Agreement which is registered against the land title and applies for 99 years. The essential conditions of an LIA are that no earthworks are disturbed, that no stock are grazed in retired areas and that maintenance is the responsibility of the landowner.

Environment BOP has a policy of offering its services only to those who request it. The farmer must make the first approach.