# Best management practices for forestry to farming conversions

I. ELLIOTT[1] and M.F. HAWKE[2]
[1]419 Paraonui Rd, RD 1, Tokoroa
[2] Bay of Plenty Farm & Pastoral Research, 23, Glenroy Place, RD 4, Rotorua
martin.hawke@xtra.co.nz

## Abstract
Conversion of land planted in exotic forestry to pastoral farming has accelerated in recent years, particularly in South Waikato and Bay of Plenty. The implementation of these conversions has sometimes been to the detriment of the environment. This project was conceived to encourage and demonstrate good practices, work with Regional Authorities and monitor the results of conversions on agricultural and environmental parameters. A best practices guideline booklet has been produced and successful field days held on conversion properties. Monitor data indicated good pasture production can be achieved in year one after conversion and water quality may be declining adjacent to conversion sites.

Earthworms were absent in converted pastures, but grass grub and clover root weevil populations were building up soon after conversion.
**Keywords:** forestry, water quality, pasture yield, environment, soil fauna

## Introduction
The motivation for this Sustainable Farming Fund project has come from a growing realisation of the custodial responsibility that farmers and developers have in the development of pastoral land. As forestry to pasture conversions are planned and implemented, consideration must be given to sound environmental and management practices that will ensure the development does not bring permanent harm to our environment.

As land managers, farmers sometimes feel there is an urban sector misunderstanding of farming issues and a view that farming is not a sustainable land use. The best response is to go about farming business in a wise proactive way, so as to show that the land management practices employed demonstrate care for the environment in which we all live and work. In this light the conversion of forest land to pasture creates new challenges and issues for the farming industry to address.

This project was funded by the Sustainable Farming Fund (SFF), the agriculture industry, farmers involved in conversion works and two regional councils (Waikato and Bay of Plenty). The group was formed because of the large scale of the conversions taking place and the new challenges this created for farmers

The group consists of dairy (predominantly) and sheep/beef farmers who are purchasing forest land on their farm boundaries for conversion to dairy or sheep/beef units and representatives from two Regional Councils, Dexcel, Ballance Agri-nutrients, consultants and a researcher.

Tens of thousands of hectares of *Pinus radiata* have already been converted to dairy pasture in South Waikato, Bay of Plenty, Southland and Canterbury. In addition, many forestry blocks (pine and eucalypt) are being logged on land suitable for sheep and beef production. Many of the activities associated with conversion are standard practices where the potential adverse effects are understood and can be managed. However there are aspects which are particular to land conversion for which there are no guidelines.

As part of this study, three farm conversions from forestry in the Bay of Plenty/South Waikato (two dairy and one sheep and beef) were monitored over a period of 30 months for stream water quality, pasture production, soil fertility and soil fauna populations. Permanent pasture and related soil fertility information on existing farm paddocks was compared with new conversions on the same farms to identify levels of production and constraints. In addition, 15 months pasture data are presented from two conversions with slopes in excess of 25 degrees.

## Key Components of Successful Conversion
A successful conversion involves the following key elements:
- Identify and map natural and physical features Obtain sound, timely advice
- Sound planning (Forest Harvest Plan, Infrastructure Plan, Development Plan)
- Implementation using appropriately trained staff and appropriate equipment
- Monitoring of activities and revision of operations where necessary

### Infrastructure plan
When converting a site from forest to farm it is important to plan the most efficient and environmentally sustainable farm layout and operation system. An infrastructure plan will help to prioritise and manage this process. Constructing races, bridges and culverts, cowshed, feed

pad and other buildings will involve land disturbance (and possible stream disturbance). Resource consent and/ or building permits may be required. Preparing applications and obtaining consents and permits can take time, which should be factored into the work plan. Background information from previous owners and local bodies should be sought as part of the process for formulating the farm development plan. Include mapping natural and physical features, archaeological sites and the forest harvest plan.

**Development plan**

Removal of stumps and other deep earthworks are the conversion activities which have most potential to cause environmental problems, particularly on steep slopes and/ or close to streams. Clearing and disposing of trees/ stumps and slash, developing seed beds, applying fertiliser and managing waterways are activities which need to be planned carefully to minimise cost and environmental impacts. The high risk areas can be identified using maps with soil and erosion information. These areas could be left in trees or replanted (if on a harvested site). Where steep areas are to be converted, stumps could be left in the ground to minimise the erosion risk. Consider planning to convert the flatter and most productive areas first, and then return to steeper areas at a later date when the majority of the adjacent land has been sown and stabilised.

**Harvesting best practices**

- Leave riparian vegetation along waterways to help filter sediment and protect fish and invertebrate habitats. Best management practices suggest this riparian margin should extend at least 10 metres on either side of a waterway.
- Protect wetlands from slash and heavy loads of sediment. Wetlands help intercept and filter contaminants generated by forestry activities.
- Wetlands and riparian margins can be enhanced later to beautify your farm, increasing its capital value. They will also help reduce farm water runoff before it enters streams.
- Install adequate culverts and run-offs to maintain natural drainage patterns. Keep culverts, fords and other water structures clear of slash and debris to allow for fish passage.
- Retire areas of native bush or regenerating areas to help preserve animal species and habitats.
- Isolate steep slopes (over 25 degrees) – keep them in forestry, replant them with other exotic species or mark them for soil conservation work once trees are removed.
- Avoid using heavy machinery on steep slopes and riparian margins. Plan appropriate sites for roads, tracks, haul directions, landings and processing sites with contractors. Ensure “no go zones” are clearly understood.
- Use low-impact extraction techniques on land prone to erosion.
- Keep machinery on specified tracks to help reduce compaction (particularly on soils that are wet or have poor structure). Compaction can inhibit drainage and root penetration, which can reduce subsequent pasture growth. Landings and tracks where machinery is continually operating should take up minimal space while still allowing effective harvesting.
- Check that special areas/cultural/historical sites have been protected.

**Post harvest of full rotation plantation forest**

- On steeper areas (up to 25 degrees), leave the stumps in place. This will have a number of environmental benefits, including minimising soil disturbance and maintaining soil stability. The ‘holding action’ of the tree roots will help to retain soil on the hill, particularly at the most vulnerable time before ground cover vegetation is established. Stumps will generally break down over a period of about 7 years.
- On flatter areas, grind the stumps and slash (rather than burning or removing them) and leave the ground material to rot on site. Incorporating ground wood material immediately adds organic material into the soil. Better moisture retention during summer is an added benefit. However, the presence of large amounts of organic material will remove nitrogen during the decomposition process. While ground material rots quickly the process can be accelerated by applying nitrogen to increase the rate of breakdown
- Alternatively, the stumps can be removed and windrowed prior to being mulched and spread

**Re-afforestation of steep land – land use options**

Harvested areas which are too steep to convert may be replanted in plantation trees or native species. Plantation areas will have a number of values including:

- Retention of soil on the steep areas
- Provide revenue in 25-35 years if replanted in a tree crop
- Landscape diversity
- Wildlife habitat
- Shade for livestock.
- Possible carbon credits

Difficult areas, riparian margins, sites which are inaccessible or difficult to harvest may be better replanted in native flora or left to regenerate. Native vegetation areas have a number of additional benefits to offset the commercial timber value and may attract government grants.

### Taxation

As there are significant costs associated with conversions, it follows that the tax implications are significant. Tax law is complicated and ever changing so it is good practice to work with an advisor to limit the chances of getting it wrong and incurring penalties and interest. This does not mean it is not useful to have an understanding of the general rules to know what questions to ask and be able to ensure records are kept in a format that simplifies the year-end process.

### Scientific assessments and farm monitoring data

The three farms that were a central part of this project were monitored for a range of parameters. They were essentially benchmarked to provide base line data in order to demonstrate the effects of conversion on pasture production, soil fertility and soil fauna populations. In addition, water quality was analysed from streams within a forest (introduced or native) and pastoral catchments close to each farm and adjacent to recent conversions.

Farmers converting from forestry to pastoral farming perceive a risk of outbreaks from insect pests such as grass grub (*Costelytra zealandica*) and clover root weevil (*Sitona lepidus*). Such outbreaks are likely to arise from the absence of natural population moderators (predators and disease) for pastoral soil fauna under forestry conditions. Data on soil fauna populations (both pest and beneficials) collected over time following the conversion process will enable the risk of pest outbreaks to be quantified so that farmers can plan mitigating actions

## Methods

Sites were selected on each property to represent existing established permanent pasture and recent conversions on comparable soil types, all within the Taupo – Rotorua Volcanic Zone. The Tokoroa site was on Tirau Ash, the Atiamuri site on Taupo sandy silt and the Manawahe site on Kaharoa Ash. Pasture sites were flat to rolling and the permanent pastures were all in excess of 10 years old. Within the paddocks selected, three small pasture exclusion cages (0.19 $m^2$/cage) were measured on a single trim 'Rate of Growth' technique (Piggott 1986) for pasture growth at 4-5 week intervals for 30 months. In addition, pasture growth on two sites with slopes of over 25 degrees was measured over a period of 15 months and compared with flat sites on the same paddock. At the same time, water samples were taken from streams and analysed for nitrate, total phosphorus concentration and suspended solids.

Soil samples were taken each February from the monitor paddocks and analysed using the MAF Quick Test procedure for pH and a range of elements (MAF 1984). In addition, an adjacent forest site was sampled for comparison.

### Soil fauna

Soil fauna populations were measured in autumn for 3 years at the selected sites.

Soil samples, hand sorted in the field for macro invertebrates and identified to species level, were taken along representative transects in eight paddocks and three forestry lots. One hundred 75 mm diameter x 100 mm deep cores were taken randomly along each transect in 2005 and 2006. In 2007 twenty spade samples (150 mm x 150 mm x 100 mm deep) were taken along the same transects. The forestry lots were sampled in 2005 only. The sampling was timed and designed to ensure that accurate estimates of earthworm populations could be made.

## Results and Discussion

### Pasture production

Pasture production from the flat/rolling sites (Fig. 1) indicated, that given adequate capital fertiliser, pastures converted from forests performed well as early as year one. On the two hill sites that were measured for 15 months, pasture production was 50% and 70% of that on the flat sites for Tokoroa and Atiamuri respectively. However, these two dairy farms only had dry stock on the hill paddocks and so were not subjected to heavy treading.

### Soil fertility

Soil pH and Olsen P levels were used as indicators of soil fertility for the purposes of this paper. The results (Fig. 2) indicated that soil pH in the forested areas was generally lower than on the pasture sites at all three locations. At Tokoroa, the area had been in pines for approximately 63 years (third crop at harvest), Atiamuri for 26 years and Manawahe for 10 years (eucalyptus).

Soil Olsen P levels were generally above optimum for pasture production (Roberts & Morton 1999) at two of the three sites in the established pasture (Fig. 3). However, on conversion sites, fertiliser inputs need to be adequate and on all three farms, careful use of fertiliser was achieved.

### Water quality

The mean nitrate concentration was, as expected, always higher in the farm catchments than the forested catchments (Cooper & Thomsen 1988). Stream water adjacent to conversion sites was similar to forested catchments (Fig. 4). This was not surprising, considering how long ground water takes to permeate into water courses.

The mean total phosphorus concentration was in all cases higher in the pastoral catchments (Fig. 5). At all three sites, stock had access to the streams. The conversion sites (logged) P level was marginally higher

**Figure 1** Pasture production at (a) Tokoroa, (b) Atiamuri, (c) Manawahe sites.

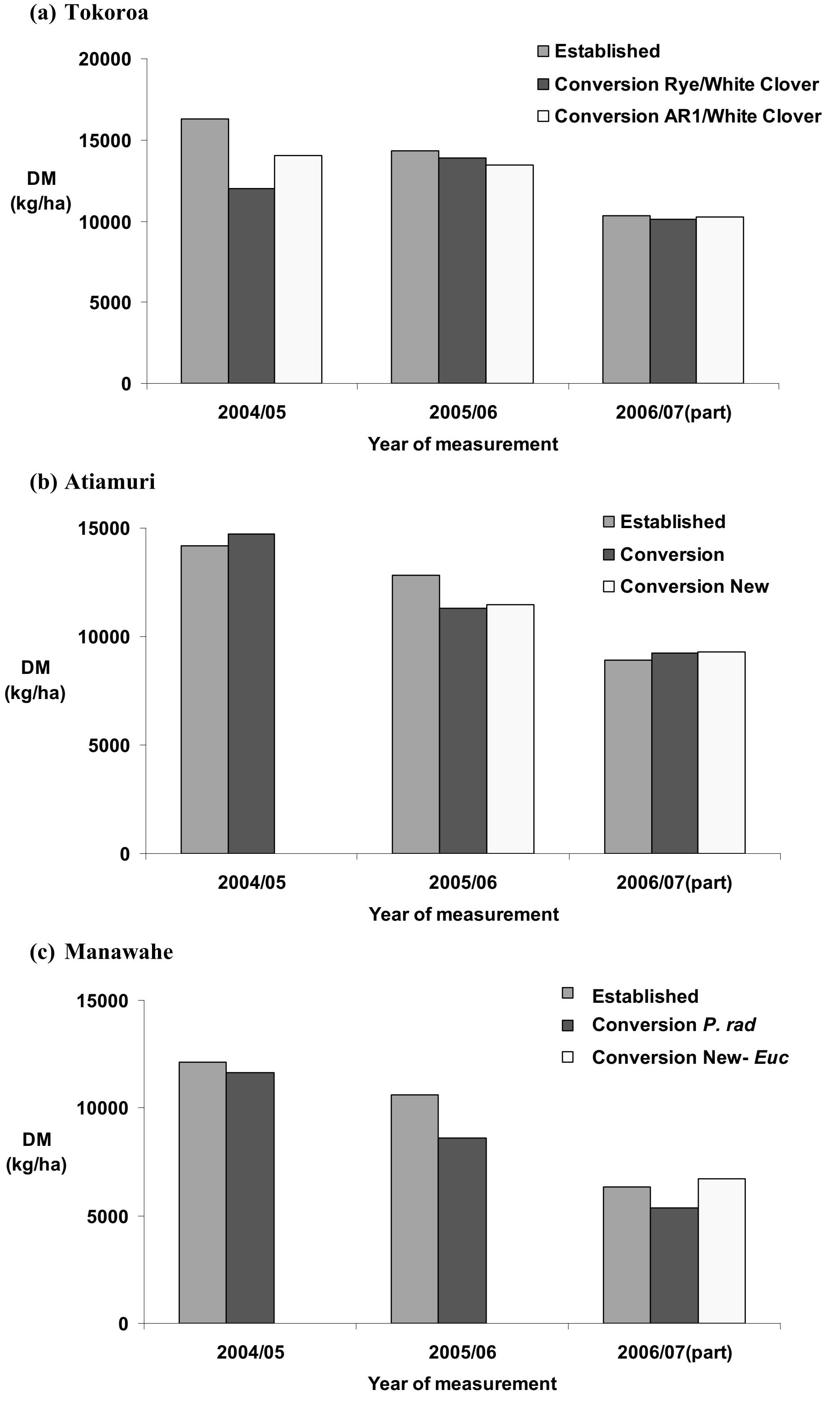


**Figure 2** Soil pH at the monitor sites.

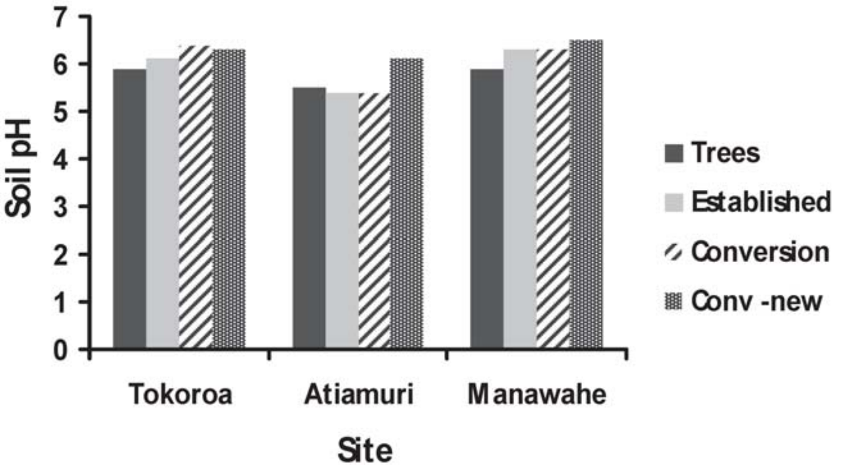



**Figure 3** Average Olsen P values.

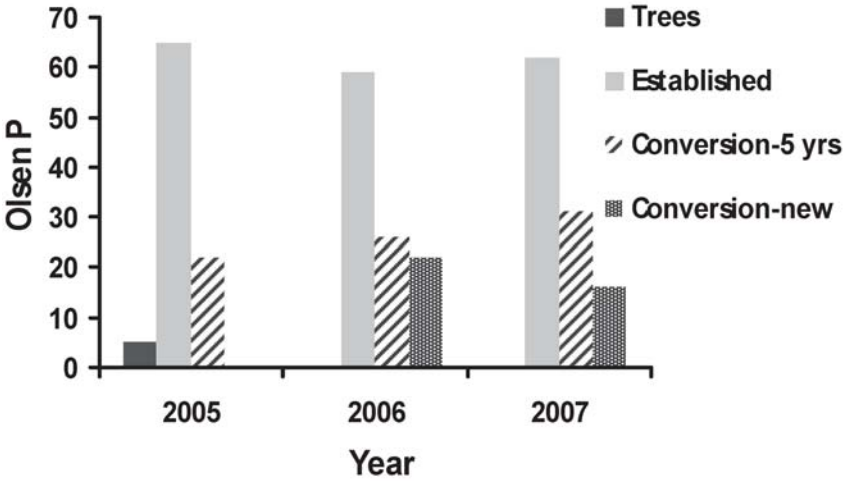



**Figure 4** Nitrate N concentration in monitor site streams. Bars represent SEMs.

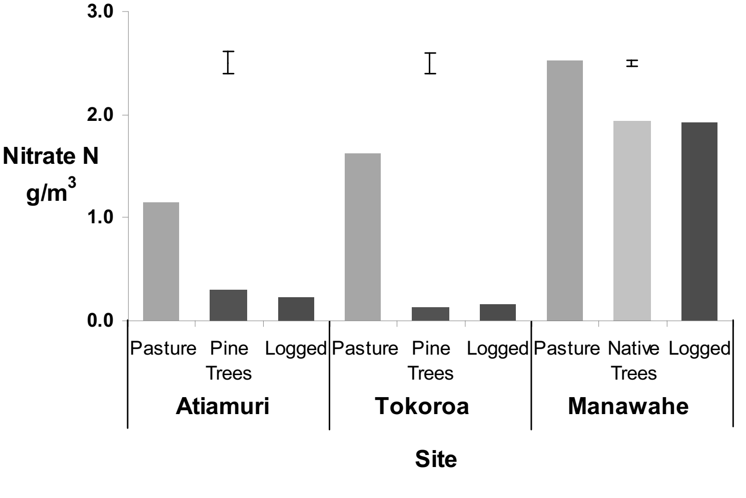


**Figure 5** Total phosphorus concentration in monitor site streams. Bars represent SEMs.

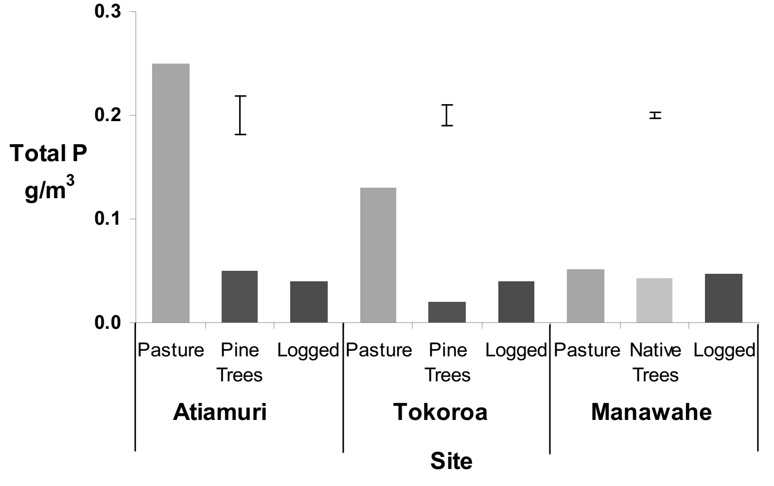
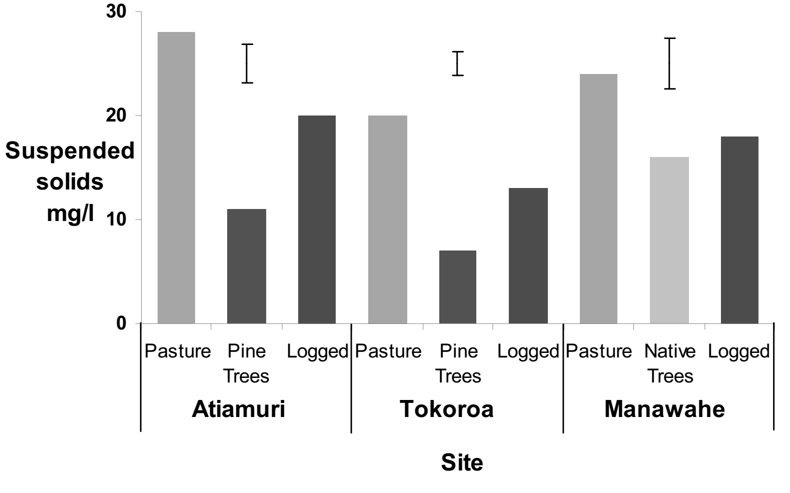



**Figure 6** Suspended solids in monitor site streams. Bars represent SEMs.




than the forest catchments sites, which may reflect increased runoff from soil disturbance.

Suspended solids were highest in the pasture catchments and the logged (conversion) sites were higher then the forested sites (Fig. 6). The breakdown and movement of debris after logging may be implicated in this result.

There are indications that stream water quality is declining (Total P and Suspended Solids) adjacent to conversion sites.

### Soil fauna

Both numbers and diversity of soil fauna in the *P. radiata* forestry blocks was notably absent. The eucalypt forestry block sustained numbers and diversity of soil fauna similar to pasture.

With the exception of earthworm populations, the numbers and diversity of the soil fauna in the pastures sampled was what might be expected for pastures of the respective ages (Table 1). Grass grub populations were very low in the most recently converted sites which had been through a cropping phase in 2005. At Tokoroa and Atiamuri, grass grub numbers were increasing at sites less than 5 years after conversion. Clover root weevil populations were high at these sites as well, even in newly established pastures.

Earthworms were absent or in very low populations in the recently converted pastures. Numbers in the established pastures were low and for the most part undetectable in the Manawahe long established pasture.

The soil fauna populations indicated that grass grubs and clover root weevils are absent after pine trees are

**Table 1** Predominant groups of soil fauna as numbers/m² in each paddock type at three sites sampled in April 2005, May 2006 and March 2007.

| | | Conversion pasture (< 1 year) | | | Conversion pasture (< 5 years) | | | Long established pasture | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Site | T | A | M | T | A | M | T | A | M |
| Grass grub | 05 | NA | NA | NA | 0 | 1 | 41 | 17 | 36 | 51 |
| | 06 | X | 0 | 32 | 9 | 23 | 48 | 70 | 82 | 217 |
| | 07 | X | 0 | 15 | 43 | 79 | 26 | 60 | 19 | 0 |
| Clover root weevil | 05 | NA | NA | NA | 299 | 122 | 28 | 64 | 0 | 64 |
| | 06 | X | 613 | 0 | 344 | 235 | 54 | 177 | 134 | 48 |
| | 07 | X | 175 | 101 | 53 | 0 | 21 | 18 | 25 | 18 |
| Earthworms | 05 | NA | NA | NA | 0 | 12 | 1 | 85 | 0 | 0 |
| | 06 | X | 0 | 0 | 0 | 45 | 2 | 747 | 204 | 43 |
| | 07 | X | 0 | 0 | 0 | 6 | 0 | 276 | 60 | 0 |

NA not available as the paddock was first sampled in 2006
X this paddock was cultivated for a crop
T=Tokoroa, A= Atiamuri, M= Manawahe

harvested, but their numbers build up and could pose a problem within a few years. Soil fauna including earthworms were virtually absent in mature pine plantations with implications for the delayed development of soil structure upon conversion to pasture. The forests sampled were aged 20 years and with a canopy cover of 75% - 85%, were virtually closed. By comparison the eucalypt forest (aged 10 yrs) with a canopy cover of 15 - 25% did not appear to confer the same degree of soil fauna degradation. In planning farm conversions from mature pine forestry, consideration should be given to re-establishing earthworm populations by translocation (Springett *et al.* 1992). This is a proven method and well tested in the 1960s (Springett *et al.* 1992). Healthy worm populations are in excess of 1000/m² (Springett 1992) and the low numbers at the Manawahe site were attributed to the recent nature of the soil following ash deposits from the Tarawera eruption in 1886.

The study highlighted the advantages of annual sampling of paddocks to track the development of grass grub populations. New pastures are particularly vulnerable to grass grub and in this instance when the forestry understorey continues to host grass grub the risk may go unidentified. Standard practice is to use treated seed when undertaking a grass to grass renovation when grass grub are present and this practice should be followed in a conversion from eucalypt forest.

Clover root weevil populations in newly converted pastures pose a serious threat to the productivity and survival of clover. Management strategies should be put in place that favour clover survival. As a large proportion of clover plants in the presence of clover root weevil are unable to fix atmospheric N, the application of fertiliser N to compensate for this loss may be considered.

## Conclusions

This project, through its field days and communications with farmers and contractors, has highlighted many of the good and bad conversion practises. It has attempted to promote in the public arena, a range of good management practices that can be followed. Contact with the relevant Regional Council is important to ensure correct procedures are in place. A guideline booklet has been produced and this will be an updated document on the SFF web site.

The initial effects of conversions indicated that aspects such as soil fertility, water quality and soil fauna should be monitored on a regular basis. The monitoring period of less than 3 years provided a glimpse of the effects of conversion. Longer periods of measurement will be needed to demonstrate sustainable farming practices and environmental effects.

Knowledge of issues that affect sustainability must be understood and acted upon by those concerned.

## ACKNOWLEDGEMENTS

The authors acknowledge the assistance of Mike Wheadon and Andy Woolhouse in the preparation of this manuscript, Bruce Willoughby for the soil fauna study and the participating farmers and consultants. The Sustainable Farming Fund (project 04/050), Environment Bay of Plenty and Ballance Agri-nutrients are thanked for funding this project and Environment Waikato and Dexcel for their considerable support.

## REFERENCES

Cooper, A.B.; Thomsen, C.E. 1988. Nitrogen and phosphorus in streamwaters from adjacent pasture, pine, and native forest catchments. *New Zealand Journal of Marine and Freshwater Research 22*: 279-291.

MAF. 1984. Fertiliser and lime recommendations for pasture and crops in New Zealand. Second Revised Edition 1984. New Zealand Ministry of Agriculture and Fisheries. Wellington.

Piggot, G.J. 1986. Methods for estimating pasture dry matter on dairy farms in Northland. *Proceedings of the New Zealand Grassland Association 47*: 243-247.

Roberts, A.H.C.; Morton, J.D. 1999. Fertiliser use on New Zealand dairy farms. In New Zealand Fertiliser Manufacturers' Research Association booklet. 37pp.

Springett, J.A.; Gray, R.A.J.; Reid, J.B. 1992. Effect of introducing earthworms into horticultural land previously denuded of earthworms. *Soil Biology and Biochemistry 24*: 1615-1622.

Springett, J.A. 1992. Distribution of lumbricid earthworms in New Zealand. *Soil Biology and Biochemistry 24*: 1377-1382.