

Soil Stability and Disturbance in the Kawhia Catchment - Changes from 2002 to 2007

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Executive summary

Background

1. Environment Waikato has requested an assessment of the extent of erosion, and coverage by soil conservation measures in a catchment that is representative of the region's west coast management zone. This zone encompasses all catchments west of the Waikato and Waipa watersheds. The assessment is intended to assist with upcoming discussions with the community as to the future promotion of catchment protection programmes in the zone.
2. EW contracted Mr. A.B. Thompson (Thelton Environmental) to undertake the assessment, with involvement of Dr. D. Hicks as needed for analysis procedure and comparisons. Following discussion with EW staff, Kawhia was selected as a representative catchment. The assessment was undertaken as a point sample from aerial photographs. This is now a standard method for assessing erosion and erosion control measures, used by EW as well as other regional councils.
3. The report starts with an overview of soil stability, soil disturbance and bare soil. It then gives results from the 2007 assessment of soil conservation measures for Kawhia, and compares them with results from a previous assessment in 2002. Results and comparisons are split according to whether land is farmed, planted in forest, or under natural vegetation, then grouped as a single catchment-wide summary.

Soil stability, soil disturbance and bare soil

4. Between 2002 and 2007, there has been minimal change in soil stability. The proportions of the Kawhia catchment that are stable i.e. free from risk of erosion; unstable i.e. at risk of erosion but currently undisturbed by natural processes; and eroded (revegetating) or eroding (bare scars), remained much the same.
5. Fresh soil disturbance by land use was recorded at a greater number of points, increasing from 3% of sample points in 2002 to 14% in 2007. However new bare soil was counter-balanced by revegetation at the points recorded as freshly disturbed in 2002. Overall, soil bared by land use disturbance remained the same, at 0.3% of catchment area.
6. Fresh soil disturbance by natural processes of erosion or deposition was recorded at a greater number of points, increasing from 6% of sample points in 2002 to 8% in 2007. However, new bare soil was outweighed by revegetation at the points recorded as freshly disturbed in 2002. Overall, soil bared by natural disturbance dropped from 0.8% to 0.2% of catchment area.
7. In 2002 less than 1% of sample points had bare soil due to extensive disturbance by building and quarrying. In 2007 extensive disturbance was recorded at 4% of sample points, due to addition of rural roads. Bare soil caused by extensive disturbance was measured for the first time in 2007, as 0.2% of the Kawhia catchment's area.

Changes in land use

8. Area of land in agricultural use has declined in Kawhia from 56% of the catchment in 2002 to 50% in 2007. The decrease is partly due to scrub reversion, but also to recording of rural roads separately in 2007 (see point 11).
9. Area of land planted in exotic forest has declined, from 4% in 2002 to 2% in 2007. A number of small forest plantations and farm woodlots have been logged, and either converted to pasture or reverted to scrub.

10. Area of land in natural vegetation (either public or private conservation land) has increased, from 39% in 2002 to 44% in 2007. The increase is mainly caused by scrub reversion on former farmland.
11. The balance of land in non-rural uses has increased, from 1% of the catchment's area in 2002 to 4% in 2007. This does not mean that non-rural uses have increased. It is an artefact of recording rural roads as a separate land use in 2007, where they pass through sample points.

Land uses' effect

12. On farmland, bare soil caused by land use-related activities decreased very slightly, from 0.28% of the catchment's area in 2002 to 0.27% in 2007.
13. In forest plantations, bare soil caused by land use-related activities increased very slightly, from 0% of the catchment's area in 2002 to less than 0.01% in 2007.
14. On land in natural vegetation, bare soil caused by land use-related activities increased, from 0% of the catchment's area in 2002 to 0.04% in 2007.
15. Amongst non-rural uses (roads, buildings, etc.) bare soil caused by land use-related activities increased from 0% of the catchment's area in 2002 to 0.15% in 2007. However the apparent increase is a result of changes in measurement technique (adding rural roads, and measuring areas of extensive disturbance for the first time).

Soil conservation cover's extent

16. Between 2002 and 2007:

- Land in natural vegetation (includes reverting land with residual rank grass or exotic scrub) increased from 39% to 44% of the Kawhia catchment.
- Land in forest plantations decreased from 4% to 2%.
- Farmland with natural soil conservation cover (bush, scrub, fern or wetland retained in pasture) increased from 7% to 9%.
- Farmland with residual soil conservation cover (rank grass, marram or exotic scrub in pasture) increased from 13% to 16%.
- Farmland with planted soil conservation cover (poplars, willows or other exotic trees in pasture) decreased from 6% to 5%.
- Farmland where soil conservation cover is needed but absent (unstable land in open pasture) decreased from 12% to 7%.
- Farmland where soil conservation cover is not needed (stable land in open pasture) decreased from 18% to 12%.
- Land occupied by roads, rural buildings, urban areas, shorelines or water bodies increased from 1% to 4% of the catchment's area (but most of the increase is due to transfer of rural roads to this category in 2007).

Soil conservation cover's effect

17. Throughout the Kawhia catchment, bare soil caused by natural processes of erosion or deposition decreased, from 0.77% of the catchment's area in 2002 to 0.21% in 2007:

- On land in natural vegetation, bare soil caused by erosion or deposition decreased from 0.47% to 0.07% of the catchment's area.
- On land in forest plantations, bare soil remained 0% of the catchment's area at both dates.
- On farmland with natural soil conservation cover, bare soil decreased from 0.15% to 0.05% of the catchment's area between dates.
- On farmland with residual soil conservation cover, bare soil decreased slightly, from 0.05% to 0.03% of the catchment's area.
- On farmland with planted soil conservation cover, bare soil increased slightly, from 0% to 0.02% of the catchment's area.
- On farmland where soil conservation cover is needed but absent (unstable land in open pasture), bare soil decreased from 0.10% to 0.03% of the catchment's area.
- On farmland where soil conservation cover is not needed (stable land in open pasture), bare soil remained 0% of the catchment's area.
- On land occupied by roads, rural buildings, urban areas, shorelines or water bodies, bare soil increased very slightly, from 0% of the catchment's area in 2002 to less than 0.01% in 2007.

Conclusions

18. Overall conclusions for the Kawhia are that:

- Between 2002 and 2007, farmed land and forest plantations decreased slightly, while natural vegetation and non-rural uses increased.
- Bare soil caused by land use increased catchment-wide, but is still less than 1% of catchment area. Most of the increase is due to recording bare surfaces associated with extensive disturbance for the first time in 2007. Other increases in bare soil, amongst natural vegetation and forest plantations, are statistically significant though minor.
- Changes in soil conservation cover 2002-2007 are measureable but minor. With few exceptions they are within statistical margins of error, so they cannot be regarded as significant. In short, there has been little change in extent or type of soil conservation cover over the five years.
- Bare soil exposed by natural processes of erosion or deposition has decreased for all categories of soil conservation cover, except for planted cover in farmland where there has been a slight increase. The other changes are statistically insignificant, because bare soil was already well below 1% of catchment area in 2002. In short, existing soil conservation cover has performed its role because there has been little natural erosion or deposition of soil during the five years between 2002 and 2007.
- The same conclusions apply to the West Coast catchment zone as a whole. This has been demonstrated by a parallel analysis of soil stability and disturbance in relation to soil conservation cover, from a sub-set of Environment Waikato's regional point sample. Analysis results are appended to the report.

1 Introduction

Environment Waikato has requested an assessment of the extent of erosion, and coverage by soil conservation measures in a catchment that is representative of the region's west coast management zone. This zone encompasses all catchments west of the Waikato and Waipa watersheds, specifically:

West coast north:	small catchments from south of Port Waikato to north of Raglan.
West coast south:	small catchments from south of Raglan to north of Awakino.
Raglan:	all catchments draining into Raglan Harbour.
Kawhia:	all catchments draining into Kawhia Harbour.
Awakino:	river and tributaries.
Mokau:	river and tributaries.

The assessment is intended to assist with upcoming discussions with the community as to the future promotion of catchment protection programmes in the zone.

Earlier soil conservation works were installed by the former Waikato Valley Authority from the 1960s through the 1980s. A previous assessment (Hicks 2006) provided basic information about their extent and condition, relative to the areas of unstable land in each catchment. The new assessment is intended to up-date landowners about any changes in soil erosion, extent of soil conservation measures, and their effectiveness, during the past five years.

EW contracted Mr. A.B. Thompson (Thelton Environmental) to undertake the assessment, with involvement of Dr. D. Hicks as needed for analysis procedure and comparisons. Following discussion with EW staff, Kawhia was selected as a representative catchment. Reasons for its selection include its geology, soils and land uses which typify hill country draining to the western coastline. Also at about 48,000 ha in area, it is the only large west coast catchment completely covered by EW's new aerial photographs in 2007 (photography is missing for small parts of other catchments due to cloud cover).

2 Method

The assessment has been undertaken as a point sample from aerial photographs. This is now a standard method for assessing erosion and erosion control measures, used by EW as well as other regional councils. Interpretation and measurement procedures are described in the Land Monitoring Forum's Manual (Burton et al 2009). The advantage of a point sample, is that it can provide statistically sound measures of unstable land, soil conservation plantings, and erosion's extent, without resorting to field surveys which would be time-consuming and expensive.

The previous assessment utilised a west coast catchment subset from a region-wide point sample, collected at a density of 1 point every 4 square kilometres on aerial photographs taken in 2002. This had the advantage of providing good data for the management zone as a whole, but few sample points for individual catchments within it; Kawhia for instance had 185 points. Re-assessment of the Kawhia catchment from 2007 aerial photographs has been carried out at a density of 1 point per square kilometre i.e. 500 points total. This is expected to provide larger sub-sample sizes, better error margins, and greater confidence in representativeness of the results.

Assessment was carried out by Mr. Thompson on Environment Waikato's Geographic Information System, using a Geomedia workspace and Manifold sampling procedure created by EW's GIS analyst Mr. D. Borman. Data analysis and report drafting were carried out jointly by Mr. Thompson and Dr. Hicks. The report has been peer-reviewed by Dr. R. Hill of EW's Resource Information Group.

3 Contents of the report

The report starts with an overview of soil stability, soil disturbance and bare soil. It then gives results from the 2007 assessment of soil conservation measures, and compares them with the previous results from 2002. Results and comparisons are split according to whether land is farmed, planted in forest, or under natural vegetation, then grouped as a single catchment-wide summary.

Report tables contain key numbers which may be useful for staff discussions and public presentations. They have been extracted from more detailed analyses, which appear as spreadsheets in Appendix A:

- Soil stability (intact, disturbed and bare).
- Soil conservation cover (extent, standard, effectiveness) on land in agriculture.
- Soil conservation cover (extent, standard, effectiveness) on land in forest plantations.
- Soil conservation cover (extent, standard, effectiveness) on land in natural vegetation.

Finally, Appendix B contains parallel spreadsheets which summarise similar data analyses for the entire west coast management zone. These have been prepared from a subset of EW's regional point sample (Thompson and Hicks, 2009a, 2009b).

4 Soil stability, soil disturbance and bare soil

4.1 Soil stability

Table 1: Soil stability in Kawhia catchment

	As percent of catchment:			
	Stable	Unstable	Eroded & eroding	Covered, removed or absent
Kawhia 2002	27	53	19	1
Kawhia 2007	29	51	16	4

In 2002, 27% of sample points in the Kawhia catchment had soil that was stable i.e. free from risk of erosion (this includes 2% where recent or fresh land use disturbance was present). In 2007 29% of sample points were stable (including 2% where recent or fresh land use disturbance was present).

In 2002 53% of sample points in the Kawhia had soil that was unstable i.e. at risk of erosion but currently undisturbed by natural processes (this includes 9% where recent or fresh land use disturbance was present). In 2007 51% of sample points were unstable (including 12% where recent or fresh land use disturbance was present).

In 2002 19% of sample points in the Kawhia had soil that was eroded (revegetating) or eroding (bare scars). In 2007 16% of sample points were eroded or eroding. The apparent decrease is due to change in measurement procedure (see next paragraph).

In 2002 1% of sample points in the Kawhia had soil that was covered by buildings and pavements, or removed by quarries, or absent along shorelines, streams and ponds. In 2007 4% of sample points had soil in this category. The apparent increase is due to application of the standard LMF measurement procedure in 2007; in particular the recording of soil as partially removed where roads run through sample points (an extra 15 points or 3%).

Soil disturbance

Table 2: Soil disturbance in the Kawhia catchment

	Percent of catchment with:			
	recent land use disturbance	fresh land use disturbance	recent natural disturbance	fresh natural disturbance
Kawhia 2002	7	3	13	6
Kawhia 2007	-	14	-	8

In 2002 7% of sample points in the Kawhia catchment had soil recently disturbed by land use (revegetating) and 3% had soil freshly disturbed by land use (bare). In 2007, application of the standard LMF procedure merged recent land use disturbance with other categories in Table 1, and recorded 14% of sample points as freshly disturbed by land use i.e. fresh land use disturbance greatly increased between 2002 and 2007.

In 2002 13% of sample points in the Kawhia had soil recently disturbed by natural processes of erosion or deposition (revegetating) and 6% had soil freshly disturbed by natural processes (bare scars). In 2007, application of the standard LMF procedure merged recent natural disturbance with other categories in Table 1, and recorded 8% of sample points as freshly disturbed by land use i.e. fresh natural disturbance increased somewhat between 2002 and 2007.

4.2 Bare soil

Table 3 Bare soil in the Kawhia catchment

	Percent of catchment with bare soil due to:		
	fresh land use disturbance	fresh natural disturbance	extensive disturbance
Kawhia 2002	0.3	0.8	-
Kawhia 2007	0.3	0.2	0.2

In 2002, 0.3% of the Kawhia catchment's area had bare soil due to fresh disturbance by land use. In 2007 bare soil was still 0.3% i.e. although fresh disturbance was recorded at an increased number of points (Table 2), new bare soil was counter-balanced by revegetation at the points recorded as freshly disturbed in 2002. Overall, soil bared by land use disturbance remained the same.

In 2002 0.8% of the Kawhia catchment's area had bare soil due to fresh disturbance by natural processes. In 2007 bare soil was 0.2% i.e. although fresh disturbance was recorded at an increased number of points (Table 2), new bare soil was outweighed by revegetation at the points recorded as freshly disturbed in 2002. Overall, soil bared by natural disturbance dropped.

Bare soil caused by extensive disturbance was not recorded in 2002. In 2007 bare soil or rock associated with buildings, quarries and roads was measured for the first time (consistent with standard LMF procedure) as 0.2% of the Kawhia catchment's area.

5 Soil stability under different land uses

Table 4 summarises key numbers about soil stability under different land uses in the Kawhia catchment.

Table 4: Soil stability under different land uses in Kawhia catchment

	Percent of catchment in agriculture	Percent of agricultural land unstable	Percent of catchment in forest plantation	Percent of forest plantation land unstable	Percent of catchment in natural vegetation	Percent of natural vegetation land unstable
Kawhia 2002	56	71	4	100	39	79
Kawhia 2007	50	75	2	63	44	63

Area of land in agricultural use has declined in Kawhia from 56% of the catchment in 2002 to 50% in 2007. The decrease is partly due to scrub reversion, but also to recording of rural roads as a land use in 2007 (see below). The percentage of agricultural land rated as unstable has increased from 71% to 75%; largely due to transfer of stable points into the rural roads category.

Area of land planted in exotic forest has declined, from 4% in 2002 to 2% in 2007. A number of small forest plantations and farm woodlots have been logged, and either converted to pasture or reverted to scrub. 100% of plantation land was rated as unstable in 2002, but just 63% in 2007. The only explanation can be the proportion of plantation land perceived as stable, by two different photo-interpreters.

Area of land in natural vegetation (either public or private conservation land) has increased, from 39% in 2002 to 44% in 2007. The increase is mainly caused by scrub reversion on former farmland. The percentage of land in natural cover that is rated unstable has declined, from 79% in 2002 to 63% in 2007. The only explanation can be the proportion of scrub and forest land perceived as stable, by two different photo-interpreters.

The balance of land in non-rural uses (not in the table) has increased from 1% of the catchment's area in 2002 to 4% in 2007. This does not mean that non-rural uses have increased. It is an artifact of recording rural roads as a land use in 2007, where they pass through sample points.

6 Extent of soil conservation

6.1 Farmland

Table 5: Soil conservation cover on land in agriculture

Agricultural land in:	Percent of unstable land with soil conservation cover	Percent of unstable land with planted soil conservation cover	Percent of unstable land with natural soil conservation cover	Percent of unstable land that has adequate soil conservation cover	Percent of unstable land where soil conservation cover needs upgrade
Kawhia 2002	69	35	34	20	49
Kawhia 2007	80	36	44	34	46

Soil conservation cover was present on 69% (about 33,125 ha) of unstable farmland at Kawhia in 2002, and increased to 80% (about 38,405 ha) by 2007. Note the definition of soil conservation cover encompasses native vegetation (wetland, scrub or bush) retained within pasture on unstable land, as well as trees deliberately planted for soil conservation works. Composition of the increase is described in the next paragraphs.

Planted or residual soil conservation cover was present on 35% of the catchment's farmland in 2002, and 36% in 2007. Deliberately planted soil conservation cover is, in the main, poplar and willow trees pair-planted along streambanks, or space-planted on hillslopes. Other exotic species e.g. pines, cypresses, gums, wattles are present in similar situations but less common. Residual soil conservation cover is exotic vegetation that remains on retired or abandoned land, and is a mix of rank grass with weeds (including shrubby weeds such as gorse and blackberry).

Natural soil conservation cover was present on 34% of the catchment's farmland in 2002, and 44% in 2007. Natural soil conservation cover is indigenous plants that have been intentionally or fortuitously left in pasture. Rush, sedge or flax on streambanks and wetlands decreased between dates, from 15% to 12%. Woody scrub on lightly grazed or reverting gullies and steep faces, and forest trees which still remain in well-grazed paddocks, jumped from 19% of unstable farmland to 32%.

Adequate soil conservation was present on 20% of the catchment's farmland in 2002, and 34% in 2007. Soil conservation cover is rated as adequate where canopy/ground cover appears in good condition, and extends over most of the unstable areas where it is planted (or retained in the case of natural cover). Most of the increased rating appears due to increasingly dense indigenous plant cover (already present though scattered in 2002). About 3% is due to increasingly dense planted cover; either rank grass on retired streambanks, or maturing poplar and willow plantings.

The balance of soil conservation is provided by cover that is in need of upgrading. Soil conservation cover is rated in need of upgrade where canopy/ground cover appears in poor condition, or does not extend over enough of the unstable area to be an effective control. The percentage did not decrease much, from 49% to 46% of unstable land, because much of the 21% jump in overall cover is as yet scattered or young.

6.2 Forest plantations

Table 6: Soil conservation cover on land in forest plantations

Forest plantation land in:	Percent of unstable land with soil conservation cover	Percent of unstable land that has planted soil conservation cover	Percent of unstable land that has natural soil conservation cover	Percent of unstable land that has adequate soil conservation cover	Percent of unstable land where soil conservation cover needs upgrade
Kawhia 2002	100	100	0	43	57
Kawhia 2007	100	40	60	60	40

Soil conservation cover was present on 100% of unstable plantation land at Kawhia at both dates. Note the definition of soil conservation cover encompasses closed canopy plantation, rank grass and exotic weeds (act as temporary ground cover around young trees), as well as native vegetation (wetland, scrub or bush) retained on unplanted areas such as gullies or steep faces.

Planted or residual soil conservation was present on 100% of unstable plantation land in 2002, and 40% in 2007. The decrease may be due to natural cover taking over from residual, but caution should be exercised interpreting these figures - we are talking about four sample points in 2002 and one point in 2007. The forest plantation sample for Kawhia is really too small to draw any conclusions, other than this land use occupies a small proportion of the catchment.

Natural soil conservation cover was not recorded on any of the catchment's unstable plantation land in 2002, and on 60% in 2007. The increase appears due to scrub regrowth amongst young trees displacing rank grass or exotic weeds, plus some wetland or fern on unplanted land, but again caution should be exercised - we are talking about just three points.

Adequate soil conservation was present on 43% of the catchment's unstable plantation land in 2002, and 60% in 2007. Soil conservation cover is rated as adequate where pine canopy is closed or where woody cover in canopy gaps extends over most of the unstable areas where it is planted (or retained in the case of natural cover). The increased rating (from two points) is due either to dense scrub regrowth amongst young re-planted pines or to retained bush on unplanted areas.

57% of the catchment's unstable plantation land was rated as having soil conservation cover in need of upgrade in 2002, because it had regrowth of exotic ground cover (rank grass and weeds) amongst young pines which had not yet closed canopy. 40% was rated in need of upgrade in 2007; one point with rank grass and one with native ground cover (fern etc).

6.3 Natural vegetation

Table 7: Soil conservation cover on land in natural vegetation

Land with natural vegetation in:	Percent of unstable land with soil conservation cover	Percent of unstable land where soil conservation cover is planted	Percent of unstable land where soil conservation cover is natural	Percent of unstable land that has adequate soil conservation cover	Percent of unstable land where soil conservation cover needs upgrade
Kawhia 2002	100	12	88	93	7
Kawhia 2007	100	33	67	62	38

At both dates 100% of unstable land in natural vegetation had plants that can be described as “soil conservation cover”, in the sense that they provide either ground cover, or root reinforcement of soil, or both.

12% had planted or residual soil conservation cover in 2002, but the percentage was much larger at 33% in 2007. The increase is due to rank grass and weeds that remains within land that was farmed but is now reverting to fern or scrub; with a few additional points either soil conservation trees that remain on reverting land, or wildling exotic trees amongst scrub.

88% had natural soil conservation cover in 2002 i.e. emerging trees in closed-canopy scrub, or scrub interspersed with forest, or successional ground cover (fern etc.) on canopy gaps within either scrub or forest. The percentage recorded as natural in 2007 was 67%. Area of natural cover has not actually decreased; what has happened is that land containing residual exotic cover (rank grass and weeds) has been added.

93% had soil conservation cover rated as adequate in 2002. All woody cover was rated adequate, on the grounds that it provides natural plant succession on disturbed sites. The percentage dropped to 62% in 2007, for the same reason i.e. addition of reverting land.

7% had soil conservation cover rated as needing upgrade in 2002. All points with herbaceous ground cover or exotic scrub were rated in need of upgrade, on the grounds that natural plant succession has not yet provided root reinforcement to soil. The upgrade is occurring anyway without any need for intervention; the percentage increased to 38% by 2007. 25% of the increase is clearly rank grass or exotic weed regrowth on reverting land, and the balance is native ground cover (mainly fern) that was unrecorded (or not present) in 2002.

7 Effectiveness of soil conservation

7.1 Farmland

Table 8: Soil conservation cover's effect within farmland

Primary cover:	Percent of all land with bare soil exposed by land use	
	Kawhia 2002	Kawhia 2007
sparse pasture	0.85	0.82
dense pasture	0.25	0.47
harvested pasture	-	0.00
Secondary cover in pasture:	Percent of unstable land with bare soil exposed by erosion	
	Kawhia 2002	Kawhia 2007
absent	0.83	0.35
scattered rush, sedge or fern	0.78	0.33
extensive rush, sedge or fern	0.00	0.07
scattered rank grass or weeds	0.91	0.45
extensive rank grass or weeds	0.00	0.18
scattered natural scrub or trees	2.0	0.60
extensive natural scrub or trees	0.0	0.31
scattered soil conservation trees	0.00	0.47
extensive soil conservation trees	0.00	0.33

On all farmland in the Kawhia, bare soil due to disturbance by land use:

- was highest where pasture is sparse, and did not change much between 2002 and 2007
- was lower where pasture is dense, and declined between 2002 and 2007
- was not present where pasture is harvested (few sample points).

On unstable farmland, bare soil due to disturbance by natural processes of erosion or deposition:

- was 0.83% by area where other vegetation was absent from pasture in 2002, and dropped to 0.35% by area in 2007.

Where other vegetation performs a soil conservation role in pasture, bare soil was:

- at similar levels in presence of scattered natural ground cover (rush, sedge, flax and fern) or scattered exotic ground cover (rank grass and weeds) at both dates
- much lower in presence of extensive natural or exotic ground cover at both dates. However measured bare ground went up from 0% in 2002 to 0.07-0.18% in 2007
- at higher levels in presence of scattered natural scrub and trees at both dates; a lower level in presence of scattered soil conservation trees in 2002, but a higher level in 2007

- At a lower level in presence of extensive natural scrub and trees or extensive soil conservation trees in 2002, but a similar level (to land where soil conservation is absent) in 2007.

7.2 Forest plantations

Table 9: Soil conservation cover's effect within forest plantations

Primary cover:	Percent of all land with bare soil exposed by land use	
	Kawhia 2002	Kawhia 2007
sparse pines (open canopy)	0.00	0.00
dense pines (close canopy)	0.00	0.33
harvested pines	-	-
Secondary cover in canopy gaps:	Percent of unstable land with bare soil exposed by erosion	
	Kawhia 2002	Kawhia 2007
no canopy gaps	0.00	0.00
rush, sedge, flax or fern	-	0.00
rank grass or weeds	0.00	0.00
natural scrub or trees	-	0.00
soil conservation or wildling trees	-	-

On all land in plantation forests in the Kawhia, bare soil due to disturbance by land use:

- was 0% where forest canopy is sparse, at both dates
- was 0% where forest canopy is dense in 2002, but increased to 0.33% of area in 2007 (forest tracks and earthworks)
- was un-measured where forest is harvested (no sample points).

On unstable land, bare soil due to disturbance by natural processes of erosion or deposition:

- was 0% at both dates where forest has closed canopy (though bare soil may be present beneath trees).

Where other vegetation performs a soil conservation role in forest canopy gaps, bare soil was:

- un-measured or 0% in presence of natural ground cover (rush, sedge, flax or fern).
- un-measured or 0% in presence of exotic ground cover (rank grass or weeds).
- un-measured or 0% in presence of natural scrub or trees.
- un-measured in presence of soil conservation or wildling exotic trees (no sample points).

7.3 Natural vegetation

Table 10: Soil conservation cover's effect within natural vegetation

Primary cover:	Percent of all land with bare soil exposed by land use	
	Kawhia 2002	Kawhia 2007
open-canopy scrub or trees	0.00	0.13
close-canopy scrub or trees	0.00	0.00
harvested scrub or trees	-	-
Secondary cover in canopy gaps:	Percent of unstable land with bare soil exposed by erosion	
	Kawhia 2002	Kawhia 2007
None	3.76	0.00
rush, sedge, flax or fern	-	1.33
rank grass or weeds	0.00	0.25
natural scrub or trees	0.28	0.23
soil conservation or wildling trees	0.00	0.00

On land in natural vegetation (conservation use whether public or private), bare soil due to disturbance by land use was:

- 0% where natural cover is sparse in 2002, but increased to 0.13% in 2007 (tracks or roads)
- 0% where natural cover is dense at both dates
- un-measured where natural cover is harvested (no sample points).

On unstable land, bare soil due to disturbance by natural processes of erosion or deposition was:

- 3.76% in 2002 where natural cover has closed canopy, but dropped to 0% in 2007.

Where other vegetation performs a soil conservation role in natural canopy gaps, bare soil was:

- un-measured in presence of natural ground cover (rush, sedge, flax or fern) in 2002, but 1.33% in 2007
- 0% in presence of exotic ground cover (rank grass or weeds) in 2002, but 0.25% in 2007
- 0.28% in presence of natural scrub or trees in 2002, and slightly lower at 0.23% in 2007
- 0% in presence of soil conservation or wildling exotic trees at both dates.

7.4 Cautionary comment

Effectiveness of soil conservation is measured by calculating bare soil as a percentage of land under different uses, and under various standards of conservation cover within each use. A previous assessment (Hicks 2006) calculated these measures for the West Coast catchment management zone as a whole, but not for individual catchments such as the Kawhia (185 points out of 1060 zone-wide) because for these, there were few sample points for each standard of conservation cover, so measures of effectiveness had high error margins.

Sections 6 and 7 of the current assessment have presented the same measures, calculated from a larger sample in the Kawhia (500 points) in 2007. The bigger sample has increased sub-sample sizes for different standards of conservation cover, and tightened error margins. However the downside is that it entails comparing 2002 sub-samples that have high error margins, with 2007 samples that have low error margins. The consequence is that trends are evident in the numbers, but the changes are not statistically significant so we cannot be sure that they are real.

Representative catchment data has proven useful in the past for assessing extent and effectiveness of soil conservation measures at a point in time. But this re-survey has revealed a statistical problem in using it to ascertain change between two points in time. A separate report (Hicks, 2010) reviews the problem and suggests a modified approach for EW to consider. The modified approach entails a single catchment-wide summary of land use's, and soil conservation's, extent and effect. Its results are presented in Sections 8 and 9, followed by conclusions in Section 10.

8 Land uses' extent and effect catchment-wide

Table 11: Land Uses' extent and effect, Kawhia catchment

	Land in category, as % of catchment		Bare soil caused by land use, as % of category	
	Kawhia 2002	Kawhia 2007	Kawhia 2002	Kawhia 2007
Natural vegetation	38.9	44.0	0.00	0.04
Forest plantations	3.8	1.6	0.00	<0.01
Farmland	56.2	49.8	0.28	0.27
Buildings, quarries, roads etc.	1.1	4.6	0.00	0.15

Between 2002 and 2007:

- Land in natural vegetation (includes reverting land with residual rank grass or exotic scrub) increased from 38.9 to 44.0% of the Kawhia catchment. On land in natural vegetation, bare soil caused by land use-related activities increased from 0.00% to 0.04% of the catchment's area.
- Land in forest plantations decreased from 3.8% to 1.6%. On land in forest plantations, bare soil caused by land use-related activities increased very slightly, from 0% of the catchment's area in 2002 to <0.01% in 2007.
- Farmland decreased from 56.2% to 49.8%. On farmland, bare soil caused by land use-related activities decreased very slightly, from 0.28% of the catchment's area in 2002 to 0.27% in 2007.

- Land occupied by rural buildings, urban areas, quarries, roads, shorelines or water bodies increased from 1.1% to 4.6%. Bare surfaces caused by land use-related activities increased from 0% of the catchment's area in 2002 to 0.15% in 2007. However these increases are apparent, not real; they are a result of changes in measurement technique (recording rural roads, and measuring bare surfaces associated with extensive disturbance).

9 Soil conservation cover's extent and effect catchment-wide

Table 12: Soil Conservation cover's extent and effect, Kawhia catchment

	Land in category, as % of catchment		Bare soil caused by erosion or deposition, as % of category	
	Kawhia 2002	Kawhia 2007	Kawhia 2002	Kawhia 2007
Natural vegetation	38.9	44.0	0.47	0.07
Forest plantations	3.8	1.6	0.00	0.00
Farmland with planted s.c. cover	5.9	4.8	0.00	0.02
Farmland with residual s.c. cover	13.0	16.4	0.05	0.03
Farmland with natural s.c. cover	7.0	8.8	0.15	0.05
Farmland, s.c. cover needed but absent	12.4	7.4	0.10	0.03
Farmland, s.c. cover not needed	17.8	12.4	0.00	0.00
Roads, buildings, etc.	1.1	4.6	0.00	<0.01

Between 2002 and 2007:

- Land in natural vegetation (includes reverting land with residual rank grass or exotic scrub) increased from 38.9 to 44.0% of the Kawhia catchment. On land in natural vegetation, bare soil caused by erosion or deposition decreased from 0.47% to 0.07% of the catchment's area.
- Land in forest plantations decreased from 3.8% to 1.6%. On land in forest plantations, bare soil remained 0% of the catchment's area at both dates.
- Farmland with natural soil conservation cover (bush, scrub, fern or wetland retained in pasture) increased from 7.0% to 8.8%. On this land bare soil decreased from 0.15% to 0.05% of the catchment's area between dates.
- Farmland with residual soil conservation cover (rank grass, marram or exotic scrub in pasture) increased from 13.0% to 16.4%. Here bare soil decreased slightly, from 0.05% to 0.03% of the catchment's area.
- Farmland with planted soil conservation cover (poplars, willows or other exotic trees in pasture) decreased from 5.9% to 4.8%. Here bare soil increased slightly, from 0% to 0.02% of the catchment's area.

- Farmland where soil conservation cover is needed but absent (unstable land in open pasture) decreased from 12.4% to 7.4%. On this land bare soil decreased from 0.10% to 0.03% of the catchment's area.
- Farmland where soil conservation cover is not needed (stable land in open pasture) decreased from 17.8% to 12.4%. Here bare soil remained 0% of the catchment's area.
- Land occupied by rural buildings, urban areas, quarries, roads, shorelines or water bodies increased from 1.1% to 4.6% (but most of the increase is due to recording rural roads for the first time). On this extensively disturbed land, bare soil caused by natural processes increased very slightly, from 0% to less than 0.01% of the catchment's area.

On 30% where some form of soil conservation cover is present on farmland, bare soil decreased to 0.10% of catchment area i.e. 0.33% of the area under soil conservation cover. On 7% where it is needed but absent, bare soil decreased to 0.03% of the catchment area i.e. 0.41% of the area without soil conservation cover.

10 Conclusions

In the Kawhia catchment between 2002 and 2007, areas of farmed land and forest plantations have decreased slightly, while the areas of natural vegetation (includes land reverting to scrub) and non-rural uses have increased.

Bare soil caused by land use has increased catchment-wide, but is still less than 1% of catchment area. When broken down into categories, most of the apparent increase is due to measuring bare surfaces associated with extensive disturbance (particularly by rural roads) for the first time in 2007. Other increases in bare soil, amongst natural vegetation and forest plantations, are statistically significant though small. The small decline in bare soil on farmland is not statistically significant.

Changes in soil conservation cover 2002-2007 are measurable but minor. They are within statistical margins of error, so cannot be regarded as significant. In short, there has been little change in extent or type of soil conservation cover over the five years.

Bare soil exposed by natural processes of erosion or deposition has decreased for all categories of soil conservation cover 2002-2007, except for planted cover in farmland where there has been a slight increase. However, all the other changes are statistically insignificant because bare soil was already well below 1% of catchment area in 2002. In short, existing soil conservation cover has performed its role, because there has been little natural erosion or deposition of soil during the five years between 2002 and 2007 and even less where soil conservation cover is present.

The same conclusions apply to the West Coast catchment zone as a whole. This has been demonstrated by a parallel analysis of soil stability and disturbance in relation to soil conservation cover, from a sub-set of Environment Waikato's regional point sample (see Appendix B).

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Appendix A Data Summary Spreadsheets for Kawhia Catchment

Spreadsheet 1 Soil stability (intact, disturbed and bare), 2007

		Points	% of points sampled		Bare soil as % of catchment's area		
				95% confidence limit		95% confidence limit	
INTACT SOIL							
	<i>(i) on stable landforms</i>	135	27.0	3.9	0.00	0.00	
	<i>(ii) on unstable landforms</i>	195	39.0	4.3	0.00	0.00	
RECENTLY DISTURBED SOIL							
	<i>(i) by land use</i>	now incl. categories	with other	-	-	-	
	<i>(ii) by erosion</i>	40	8.0	2.4	0.00	0.00	
FRESHLY DISTURBED SOIL							
	<i>(i) by land use</i>	grazing pressure	11	2.2	1.3	0.04	0.03
		cultivation	0	0.0	0.0	0	0.00
		harvest	1	0.2	0.4	<0.01	<0.01
		spraying	0	0.0	0.0	0	0.00
		drains	0	0.0	0.0	0	0.00
		tracks	51	10.2	2.7	0.24	0.08
		earthworks	1	0.2	0.4	<0.01	<0.01
		roads	5	1.0	0.9	0.04	0.04
		sub-total	69	13.8	3.0	0.32	0.19
	<i>(ii) by erosion</i>	landslide	4	0.8	0.8	0.02	0.02
		debris avalanche	0	0.0	0.0	0	0.00
		slump or earthflow	3	0.6	0.7	0.02	0.02
		large slope failure	1	0.2	0.4	<0.01	<0.01
		tunnel gully	0	0.0	0.0	0	0.00
		gully	5	1.0	0.9	0.11	0.12
		large gully	0	0.0	0.0	0	0.00
		streambank scour	8	1.6	1.1	0	0.00
		streambank deposit	7	1.4	1.0	0	0.00
		sandblow	0	0.0	0.0	0	0.00

		Points	% of points sampled		Bare soil as % of catchment's area	
				95% confidence limit		95% confidence limit
	sheetwash or scree	0	0.0	0.0	0	0.00
	rockfall	10	2.0	1.2	0.05	0.04
	sub-total	38	7.6	2.3	0.21	0.08
<i>Soil covered or removed</i>	buildings plus quarries	5	1.0	0.9	0.09	0.16
	open space	0	0.0	0.0	0	0.00
	roads, railways, airfields	15	3.0	1.5	0.06	0.06
	sub-total	20	4.0	1.7	0.15	0.17
<i>Soil absent</i>	lake	3	0.6	0.7	0	0.00
	riverbed	0	0.0	0.0	0	0.00
	geothermal area	0	0.0	0.0	0	0.00
	sub-total	3	0.6	0.7	0.00	0.00
ALL SOIL IN CATCHMENT		500	100.0	0.0	0.68	0.21

Spreadsheet 2 Soil Conservation cover on land in agricultural use, 2007

	sample points	% of catchment		sample points	% of all land	soil exposed by land use	
All land	249	49.8	where primary cover is:			% of category	95% conf. lim.
			<i>sparse pasture</i>	55	22.1	1.05	0.36
			<i>dense pasture</i>	193	77.5	0.47	0.18
			<i>harvested pasture</i>	1	0.4	0.00	0.00
		% of land use		sample points	% of all land	soil exposed by erosion	
Unstable land	187	75.1	where secondary cover is:			% of category	95% conf. lim.
			<i>absent from pasture</i>	37	19.8	0.35	0.35
			<i>scattered rush, sedge and fern</i>	9	4.8	0.33	0.62
			<i>scattered rank grass and weeds</i>	33	17.6	0.45	0.50
			<i>extensive rush, sedge and fern</i>	14	7.5	0.07	0.13
			<i>extensive rank grass and weeds</i>	11	5.9	0.18	0.34
			<i>scattered natural scrub and trees</i>	30	16.0	0.60	0.44
			<i>scattered soil conservation trees</i>	15	8.0	0.47	0.41
			<i>extensive natural scrub and trees</i>	29	15.5	0.31	0.35
			<i>extensive soil conservation trees</i>	9	4.8	0.33	0.44

Spreadsheet 3 Soil conservation cover (extent, standard, effectiveness) on land in forest plantations, 2007

	sample points	% of catchment		sample points	% of all land	soil exposed by land use	
All land	8	1.6	where primary cover is:			% of category	95% conf. lim.
			<i>pinus (open canopy)</i>	2	25.0	0.00	0.00
			<i>pinus (closed canopy)</i>	6	75.0	0.33	0.60
			<i>pinus (harvested)</i>	0	0.0	0.00	0.00
		% of land use		sample points	% of unstable land	soil exposed by erosion	
Unstable land	5	62.5	where secondary cover is:			% of category	95% conf. lim.
			<i>absent (no canopy gaps)</i>	1	20.0	0.00	0.00
			<i>rush, sedge, flax, or fern</i>	1	20.0	0.00	0.00
			<i>rank grass or weeds</i>	1	20.0	0.00	0.00
			<i>natural scrub or trees</i>	2	40.0	0.00	0.00
			<i>soil conservation or wildling trees</i>	0	0.0	0.00	0.00

Spreadsheet 4 Soil conservation cover (extent, standard, effectiveness) on land in natural vegetation, 2007

	sample points	% of catchment		sample points	% of all land	soil exposed by land use	
All land	220	44.0	where primary cover is:			% of category	95% conf. lim.
			<i>scrub or trees (open canopy)</i>	167	75.9	0.13	0.10
			<i>scrub or trees (closed canopy)</i>	53	24.1	0.00	0.00
			<i>scrub or trees (harvested)</i>	0	0.0	0.00	0.00
		% of land use		sample points	% of unstable land	soil exposed by erosion	
Unstable land	139	63.2	where secondary cover is:			% of category	95% conf. lim.
			<i>absent (no canopy gaps)</i>	21	15.1	0.00	0.00
			<i>rush, sedge, flax, or fern</i>	9	6.5	1.33	2.46
			<i>rank grass or weeds</i>	44	31.7	0.25	0.28
			<i>natural scrub or trees</i>	63	45.3	0.23	0.20
			<i>soil conservation or wildling trees</i>	2	1.4	0.00	0.00

	Points:		Points as % of sample:		Significant change?:
	2002	2007	2002	2007	
Stable surfaces					
with intact soil	49	135	26.5	27.0	
95% conf. limit			6.4	3.9	N
with soil disturbed by land use	1	11	0.5	2.2	
95% conf. limit			1.1	1.3	N
Erosion-prone surfaces					
with intact soil	93	195	50.3	39.0	
95% conf. limit			7.2	4.3	N
with soil disturbed by land use	5	58	2.7	11.6	
95% conf. limit			2.3	2.8	Y
Eroded and eroding surfaces					
with revegetating soil	24	40	13.0	8.0	
95% conf. limit			4.8	2.4	N
with soil disturbed by natural processes	11	38	5.9	7.6	
95% conf. limit			3.4	2.3	N
Extensively disturbed surfaces					
rural buildings etc.	0	18	0.0	3.6	
95% conf. limit			0.0	1.6	Y
urban areas etc.	2	2	1.1	0.4	
95% conf. limit			1.5	0.6	N
shorelines etc.	0	3	0.0	0.6	
95% conf. limit			0.0	0.7	Y
All surfaces					
as percentage of sample	185	500	100.0	100.0	

Note 1: " % of region" sub-totals/totals may differ by 0.01% due to rounding

Note 2: confidence limits are not additive

Spreadsheet 6 Changes in Bare Soil, Kawhia Catchment, 2002 - 2007

	Disturbed points		Bare soil as % of region:		Significant change?:
	2002	2007	2002	2007	
By land use:					
grazing pressure	1	11	0.03	0.04	
95% conf.			0.05	0.03	N
Cultivation	1		0.03		
95% conf.			0.06		Y
Harvest		1		<0.01	
95% conf.				<0.01	Y
Spraying					
95% conf.					
Drains					
95% conf.					
Tracks	4	51	0.22	0.24	
95% conf.			0.21	0.08	N
Earthworks		1		<0.01	
95% conf.				<0.01	Y
Roads	not rec	5		0.04	
95% conf.				0.04	-
All rural land use disturbance	6	69	0.28	0.32	
95% conf.			0.22	0.09	N
By natural processes:					
landslide	4	4	0.21	0.02	
95% conf.			0.23	0.02	N
debris avalanche					
95% conf.					
slump or earthflow	2	4	0.04	0.02	
95% conf.			0.05	0.02	N
tunnel gully					
95% conf.					
gully	4	5	0.11	0.02	
95% conf.			0.12	0.01	N
streambank scour		8		0.03	
95% conf.				0.02	Y
streambank deposit		7		0.07	
95% conf.				0.06	Y
sandblow	1		0.41		
95% conf.			0.80		Y
sheetwash					
95% conf.					
rockfall or bare rock		10		0.05	
95% conf.				0.04	Y
geothermal					
95% conf.					

All rural natural disturbance	11	38	0.77	0.21	
95% conf.			0.84	0.08	N
Extensive disturbance:					
rural buildings etc.	not rec.	9	0.00	0.15	
			0.00	0.17	Y
urban areas etc.	not rec.	0		0.00	
				0.00	-
shorelines etc:	not rec.	0		0.00	
				0.00	-
All extensive disturbance	Not rec.	9	0.00	0.15	
			0.00	0.17	Y
All disturbance:	17	116	1.05	0.68	
95% conf.			0.86	0.21	N

Spreadsheet 7 Land Uses' Extent and Effect, Kawhia Catchment, 2002 - 2007

	2002	2007	2002	2007		2002	2007	
Sample points	185	500	Land in category			Bare soil caused by land use		
			as % of catchment		Signif. change?	as % of catchment		Signif. change?
Natural vegetation	72	220	38.9	44.0		0.00	0.04	
95% c.i.			7.0	4.4	N	0.00	0.03	Y
Forest plantations	7	8	3.8	1.6		0.00	<0.01	
95% c.i.			2.7	1.1	N	0.00	0.01	Y
Farmland	104	249	56.2	49.8		0.28	0.27	
95% c.i.			7.1	4.4	N	0.22	0.08	N
Roads, rural buildings, urban areas, etc.	2	23	1.1	4.6		0.00	0.15	
95% c.i.			1.5	1.8	Y	0.00	0.17	Y
All land in catchment	185	500	100.0	100.0		0.28	0.47	
95% c.i.			-	-	-	0.22	0.19	N

Spreadsheet 8 Soil Conservation Cover's Extent and Effect, Kawhia Catchment, 2002 - 2007

	2002	2007	2002	2007		2002	2007	
Sample points	185	500	Land in category			Bare soil caused by erosion or deposition		
			as % of catchment		Signif. change?	as % of catchment		Signif. change?
Natural vegetation	72	220	38.9	44.0		0.47	0.07	
95% c.i.			7.0	4.4	N	0.81	0.06	N
Forest plantations	7	8	3.8	1.6		0.00	0.00	
95% c.i.			2.7	1.1	N	0.00	0.00	N
Farmland with planted soil conservation cover	11	24	5.9	4.8		0.00	0.02	
95% c.i.			3.4	1.9	N	0.00	0.02	Y
Farmland with residual soil conservation cover	24	82	13.0	16.4		0.05	0.03	
95% c.i.			4.8	3.2	N	0.08	0.04	N
Farmland with natural soil conservation cover	13	44	7.0	8.8		0.15	0.05	
95% c.i.			3.7	2.5	N	0.18	0.04	N
Farmland, soil conservation cover absent	23	37	12.4	7.4		0.10	0.03	
95% c.i.			4.8	2.3	N	0.15	0.03	N
Farmland, soil conservation cover not needed	33	62	17.8	12.4		0.00	0.00	
95% c.i.			5.5	2.9	N	0.00	0.00	N
Roads, rural buildings, urban areas, etc.	2	23	1.1	4.6		0.00	<0.01	
95% c.i.			1.5	1.8	Y	0.00	<0.01	Y
All land in catchment	185	500	100.0	100.0		0.77	0.21	
95% c.i.			-	-	-	0.84	0.08	N

Note 1: " % of region" sub-totals/totals may differ by 0.01% due to rounding

Note 2: confidence limits are not additive

Appendix B Data Summary Spreadsheets for West Coast Management Zone, 2007

Table 1 Summary of Soil Stability for Waikato West Coast Catchments, 2007

		Points	% of points sampled		Bare soil as % of catchment's area	
					95% confidence limit	95% confidence limit
INTACT SOIL						
<i>(i) on stable landforms</i>						
		301	28.4	2.7	0.00	0.00
<i>(ii) on unstable landforms</i>						
		287	27.1	2.7	0.00	0.00
RECENTLY DISTURBED SOIL						
<i>(i) by land use</i>						
		now incl. with other categories			0.00	0.00
<i>(ii) by erosion</i>						
		159	14.8	2.1	0.00	0.00
FRESHLY DISTURBED SOIL						
<i>(i) by land use</i>						
	grazing pressure	28	2.6	1.0	0.08	0.03
	cultivation	1	0.1	0.2	0.04	0.08
	harvest	3	0.3	0.3	0.03	0.05
	spraying	1	0.1	0.2	<0.01	<0.01
	drains	3	0.3	0.3	0.02	0.02
	tracks	112	10.6	1.9	0.48	0.10
	earthworks	3	0.3	0.3	0.03	0.03
	unsealed roads	8	0.8	0.5	0.05	0.04
	sub-total	159	15.0	2.2	0.73	0.15
<i>(ii) by erosion</i>						
	landslide	46	4.3	1.2	0.16	0.05
	debris avalanche	11	1.0	0.6	0.05	0.03
	slump or earthflow	6	0.6	0.5	0.01	0.01
	large slope failure		0.0	0.0		
	tunnel gully	4	0.4	0.4	0.01	0.01
	gully	22	2.1	0.9	0.06	0.03
	large gully		0.0	0.0		
	streambank scour	16	1.5	0.7	0.03	0.02
	streambank deposit	4	0.4	0.4	0.04	0.04
	sandblow	7	0.7	0.5	0.29	0.28
	sheetwash or scree		0.0	0.0		
	rockfall	14	1.3	0.7	0.06	0.03
	sub-total	130	12.3	2.0	0.70	0.29
EXTENSIVELY DISTURBED SOIL						

<i>Soil covered or removed</i>	buildings	8	0.8	0.5	0.01	0.01
	open space	1	0.1	0.2	0.01	0.03
	roads, railways, airfields	11	1.0	0.6	0.02	0.03
	sub-total	20	1.9	0.8	0.04	0.04
<i>Soil absent</i>	lake	4	0.4	0.4	0.10	0.14
	riverbed		0.0	0.0		
	geothermal area		0.0	0.0		
	sub-total	4	0.4	0.4	0.10	0.14
ALL SOIL IN CATCHMENT		1060	100.0	0.0	1.57	0.37

Table 2 Soil Conservation Cover on Land in Agricultural Use, Waikato West Coast Catchments, 2007

	sample points	% of area		sample points	% of all land	soil exposed by land use	
All land	583	55.1	where primary cover is:			% of category	95% conf. lim.
			<i>sparse pasture</i>	193	33.1	1.19	0.40
			<i>dense pasture</i>	389	66.7	0.96	0.33
			<i>harvested pasture</i>	1	0.2	4.00	7.84
		% of land use		sample points	% of all land	soil exposed by erosion	
Unstable land	350	60.0	where secondary cover is:			% of category	95% conf. lim.
			<i>absent from pasture</i>	109	31.1	2.44	1.71
			<i>scattered rush, sedge and fern</i>	29	8.3	0.59	0.45
			<i>scattered rank grass and weeds</i>	33	9.4	0.42	0.37
			<i>extensive rush, sedge and fern</i>	17	4.9	0.59	0.52
			<i>extensive rank grass and weeds</i>	17	4.9	0.82	0.64
			<i>scattered natural scrub and trees</i>	68	19.4	1.06	0.52
			<i>scattered soil conservation trees</i>	29	8.3	0.89	0.60
			<i>extensive natural scrub and trees</i>	29	8.3	1.38	1.58
			<i>extensive soil conservation trees</i>	19	5.4	0.68	0.62

Table 5 Changes in Soil Stability & Disturbance Throughout Waikato West Coast Catchments

	Points:		Points as % of sample:		Significant change?:
	2002	2007	2002	2007	
Stable surfaces					
with intact soil	314	301	29.7	28.4	
95% conf. limit			2.8	2.7	N
with soil disturbed by land use	25	82	2.4	7.8	
95% conf. limit			0.9	1.6	Y
Erosion-prone surfaces					
with intact soil	478	287	45.2	27.1	
95% conf. limit			3.0	2.7	N
with soil disturbed by land use	24	77	2.3	7.3	
95% conf. limit			0.9	1.6	Y
Eroded and eroding surfaces					
with revegetating soil	134	159	12.7	14.8	
95% conf. limit			2.0	2.1	N
with soil disturbed by natural processes	63	130	6.0	12.3	
95% conf. limit			1.4	2.0	Y
Extensively disturbed surfaces					
rural buildings etc.	16	18	1.5	1.7	
95% conf. limit			0.7	0.8	N
urban areas etc.	2	2	0.2	0.2	
95% conf. limit			0.3	0.3	N
shorelines etc.	2	4	0.2	0.4	
95% conf. limit			0.3	0.4	N
All surfaces					
as percentage of sample	1058	1060	100.0	100.0	

Note 1: " % of region" sub-totals/totals may differ by 0.01% due to rounding

Note 2: confidence limits are not additive

Table 6 Changes in Bare Soil, Waikato West Coast Catchments

	Disturbed points		Bare soil as % of region:		Significant change?:
	2002	2007	2002	2007	
By land use disturbance:					
grazing pressure	9	28	0.04	0.08	
95% conf.			0.03	0.03	N
Cultivation	3	1	0.09	0.04	
95% conf.			0.13	0.08	N
Harvest	6	3	0.09	0.03	
95% conf.			0.11	0.05	N
Spraying	0	1	-	<0.01	
95% conf.			-	<0.01	Y
Drains	3	3	0.04	0.02	
95% conf.			0.04	0.02	N
Tracks	28	112	0.26	0.48	
95% conf.			0.10	0.10	Y
Earthworks	0	3	-	0.03	
95% conf.			-	0.03	Y
Roads	not rec. in 2002	8	-	0.05	
95% conf.			-	0.04	-
all rural land use disturbance	49	159	0.52	0.73	
95% conf.			0.20	0.15	N
By natural processes:					
Landslide	15	46	0.12	0.16	
95% conf.			0.08	0.05	N
debris avalanche	5	11	0.06	0.05	
95% conf.			0.07	0.03	N
slump or earthflow	20	6	0.12	0.01	
95% conf.			0.07	0.01	Y
tunnel gully	0	4	-	0.01	
95% conf.			-	0.01	Y
gully	15	22	0.07	0.06	
95% conf.			0.04	0.03	N
streambank scour	2	16	0.01	0.03	
95% conf.			0.01	0.02	N
streambank deposit	1	4	0.02	0.04	
95% conf.			0.05	0.04	N
sandblow	3	7	0.17	0.29	
95% conf.			0.19	0.28	N
sheetwash	0	0	-	-	
95% conf.			-	-	-
rockfall or bare rock	2	14	0.02	0.06	
95% conf.			0.03	0.03	N
geothermal	0		-	-	

	Disturbed points		Bare soil as % of region:		Significant change?:
	2002	2007	2002	2007	
95% conf.			-	-	-
all rural natural disturbance	63	130	0.59	0.70	
95% conf.			0.23	0.29	N
By extensive disturbance:					
rural buildings etc.	not rec.	6	0.00	0.04	
			0.00	0.04	Y
urban areas etc.	not rec.	0	-	0.00	
			-	0.00	-
shorelines etc:	not rec.	4	-	0.10	
			-	0.14	-
all other disturbance	0	10	0.00	0.14	
			0.00	0.14	Y
All disturbance:	112	299	1.11	1.57	
95% conf.			0.30	0.37	N

Note 1: " % of region" sub-totals/totals may differ by 0.01% due to rounding

Note 2: confidence limits are not additive

Table 7 Land Uses' Extent and Effect, West Coast Catchment Management Zone

	2002	2007	2002	2007		2002	2007	
Sample points	1058	1060	Land in category			Bare soil caused by land use		
			as % of catchment		Signif. change?	as % of catchment		Signif. change?
Natural vegetation	349	366	33.0	34.5		0.08	0.08	
95% c.i.			2.8	2.9	N	0.01	0.04	N
Residual vegetation	28	31	2.6	2.9		0.01	0.02	
95% c.i.			1.0	1.0	N	0.02	0.02	N
Forest plantations	48	53	4.5	5.0		0.03	0.05	
95% c.i.			1.3	1.3	N	0.03	0.05	N
Farmland	613	586	57.9	55.3		0.39	0.57	
95% c.i.			3.0	3.0	N	0.17	0.14	N
Rural buildings, urban areas, etc.	18	20	1.7	1.9		0.00	0.04	
95% c.i.			0.8	0.8	N	0.00	0.04	Y
Shorelines and waterbodies	2	4	0.2	0.4		0.00	<0.01	
95% c.i.			0.3	0.4	N	0.00	<0.01	Y
All land in catchment	1058	1060	100.0	100.0		0.51	0.77	
95% c.i.			-	-	-	0.21	0.15	N

Table 8 Soil Conservation Cover's Extent and Effect, West Coast Catchment Management Zone

	2002	2007	2002	2007		2002	2007	
Sample points	1058	1060	Land in category			Bare soil caused by erosion or deposition		
			as % of catchment		Signif. change?	as % of catchment		Signif. change?
Natural vegetation	349	366	33.0	34.5		0.09	0.08	
95% c.i.			2.8	2.9	N	0.07	0.04	N
Residual vegetation	28	31	2.6	2.9		0.12	0.16	
95% c.i.			1.0	1.0	N	0.16	0.22	N
Forest plantations	48	53	4.5	5.0		0.01	0.01	
95% c.i.			1.3	1.3	N	0.01	0.01	N
Farmland with planted soil conservation cover	34	50	3.2	4.7		0.01	0.05	
95% c.i.			1.1	1.3	N	0.01	0.04	N
Farmland with residual soil conservation cover	147	143	13.9	13.5		0.01	0.03	
95% c.i.			2.1	2.1	N	0.01	0.02	N
Farmland with natural soil conservation cover	44	48	4.2	4.5		0.10	0.13	
95% c.i.			1.2	1.3	N	0.06	0.06	N
Farmland, soil conservation cover absent	181	236	17.1	22.3		0.27	0.23	
95% c.i.			2.3	2.5	Y	0.15	0.18	N
Farmland, soil conservation cover not needed	207	109	19.6	10.3		0.00	0.00	
95% c.i.			2.4	1.8	Y	0.00	0.00	N
Rural buildings, urban areas, etc.	18	20	1.7	1.9		0.00	<0.01	
95% c.i.			0.8	0.8	N	0.00	<0.01	Y
Shorelines and waterbodies	2	4	0.2	0.4		0.00	0.10	
95% c.i.			0.3	0.4	N	0.00	0.14	Y
All land in catchment	1058	1060	100.0	100.0		0.59	0.80	
95% c.i.			-	-	-	0.24	0.32	N