

Soil Conservation Survey of the Pokaiwhenua Catchment

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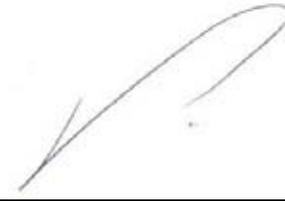
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Introduction

These notes summarise the results of a survey carried out in January 2005 at the request of Environment Waikato. The survey's purpose is to ascertain extent of vegetative soil conservation cover in the Pokaiwhenua catchment, and measure what changes in the percentage of bare ground have accrued from them. This information is required for a 5-year review of soil conservation's costs and benefits in the Middle Waikato sub-catchments.

The Pokaiwhenua has been selected by Environment Waikato staff because they regard it as typical of land in the Middle Waikato sub-catchments in terms of terrain, land use, and types of soil conservation measure. It is approximately 472 square kilometres in extent, draining westward from the Mamaku plateau past Tokoroa and entering the Waikato at Lake Arapuni. The headwaters are a high plateau of ignimbrite, dissected into narrow steep-sided gorges where streams descend its edge. Middle reaches are an undulating ignimbrite plateau mantled by pumice and ash. Lower reaches are moderately steep hill country; ignimbrite with patchy ash cover on slopes, and terraces of waterlaid pumiceous alluvium in valley bottoms.

Environment Waikato wishes to :

- Identify how much land needs soil conservation in the Pokaiwhenua catchment,
- Ascertain whether such land has vegetative soil conservation measures. These may be spaced tree plantings in pasture, close afforestation with commercial tree species, or natural vegetation (retained, reverting or planted),
- Obtain measurements of any changes in soil erosion or disturbance where vegetative soil conservation measures are present.

Its brief does not entail mapping exact locations and types of measure on all land in the Pokaiwhenua - to do so would take a great deal of time - rather, to obtain reliable summary measurements for the catchment from 2002 and 1992 aerial photographs.

1 Method

Survey design is the same as for earlier surveys in the Matahuru and Mangarama catchments (Hicks 2001a, 2001b). It combines two elements of state-of-environment survey :

- point sampling,
- recording of land as either stable, unstable, recently eroded or freshly eroded, with four elements of soil conservation effectiveness survey :
- whether land needs treatment,
- what type of treatment is required,
- what treatment is present,
- whether its extent is sufficient.

Retaining these features enables Pokaiwhenua results to be compared with results from the earlier surveys, despite changes in measurement method detailed below.

Measurement method incorporates technical improvements made possible by Environment Waikato's (EW's) 2002 aerial photographic coverage. This is colour aerial photography, rectified to fit a map grid, scanned, and installed as a layer in EW's geographic information system (GIS). It enabled :

- random selection of sample points (two per square kilometre),
- on-screen photo-interpretation of landform stability and vegetative soil conservation cover at a viewing scale of 1:10000,
- measurement of bare ground due to erosion or other soil disturbance, within a one hectare area around each sample point,
- simultaneous data entry into a GIS attribute layer.

Data were copied from the GIS attribute layer into an Excel spreadsheet, checked for consistency and corrected where necessary, then sorted into categories. Point counts were carried out for each category and converted to percentages of the sample. Averages and standard errors were calculated where appropriate.

2 Results

2.1 Landform Stability

998 points were sampled. Their distribution is :

S	Stable landforms	532
U	Unstable inactive (vegetated)	291
R	Unstable recently eroded (revegetating)	77
E	Unstable freshly eroded (bare)	98

Table 1 gives margins of error, and a more detailed break-down of data by landform. 53% of the catchment is occupied by stable landforms, not at risk from natural erosion, such as ash-mantled downlands and elevated terraces. The proportion of unstable land is 47%. These are landforms such as swales on downlands (risk of tunnel or gully erosion), terrace scarps (risk of gullies or landslides), steep hillslopes (risk of landslides), streambanks (risk of bank scour), and floodways (risk of scour or siltation). Out of the 47%, 29% shows signs of past erosion but is currently inactive and well-vegetated. 8% shows signs of recent erosion that is now revegetating. Another 11% shows signs of fresh erosion i.e. patches of bare ground. Note that this is land where erosion is present in some of its area. Actual percentage of bare ground is less (see Soil Disturbance section).

Table 1: Landform Stability, Pokaiwhenua Catchment.

Landforms					Stability			
		All landforms			Stable	Unstable		
						inactive	recently eroded	freshly eroded
		n	% of catchment	+ 2 s.e.	n	n	n	n
Floodways & streambanks		103	10.3	1.9	0	40	29	34
Terraces		151	15.1	2.2	127	16	1	7
Downlands		466	46.7	3.1	300	118	16	32
Hillslopes		226	22.6	2.6	60	115	29	22
Ridges		52	5.2	1.4	45	2	2	3
Totals	n	998	100.0	0.0	532	291	77	98
		% of catchment stable or unstable:			53.3	29.2	7.7	9.8
		+ 2 s.e.:			3.1	2.8	1.7	1.8

2.2 Need for Conservation Measures

This was assessed for each of the unstable points (U, R and E), using the following criteria :

- No fresh or recent erosion : no soil conservation cover needed
- Streambank erosion : spaced tree planting in pasture
- Streambank deposition : retention of/reversion to natural cover
- Streambank erosion and deposition (combined) : retention of/reversion to natural cover and spaced tree planting
- Tunnel erosion : spaced tree planting in pasture
- Gully erosion : spaced tree planting
- Gully and streambank erosion (combined) : spaced tree planting
- Slip erosion : close tree planting
- Slip and streambank erosion (combined) : close tree planting and spaced tree planting
- Rock outcrops : retention of/reversion to natural cover

Note that these are optimal measures (another measure or some combination may also be acceptable for erosion control). For 466 unstable points sampled, an optimal distribution of measures according to need is:

N	None	141
S	Spaced trees	252
SS	Spaced trees and spaced trees	7
SR	Spaced trees and natural cover	9
C	Close trees	36
CS	Close trees and spaced trees	6
CR	Close trees and natural cover	0
R	Natural cover	15

Out of 466 unstable points, 141 (30%) are well-vegetated and do not appear to have been active for a very long time, so have been rated as not requiring treatment.

325 points show signs of erosion within recent decades - old scars which have re-grassed, reverted to scrub or wetland, or been planted with trees.

Of these, 252 (55%) have been rated as needing spaced tree planting in pasture - to control streambank erosion, tunnels (soil pipes) or gullies. A further 7 (2%) have been rated as needing additional spaced planting to control streambank erosion associated with tunnels or gullies. Another 9 (2%) have been rated as needing natural cover to control deposition associated with streambank erosion.

36 (7%) have been rated as needing close tree planting, either commercial timber species or soil conservation species - to control gully or landslide erosion. A further 6 (1%) have been rated as needing a combination of close planting with spaced planting to control additional streambank erosion.

15 (3%) have been rated as needing retention of natural cover - to control streambank deposition in floodways, or to minimise sheet erosion on shallow soils with rocky outcrops.

Table 2 gives sample error margins, and a more detailed break-down of data by erosion risk.

Table 2: Need for Soil Conservation Measures, Pokaiwhenua Catchment

	All landforms			Landforms needing measures :							
				None	Spaced trees	Spaced trees + spaced trees	Spaced trees + natural cover	Close trees	Close trees + spaced trees	Close trees + natural cover	Natural cover
	n	% of catchment	+ - 2 s.e.	n	n	n	n	n	n	n	n
Stable landforms :	532	53.3	3.1	532							
Unstable landforms :	466	46.7	3.1								
Reason for measures :											
None	141	14.1	2.2	141							
Streambank erosion	90	9.0	1.8		90						
Streambank deposition	5	0.5	0.4								5
Streambank erosion & deposition	7	0.7	0.5				9				
Tunnel erosion	94	9.4	1.8		94						
Gully erosion	70	7.0	1.6		68						
Gully and streambank erosion	7	0.7	0.5			7					
Landslide erosion	34	3.4	1.1					36			
Landslide and streambank erosion	6	0.6	0.5						6		
Rock outcrops	12	1.2	0.7								10
n	998	100.0	0.0	141	252	7	9	36	6	0	15
as % of unstable landforms :				30.3	54.1	1.5	1.9	7.7	1.3	0.0	3.2
+ - 2 s.e. :				2.9	3.1	0.8	0.9	1.7	0.7	0.0	1.1

2.3 Extent of Measures

Spaced tree plantings, close tree plantings, and retained/reverting natural cover have been recorded at any sample points where they are present. Percentage cover has been ascertained by counting 100 points overlaid on a one hectare area at each sample point. At the 532 stable and 141 unstable but inactive points, these vegetation covers are likely to have been planted or retained for other reasons e.g. commercial and amenity value. At the 325 unstable points where soil conservation measures are needed, the vegetation may or may not be intentionally planted. In each instance, its soil conservation value has been rated as absent (a), present but inappropriate (x), present but insufficient (i), or present and sufficient (s). Criteria for assessing measures were :

Streambank erosion, streambank deposition :

These features are linear, typically passing through a sample area from one side to the other, so about 10% cover is needed for effective erosion control.

If pasture : absent

If close tree plantings : inappropriate

If 1 - 9% spaced tree plantings or scrub reversion or retained natural cover : insufficient

If 10% or greater spaced tree plantings or scrub reversion or retained natural cover : sufficient

Tunnel erosion, gully erosion :

These features are semi-linear i.e. branch but rarely pass through a sample area. Typically between 10 and 20% cover is needed for effective erosion control.

If pasture : absent

If close tree plantings : inappropriate

If 1 - 19% spaced tree plantings or scrub reversion or retained natural cover : insufficient

If 20% or greater spaced tree plantings or scrub reversion or retained natural cover : sufficient

Landslide erosion, sheet erosion near rock outcrops :

These features are non-linear and dotted anywhere through a sample area. Greater than 90% cover is generally needed for effective erosion control.

If pasture : absent

If spaced tree plantings : inappropriate

If 1 - 89% close tree plantings or scrub reversion or retained natural cover : insufficient

If 90% or greater close tree plantings or scrub reversion or retained natural cover : sufficient

Note that besides the optimal measure (if present), other measures have also been rated if they are present and appropriate for erosion control at the site. An example is close tree planting in a gully, as an alternative to spaced planting.

At the 325 sample points where soil conservation measures are needed, their actual distribution is :

	Sub-totals, of which :	Inappropriate	Insufficient	Sufficient
None	82	-	-	-
Spaced trees	71	7	42	22
Spaced trees + spaced trees	1	0	1	0
Spaced trees + natural cover	12	0	1	11
Close trees	64	53	4	7
Close trees + spaced trees	9	0	5	4
Close trees + natural cover	38	0	5	33
Natural cover	49	0	12	37
Totals	243	60	69	114

Table 3 gives sample error margins and percentage break-downs for measures actually present cf. measures needed.

Table 3: Extent of Soil Conservation Measures, Pokaiwhenua Catchment

Stable landforms :	532								
Unstable landforms, no measures needed :	141								
Unstable landforms, measures needed :	325								
		Spaced trees	Spaced trees + spaced trees	Spaced trees + natural cover	Close trees	Close trees + spaced trees	Close trees + natural cover	Natural cover	Totals
Needed :		252	7	9	36	6	0	15	325
Present :									
No measures		64	2	2	7			7	82
Spaced trees		61		1	3	1		4	70
Spaced trees + spaced trees			1						1
Spaced trees + natural cover		10			2				12
Close trees		50		1	9	2		2	64
Close trees + spaced trees		6		2	1				9
Close trees + natural cover		25	3	2	4	2		2	38
Natural cover		36	1	1	10	1			49
Total present :	n	188	5	7	29	6	0	8	243
cover as % of needed		57.8	1.5	2.2	8.9	1.8	0.0	2.5	74.8
	+ 2 s.e.	5.4	1.3	1.6	3.1	1.5	0.0	1.7	4.7

Where land is unstable (for whatever reason), 82 (25%) of sites need vegetative soil conservation but have not yet been planted. 60(18%) have vegetative cover inappropriate for the type of erosion that occurs. 69 (22%) have vegetative cover that is appropriate but insufficient in extent. 114 (35%) have planted, reverting or retained vegetative cover that appears sufficient to control the type of erosion present.

2.4 Soil Disturbance Under Different Standards Of Conservation Measure

Bare soil, whether due to natural erosion or land use, has been measured by counting 100 points overlaid on a one hectare area at each sample point. Type of natural erosion or land disturbance has been recorded in each instance.

For natural erosion on unstable land, the following are bare soil percentages, averaged for each category of soil conservation cover :

Absent	1.9%
Spaced trees	1.2%
Spaced trees + natural cover	1.2%
Close trees	1.2%
Close trees + spaced trees	1.3%
Close trees + natural cover	1.0%
Natural cover	1.2%
All sites with inappropriate cover :	1.2%
All sites with insufficient cover :	1.4%
All sites with sufficient cover :	1.0%

Table 4 gives sample error margins and also the types of natural erosion present.

Table 4: Soil Disturbance by Natural Erosion, Pokaiwhenua Catchment

	Number of sample sites (n)	Streambank erosion (% of area)	Streambank deposition (% of area)	Tunnels (% of area)	Gullies (% of area)	Landslides (% of area)	Rock outcrops (sheetwash & rockfall) (% of area)	All natural erosion (% of area)	+ 2 s.e.
Measures present :									
None :	82	0.2	0.1	0.6	0.4	0.3	0.4	1.9	0.6
Spaced trees	71	0.5	0.1	0.4	0.1	0.1	0.1	1.2	0.6
Spaced trees + close trees	9	0.5	0.8	0.0	0.0	0.0	0.0	1.3	1.5
Close trees	64	0.3	0.0	0.1	0.6	0.2	0.1	1.2	0.5
Spaced trees + natural cover	12	0.3	0.0	0.0	0.8	0.0	0.0	1.2	1.2
Close trees + natural cover	38	0.6	0.1	0.0	0.1	0.1	0.1	1.0	0.7
Natural cover	49	0.5	0.0	0.2	0.2	0.2	0.1	1.2	0.6
Measures rated:									
Inappropriate	60	0.3	0.0	<0.1	0.6	0.1	0.2	1.2	0.5
Insufficient	69	0.4	0.2	0.5	<0.1	0.2	0.1	1.4	0.6
Sufficient	114	0.6	<0.1	<0.1	0.2	0.1	<0.1	1.0	0.4

Natural erosion appears to be lower where soil conservation cover has been planted or retained, than where it is absent. This holds true whatever the cover. A cautionary note : because the percentage of bare soil is so low in all instances, error margins overlap i.e. the differences are not statistically significant.

Plantings rated inappropriate have about two-fifths less erosion by area, than sites which remain unplanted. Plantings rated insufficient have about a quarter less erosion. Those rated sufficient have about half as much. The difference is statistically significant only in the third instance.

Error margins are already fairly small so cannot be attributed to sample design. Increasing sample size, or changing sampling criteria, might further reduce error margins but not by much. The lack of statistical significance in results is more likely a consequence of natural erosion in the Pokaiwhenua being currently at a low level. Differences between these categories of soil conservation cover might be expected, if a survey were to be carried out after a storm or wet winter e.g. Hicks 2001a, 2001b.

Exposure of soil by land-use-related activities is more extensive. These are farm or forestry tracks, earthworks associated with farming or forestry, drain excavation or cleaning, soil bared by timber harvest, stock trampling or cultivation. Most such disturbances are temporary and rectified within the space of a year by re-grassing or tree planting.

For land use disturbance, the following are bare soil percentages within each category of landform stability (differences amongst categories of soil conservation cover on unstable land are not given - they are not to be expected because the cover has no effect on incidence of bulldozing etc.) :

Stable land	5.9%
Unstable inactive land	6.6%
Unstable active land	3.2%
All land	5.3%

Table 5 gives sample error margins, and also the different types of land-use-related disturbance.

Table 5: Soil Disturbance by Land Use, Pokaiwhenua Catchment

Landforms	Number of sample sites (n)	Farm or forest tracks (% of area)	Farm or forest earthworks (% of area)	Farm drainage (% of area)	Tree harvest (% of area)	Stock trampling (% of area)	Cultivation (% of area)	All disturbance	
								(% of area)	+ - 2 s.e.
Stable	532	2.8	0.7	0.1	1.1	0.2	1	5.9	0.9
Unstable inactive	141	2.6	0.7	0.1	2.5	0.3	0.4	6.6	1.1
Unstable active	325	1.1	0.3	0.1	1.2	0.2	0.3	3.2	0.8
Totals	998	2.4	0.6	0.1	1.3	0.2	0.7	5.3	0.5

Soil disturbance by land use is highest on unstable inactive land, though here it does not significantly differ from the level on stable land. On unstable land where erosion is active, the incidence of land-use disturbance is halved i.e. significantly less.

Half the land use disturbance is tracking. Note that the dataset does not differentiate metalled from unsurfaced tracks (this distinction cannot be made consistently on the aerial photos). A quarter is soil exposed by tree harvest - much of it skidder or hauler paths. Other types of disturbance - earthworks, drainage, stock trampling, cultivation - collectively account for the remaining quarter of exposed soil, but individually are minor in extent.

2.5 Changes in Soil Erosion/Disturbance between 1992 and 2002

The same sample points were located on 1992 aerial photographs of the Pokaiwhenua. Comparisons are limited by several features of the 1992 photography - it is black-and-white, scale 1:27500, un-rectified, not scanned, and not in the GIS. Enough data have been obtained to state how soil erosion has changed over the past ten years, but caution needs to be exercised interpreting the change.

Changes in % bare soil due to natural erosion

Table 6 shows how percentage bare soil, averaged for each type of natural erosion has changed on all land in the catchment.

Table 6: Change in Soil Disturbance by Natural Erosion, Pokaiwhenua Catchment

Disturbance by natural erosion	n eroded in 1992	% area eroded in 1992	+ 2 s.e.	n eroded in 2002	% area eroded in 2002	+ 2 s.e.
Streambank erosion	28	0.2	0.1	31	0.1	0.1
Streambank deposition	7	<0.1	<0.1	5	<0.1	<0.1
Tunnels	22	0.1	0.1	18	0.1	0.1
Gullies	38	0.3	0.1	21	0.1	0.1
Landslides	22	0.2	0.1	14	0.1	0.1
Rock outcrops	17	<0.1	<0.1	17	<0.1	<0.1
Totals	134	0.9	0.2	106	0.4	0.1

Bare soil has declined :

- streambank erosion - by half,
- streambank deposition - no change,
- tunnels - no change,
- gullies - by two thirds,
- landslides - by half,
- rock outcrops - no change.

Natural erosion, expressed as a percentage of catchment area, was already low in 1992. Consequently the declines for any individual erosion type to 2002 are within margins of error and cannot be regarded as statistically significant. However the total

decline (all types combined) from 0.9% to 0.4% is outside error margins, so can be regarded as a real trend.

Changes in % bare soil due to land use

Table 7 shows how percentage bare soil, averaged for each type of land-use related soil disturbance, has changed on all land in the catchment.

Table 7: Change in Soil Disturbance by Land Use, Pokaiwhenua Catchment

Disturbance by land use	n disturbed in 1992	% area disturbed in 1992	+ - 2 s.e.	n disturbed in 2002	% area disturbed in 2002	+ - 2 s.e.
Farm or forest tracks	118	1.8	0.2	276	2.4	0.3
Farm or forest earthworks	47	0.6	0.2	51	0.6	0.2
Farm drainage	24	0.2	0.1	9	0.1	0.1
Tree harvest	41	0.4	0.2	125	1.3	0.3
Stock trampling	37	0.3	0.1	40	0.2	0.1
Cultivation	9	0.3	0.3	30	0.7	0.3
Totals	276	3.6	0.4	531	5.3	0.5

The pattern of change is variable. Bare soil due to :

- farm and forest tracking - increased by a quarter,
- tree harvest - tripled,
- cultivation - doubled,
- earthworks - no change,
- stock trampling - down by a third,
- drainage - halved.

Increases in bare ground due to farm/forest tracking and tree harvest are statistically significant. The other changes are not. Overall bare soil due to land use disturbance has increased by half from 3.6% to 5.3% of catchment area.

2.6 Comparison of Project Watershed Estimates with Point Sample Data

Riparian areas (streambanks and floodways)

Correspond to LUC classes 4w, 6w and 7w. Project Watershed estimated that measures were present along 15% of riparian length in the Middle Waikato sub-catchments. It envisaged adding them to another 20% between 2001 and 2010 i.e. 35% total. The Pokaiwhenua point sample has measures present at 46% of points along erosion-prone streambanks and floodways :

- 29% are space-planted poplars and willows,
- 17% are retained or reverting native cover.

Close-planted timber species – not envisaged as a conservation measure by Project Watershed – are present on another 46%.

Hill country (hillslopes and ridges)

Correspond to LUC classes 6e, 7e and 8e. Project Watershed estimated that measures were present on 15% of hill country area in the Middle Waikato sub-catchments. It envisaged adding them to another 10% between 2001 and 2010 i.e. 25% total. The Pokaiwhenua point sample has measures present on 39% of erosion-prone hill country :

- 12% are space-planted poplars and willows,
- 7% are retained or reverting native cover,
- 20% are close-planted timber species.

Un-targeted land (terraces and downlands)

Correspond to LUC classes 2e, 3e, 4e. Project Watershed did not view this land as a priority for soil conservation so did not estimate present or proposed measures. The Pokaiwhenua point sample has measures present on 44% of erosion-prone terraces and downlands :

- 21% are space-planted poplars and willows,
- 11% are retained or reverting native cover,
- 12% are close-planted timber species.

Comments

Soil conservation measures in the Pokaiwhenua already exceed Project Watershed targets. Possible explanations are :

- Estimates of year 2000 extent for the Middle Waikato are under-estimates, or
- Measures in the Pokaiwhenua are above the averages for the Middle Waikato, or
- The point sample has detected vegetation planted by landowners, additional to vegetation planted by WVA and EW (the basis for year 2000 estimates?).

This does not mean that no further soil conservation measures are needed. On the contrary, the following areas remain un-planted:

- 8% of erosion-prone streambanks and floodways,
- 61% of erosion-prone hillslopes and ridges,
- 56% of erosion-prone terraces and downlands.

3 Conclusions

- 47% of the Pokaiwhenua catchment is unstable land, showing evidence of past erosion.
- Much of this land is inactive i.e. there has been no fresh or recent erosion. On 30% of the unstable land (14% of catchment area) there is no foreseeable need for soil conservation measures.
- The other 70% of unstable land (33% of catchment area) needs vegetative soil conservation measures to protect against streambank erosion or deposition, tunneling (soil piping), gullies, landslides and sheet erosion.
- Vegetative soil conservation measures have been installed on 75% of the land where they are needed (24% of catchment area). Another 9% of catchment area remains to be planted.
- 25% of installed measures have been rated as inappropriate i.e. unlikely to control types of erosion present at the site. 28% of installed measures have been rated as appropriate but insufficient in extent. 47% have been rated as appropriate and sufficient.
- Bare soil due to natural erosion is 1.9% by area, on unstable land where vegetative soil conservation measures are absent. Bare ground declines to between 1.3% and 1.0% amongst different types of soil conservation planting. The decline is statistically significant i.e. we can be sure it is real, only amongst soil conservation cover rated as sufficient.
- Soil disturbance by land use is currently 5.3% of the catchment's area. 2.4% is farm and forest tracking, a proportion of which is metalled rather than bare soil. 1.3% is soil exposure by tree harvest. Earthworks, drainage, stock trampling and cultivation individually occupy between 0.1% and 0.7% of the catchment. With the exception of tracking, these forms of soil disturbance are short-term. At any one site they are remedied within months by revegetation carried out in the normal course of farming or forestry. However, it may be of interest to know that sites bare at any one time add up to a measurable percentage of catchment area - currently larger than sites bared by natural erosion.
- Between 1992 and 2002 natural erosion has declined throughout the catchment, from 0.9% to 0.4% by area. Most of the decline is due to healing of streambank erosion, gullies and landslide scars.
- Between 1992 and 2002 soil disturbance by land use has increased by about half, from 3.6% to 5.3% of the catchment's area. Most of the increase is accounted for by farm or forest tracking and by timber harvest.
- Soil conservation measures in the Pokaiwhenua already exceed Project Watershed estimates of work required and targets.
- About 10.6% of the catchment has insufficient or requires spaced pole planting, 2.5% block planting and 0.4% retiring.
- Remaining soil conservation requirements by landform are 8% of erosion-prone streambanks and floodways, 61% of erosion-prone hillslopes and ridges and 56% of erosion-prone terraces and downlands.

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