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Soil Conservation Survey of the Matahuru Catchment

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Introduction

These notes summarise the results of a survey carried out in May 2005 at the request of Environment Waikato. The survey's purpose is to ascertain extent of vegetative soil conservation cover in the Matahuru catchment, and measure what reductions have accrued from them. This information is required for a 5-year review of soil conservation in the Lower Waikato sub-catchments.

The Matahuru has been selected by Environment Waikato staff because they regard it as typical of the Lower Waikato sub-catchments in its terrain, land use, and soil conservation measures. It is 97 square kilometres in extent, draining west and south from the Hapuakohe range, then turning north-west to enter Lake Whangape. The headwaters are steep greywacke hill country. Middle reaches are easier greywacke hills, partly mantled by volcanic ash, separated by a broad valley floor of rolling ash-mantled downlands and flat alluvial terraces. Lower reaches flow along a narrow floodway, excavated through an undulating divide between the Hamilton and Huntly lowlands.

The survey brief is to :

Identify how much land needs soil conservation,

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.

Doing this does not entail mapping exact locations and types of measure on all land in the Matahuru - to do so would take a great deal of time - rather, to obtain reliable summary measurements for the catchment from 2002 aerial photographs. These should be in a format consistent with previous identification of target land for soil conservation (Project Watershed 2001), and comparable with an earlier survey from 1992 aerial photographs.

Method

Survey design is similar to the earlier survey (Hicks 2001). 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 data to be compared with results from the earlier survey, 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 (five per square kilometre),
- photo-interpretation of landform stability and vegetative soil conservation cover, from prints at a scale of 1:10000,
- measurement of bare ground due to erosion or other soil disturbance, within a one hectare area around each sample point,
- data entry into an Excel spreadsheet (convertible to a GIS attribute layer).

482 points were sampled. Data were 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. Sample averages and standard errors were calculated where appropriate.

Results

Table 1: Landform stability

	All landforms			Stable	Unstable inactive	Unstable recently eroded	Unstable freshly eroded
	n	% of catchment	+- 2 s.e.	n	n	n	n
Alluvial streams	24	5.0	1.9		13	2	9
Hill streams	22	4.6	1.9		10	0	12
Floodways	8	1.7	1.1	1	7		
Terraces	53	11.0	2.8	42	9		2
Downlands	115	23.9	3.8	78	27		10
Footslopes	48	10.0	2.7	13	17	3	15
Hillslopes	132	27.4	4.0	7	63	19	43
Ridges	80	16.6	3.3	28	38	2	12
n	482	100.0	0.0	169	184	26	103
% of catchment stable or unstable :				35.1	38.2	5.4	21.4
+- 2 s.e. :				4.3	4.3	2.0	3.7

35% of the catchment is occupied by stable landforms, not at risk from natural erosion, such as ash-mantled downlands, elevated terraces, and moderate ridges or spurs in hill country.

The proportion of unstable land is 65%. 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 or slumps), streambanks (risk of bank scour), and floodways (risk of scour or siltation).

Out of the 65%, 38% shows signs of past erosion but is currently inactive and well-vegetated. 5% shows signs of recent erosion now revegetating. Another 21% shows signs of fresh erosion i.e. patches of bare ground interspersed amongst vegetation.

Note that the 21% is land where erosion is present in some of its area. Actual percentage of bare ground is considerably less (see Soil Disturbance section). Table 1 gives margins of error, and a more detailed break-down of data by landform.

This was assessed for each of the 313 unstable points, using the following criteria :

No fresh or recent erosion:	no soil conservation cover needed
Streambank erosion:	spaced trees in pasture
Streambank deposition::	dense ground cover
Streambank erosion and deposition (combined:	spaced trees with dense ground cover
Streambank and other erosion:	as above, with either extra spaced trees, or close trees, depending on erosion type
Tunnel erosion:	spaced trees in pasture
Tunnel and other erosion:	as above, with either extra spaced trees, or close trees, depending on erosion type
Gully erosion:	spaced trees where slight, extra spaced trees or close trees where severe
Gully and other erosion:	as above, with either extra spaced trees, or close trees, depending on erosion type
Landslide erosion:	spaced trees where slight, close trees where severe
Landslide and other erosion:	as above, with either extra spaced trees, or close trees, depending on erosion type
Slump/earthflow erosion:	spaced trees in pasture where slight, extra spaced trees or close trees where severe
Slump/earthflow and other erosion:	as above, with either extra spaced trees, or close trees, depending on erosion type
Sheetwash and rock outcrops :	dense ground cover

Note that these are optimal measures - another measure or some combination, though not as good, may be acceptable for erosion control. Also note that the assessment need not always entail planting exotic vegetation - it makes provision for retained or reverting natural cover where already present.

Out of 313 unstable points, 49 (16%) are well-vegetated and do not appear to have been active for a very long time, so have been rated as not requiring treatment.

264 points (84%) 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, 86 (27%) have been rated as needing spaced trees in pasture, to control streambank erosion , tunnels (soil pipes) or gullies. A further 15 (5%) have been rated as needing additional spaced trees to control streambank erosion associated with tunnels or gullies. Another 20 (6%) have been rated as also needing dense ground cover to control deposition associated with streambank erosion.

60 (19%) have been rated as needing close trees, either commercial timber species or soil conservation species or native tree and shrub cover, to control landslide erosion. A further 77 (25%) have been rated as needing a combination of close trees with spaced trees to control additional gully or streambank erosion. Just 2 (<1%) have been rated as needing a combination of close trees with dense ground cover (to control deposition on flood-prone valley bottoms).

5 (2%) have been rated as needing dense ground cover alone - to control streambank deposition in floodways, or sheetwash on shallow soil around rock outcrops.

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

Secondary vegetation has been recorded at any sample points where it is present, together with the nature of cover i.e. trees, shrubs or ground cover, scattered or extensive, exotic or natural. At the 169 stable and 49 unstable but inactive points, secondary vegetation is likely to have been planted or retained for other reasons e.g. commercial or amenity value. At the 264 unstable points where soil conservation measures are needed, the vegetation may or may not be intentionally planted :

- 14% have spaced tree plantings (including points with extra spaced trees),
- 4% have spaced tree plantings with associated ground cover,
- 8% have close tree plantings (including 3% with additional spaced trees),
- 0% have close tree plantings with associated ground cover,
- 51% have natural cover, of which 36% is spaced trees or shrubs (in pasture), including 4% with additional planted cover, 7% is close-canopy trees or shrubs (in bush), and 8% is wetland plants or exotic weeds.

Overall 77% of the unstable points that need vegetative soil conservation cover, have it in some form. Just 23% lack any measures. Clearly a high proportion of the Matahuru's soil conservation cover is natural vegetation that has been retained on pockets of unfarmed land. Nevertheless planted measures are significant, occurring at 26% of unstable points. Table 3 gives sample error margins, together with a more detailed break-down of the match between measures needed and measures present.

Table 2: Need for soil conservation measures, Matahuru catchment

	All landforms			Landforms needing measures :							
				None	Spaced trees	Spaced trees + spaced trees	Spaced trees + ground cover	Close trees	Close trees + spaced trees	Close trees + ground cover	Ground cover
	n	% of catchment	+- 2 s.e.	n	n	n	n	n	n	n	n
Stable landforms :	169	35.1	4.3								
Unstable landforms :	313	64.9	4.3								
Reason for measures :											
None :	49	10.2	2.7	49							
Streambank erosion	23	4.8	1.9		23						
Streambank deposition	3	0.6	0.7								3
Streambank erosion & deposition	15	3.1	1.6				15				
Streambank and other erosion	18	3.7	1.7			3	4		10	1	
Tunnel erosion	13	2.7	1.4		13						
Tunnel and other erosion	11	2.3	1.3		4	1			6		
Gully erosion	23	4.8	1.9		23						
Gully and other erosion	53	11.0	2.8			3	1		49		
Landslide erosion	76	15.8	3.3		16			60			
Landslide and other erosion	16	3.3	1.6			4			12	1	
Slump erosion	7	1.5	1.1		7						
Slump and other erosion	4	0.8	0.8			4					
Sheetwash and rockfall	2	0.4	0.6								2
n	482	100.0	0.0	49	86	15	20	60	77	2	5
as % of unstable landforms :				15.7	27.5	4.8	6.4	19.2	24.6	0.6	1.6
+ - 2 s.e. :											

Table 3: Extent of soil conservation measures, Matahuru catchment

Stable landforms :	169
Unstable landforms, no measures needed :	49
Unstable landforms, measures needed :	264

		Spaced trees	Spaced trees + spaced trees	Spaced trees + ground cover	Close trees	Close trees + spaced trees	Close trees + ground cover	Ground cover	Totals	%	+- 2 s.e.
Cover needed	n =	86	14	20	60	77	2	5	264		
Cover present											
None :		22	3	2	18	16		1	62	23.5	5.1
Planted :											
spaced trees		17	3	10	3	3			36	13.6	4.1
+ extra spaced trees									0	0.0	0.0
+ ground cover		5	2	2		1			10	3.8	2.3
close trees		4			5	4	1		14	5.3	2.7
+ spaced trees		1		3		3			7	2.7	1.9
+ ground cover									0	0.0	0.0
Natural :											
spaced trees or shrubs		25	2	2	17	37		1	85	32.2	5.6
+ planted cover		3		1	3	3			10	3.8	2.3
close trees or shrubs		1			12	6			19	7.2	3.1
ground cover (wetlands)		2	1	1	6			3	13	4.9	2.6
ground cover (exotic weeds)		5			2	1			8	3.0	2.1
Total present :	n =	63	8	19	48	58	1	4	202	76.5	5.1

Table 4: Adequacy of soil conservation measures, Matahuru catchment

Stable landforms :	169
Unstable landforms, no measures needed :	51
Unstable landforms, measures needed :	262

Cover present	Totals	Absent	Inappropriate	Mis-placed	Insufficient	Sufficient
None :	62	62				
Planted :						
spaced trees	36		1	6	21	8
+ extra spaced trees	0					
+ ground cover	10				8	2
close trees	14		3	1	4	6
+ spaced trees	7				6	1
+ ground cover	0					
Natural cover :						
spaced trees or shrubs	85		1	5	51	28
+ planted cover	10				1	9
close trees or shrubs	19				2	17
ground cover (wetlands)	13		10		2	1
ground cover (exotic weeds)	8		6		2	
Totals :						
n	264	62	21	12	97	72
%	100.0	23.5	8.0	4.5	36.7	27.3
+- 2 s.e	0.0	5.1	3.3	2.5	5.8	5.4

At the 264 unstable points where measures are needed, vegetation's soil conservation value has been rated as absent (a), present but inappropriate (x), present but mis-placed (m), present but insufficient (i), or present and sufficient (s). Criteria for assessing measures were :

Absent : needed cover (as defined in Section 2) is not there.

Mis-placed : needed cover is present but not on unstable areas.

Inappropriate : a different cover is present on unstable areas i.e. not a type which could be expected to stabilise them.

Insufficient : needed cover is present on unstable areas, but is too scattered to achieve stability.

Sufficient : needed cover is present on unstable areas, and is extensive enough to achieve stability.

Where land is unstable (for whatever reason) and in need of measures :

- 62 (23%) of sites need vegetative soil conservation but have not yet been planted.

- 21 (8%) have vegetative cover inappropriate for the type of erosion that occurs.

- 12 (5%) have appropriate vegetative cover, but mis-placed i.e. not on the part which is erosion-prone.

- 97 (37%) have vegetative cover that is appropriate but insufficient in extent.

- 72 (27%) have planted, reverting or retained vegetative cover that appears sufficient to control the type of erosion present.

Overall 64% has measures that can be regarded as adequate for erosion control. However 37% of this - the insufficient category - needs inter-planting to increase its effectiveness. Table 4 gives error margins and additional break-downs for points in each category.

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 : 1.6% bare soil

Planted cover :

Spaced trees	1.7%
Spaced trees + ground cover	1.1%
Close trees	0.9%
Close trees + spaced trees	0.9%

Natural cover :

Spaced trees and shrubs	1.0%
Spaced trees and shrubs + planted cover	1.2%
Close trees and shrubs	0.0%
Ground cover (wetland plants)	1.7%
Ground cover (exotic weeds)	1.8%

When all categories of soil conservation cover are combined, bare soil occupies 1.2% of unstable land. This equates to 0.7% of the catchment's area. Table 5a gives sample error margins and also the types of natural erosion present.

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, except for spaced trees. However because the percentage of bare soil is low in all instances, error margins overlap i.e. the differences are not statistically significant.

Table 5: Soil disturbance by natural erosion,Matahuru catchment

Table 5a - Bare soil as percentage of area in specified cover

	Number of sample sites	Streambank erosion	Streambank deposition	Tunnels	Gullies	Landslides	Slumps	Sheetwash & rockfall	All natural erosion	
	n	% contrib.	% contrib.	% contrib.	% contrib.	% contrib.	% contrib.	% contrib.	% bare soil	+- 2 s.e.
Cover present										
None :	62	0.03	0.10	0.56	0.25	0.47	0.12	0.02	1.57	0.50
Planted :										
spaced trees	36	0.64	0.30	0.25	0.39	0.11			1.69	0.59
+ extra spaced trees	0									
+ ground cover	10		0.20	0.20	0.50		0.20		1.10	0.72
close trees	14			0.29		0.64			0.93	0.87
+ spaced trees	7		0.43		0.14	0.29			0.86	0.83
+ ground cover	0									
Natural :										
spaced trees and shrubs	85	0.15	0.06	0.04	0.24	0.33	0.21		1.04	0.33
+ planted cover	10	0.60			0.10	0.50			1.20	1.17
close trees and shrubs	19								0.00	0.00
ground cover (wetland plants)	13	0.38	0.31		0.38	0.38	0.23		1.69	1.44
ground cover (exotic weeds)	8	0.50			0.87	0.37			1.75	1.72
All	264	0.20	0.12	0.19	0.26	0.32	0.11	0.01	1.22	0.14

Table 5b - Bare soil as percentage of area in specified standard of cover :

	Number of sample sites	Streambank erosion	Streambank deposition	Tunnels	Gullies	Landslides	Slumps	Sheetwash & rockfall	All natural erosion	
	n	% contrib.	% contrib.	% contrib.	% contrib.	% contrib.	% contrib.	% contrib.	% bare soil	+- 2 s.e.
Cover rated :										
Absent	62	0.03	0.10	0.56	0.25	0.47	0.12	0.02	1.57	0.50
Mis-placed	12	0.62	0.15	0.31		0.39	1.23		2.69	1.86
Inappropriate	21		0.26	0.05	0.62	0.52	0.15		1.55	0.91
Insufficient	97	0.32	0.19	0.14	0.38	0.22	0.04		1.28	0.41
Sufficient	72	0.17			0.07	0.26			0.52	0.30

Table 6: Soil disturbance by land use Matahuru catchment

	Number of sample sites	Farm or forest tracks	Farm or forest earthworks	Farm drainage	Tree harvest	Stock trampling	Cultivation	Harvest	All disturbance	
	n	% of area	% of area	% of area	% of area	% of area	% of area	% of area	% of area	+- 2 s.e.
Landforms :										
Stable	169	1.95	0.11	0.07	0.00	1.02	2.30	3.28	8.73	2.68
Unstable, soil conservation not needed	49	0.63	0.12	0.16	0.00	1.80	0.00	1.24	3.94	2.28
Unstable, soil conservation needed	264	1.54	0.15	0.09	0.00	1.02	0.05	0.00	2.92	0.56
All within catchment	482	1.59	0.13	0.09	0.00	1.10	0.83	1.28	5.06	1.05

The pattern becomes clearer when data are re-analysed according to standard of conservation cover (Table 5b) :

No cover :	1.6% bare soil
Inappropriate cover :	1.6%
Mis-placed cover :	2.7%
Insufficient cover :	1.3%
Sufficient cover :	0.5%

Plantings rated mis-placed actually have more erosion, than sites which remain unplanted (or which have inappropriate plantings). Plantings rated insufficient have slightly less erosion. Those rated sufficient have about a third as much. The difference is statistically significant only in the third instance.

The lack of statistical significance is a consequence of natural erosion in the Matahuru being currently at a low level. Significant 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 (Hicks 2001).

Exposure of soil by land-use-related activities is more extensive than exposure by natural erosion. 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 :	8.7% bare soil
Unstable land where soil conservation not needed :	3.9%
Unstable land where soil conservation needed :	2.9%
All land within catchment :	5.1%

Table 6 gives sample error margins, and also the different types of land-use-related disturbance.

A third of 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 fifth is stock trampling or heavy grazing. Cultivation is just under a fifth, and soil exposure by harvest of crops, hay or silage, just over a quarter. Other types of disturbance - earthworks, drainage, timber harvest - collectively account for the balance of exposed soil, but individually are minor in extent.

Soil disturbance by land use is highest on stable land, and significantly more than on unstable inactive land. On unstable land where erosion is active, the incidence of land-use disturbance is less than on unstable inactive land, though not significantly so.

Changes in the catchment between 1992 and 2002

Comparisons with 1992 data 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. Also 1992 soil conservation assessments were only carried out for hill country within the Matahuru, at Environment Waikato's request, for Project Watershed in 2001.

Soil stability

Assessed for whole catchment at both dates, but using improved version of point sampling method on the 2002 photographs.

Stable land :	1992	34% of catchment; 2002 35%
Unstable inactive land :	1992	56% of catchment; 2002 38%
Unstable land containing recent erosion :	1992	8% of catchment; 5%
Unstable land containing fresh erosion :	1992	2% of catchment; 21%
Bare soil due to fresh erosion :	1992	2.3%; 2002 0.7%

The leap in unstable land containing fresh erosion is due to the change in sampling method. In 1992 the fresh erosion category only included scars directly under sampling points. In 2002 the category included scars disseminated within one hectare areas around sampling points. However what's visible in 2002 is mostly small patches cf. the large scars still visible in 1992 after storms in the 1980s - hence the decline in bare soil 1992 - 2002.

Need for conservation measures

Assessed only for hill country from 1992 photographs (at EW's request for Project Watershed in 2001). Assessed for whole catchment from 2002 photographs.

None required :	1992	22% of unstable hill country;	2002	16% of unstable land in catchment
Spaced pole planting :	1992	24% of unstable hill country;	2002	32% of unstable land
Block afforestation :	1992	18% of unstable hill country;	2002	19% of unstable land

Retirement and reversion : 1992 36% of unstable hill country; 2002 33% of unstable land

Including the downlands and terraces has brought in some extra land with streambanks or gullies that need spaced planting. The 2002 assessment criteria do not distinguish retirement and reversion as a separate category, but it approximates points assessed as needing both close and spaced planting, plus points that need ground cover.

Extent of measures

None present : 1992 54% of unstable hill country; 2002 23% of unstable land needing measures

Spaced pole planting :	1992	3% of unstable hill country;	2002	17% of unstable land
Block afforestation :	1992	2% of unstable hill country;	2002	8%

Retirement and reversion :	1992	40% of unstable hill country;	2002	51%

Including the downlands and terraces has picked up a lot of pole planting along watercourses and farm woodlots on easy-contour gullies, also some bush and wetland remnants here, that weren't detected by restricting the 1992 survey (for Project Watershed in 2001) to hill country; though the leap in retirement and reversion is partly accounted for by scattered scrub reversion in hill country pasture 1992-2002.

Adequacy of measures

Absent :	1992	54% of unstable hill country;	2002	23% of unstable land needing measures
Inappropriate :	1992	not assessed	2002	8% of unstable land
Misplaced :	1992;	not assessed	2002	5% of unstable land
Insufficient :	1992	17% of unstable hill country;	2002	37% of unstable land
Sufficient :	1992	29% of unstable hill country;	2002	27% of unstable land

Including downlands and terraces has boosted percentage of land where measures are present, though extra measures detected fall into the mis-placed, inappropriate or insufficient categories; of which only the latter can be regarded as adequate.

Erosion under different types of conservation measure

None present :	1992	9% bare soil due to fresh erosion on unstable hill country ;	2002	1.6% bare soil on unstable land needing measures
Spaced pole planting :	1992	0% bare soil due to fresh erosion;	2002	1.7% bare soil
Block afforestation :	1992	0% bare soil due to fresh erosion;	2002	0.9% bare soil
Retirement and reversion :	1992	0.8% bare soil due to fresh erosion;	2002	1.0% to 1.8% bare soil

Comment : two effects occur here. Including downstream parts of the catchment has greatly dropped % bare soil on un-planted land (un-planted unstable land downstream currently doesn't have much erosion). Greater precision of the point sampling method has improved detection of bare soil amongst soil conservation plantings. This can be best explained by reference to 2002 error margins which are 0.14% to 1.17% for bare soil cf. 2 to 4% for the 1992 data. It also appears to have improved detection of bare soil amongst natural cover.

Erosion under different standards of conservation measure

Measures absent :	1992	9% bare soil due to fresh erosion on unstable hill country	2002	1.6% bare soil on unstable land needing measures
Measures misplaced or inappropriate :	1992	not assessed separately;	2002	1.6% to 2.7% bare soil
Measures insufficient :	1992	2% bare soil due to fresh erosion;	2002	1.3% bare soil
Measures sufficient :	1992	0% bare soil due to fresh erosion;	2002	0.5% bare soil

What the data show at both dates - conclusively in 2002 due to better error margins - is that it doesn't matter whether poles or pines are planted, or whether native reversion is allowed as an alternative. What matters is planting (or retaining) enough of whatever woody vegetation cover, in the right places on erodible land.

Soil disturbance by land use

Not measured from 1992 photographs. 2002 data are :

Cultivation :	0.8% bare soil catchment-wide
Grazing pressure :	1.1% bare soil
Crop or pasture harvest :	1.3% bare soil
Timber harvest :	0% bare soil
Farm or forest tracks :	1.6% bare soil
Drainage :	0.1% bare soil
Earthworks :	0.1% bare soil

In 2002 5.1% of the catchment's soil was exposed by land use-related activities. This compares with 0.7% exposed by natural erosion.

Conclusions

65% of the Matahuru 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 16% of the unstable land (11% of catchment area) there is no foreseeable need for soil conservation measures.

The other 84% of unstable land (54% of catchment area) needs vegetative soil conservation measures to protect against streambank erosion or deposition, tunneling (soil piping), gullies, landslides and slumps.

Vegetative soil conservation measures have been installed or retained on 77% of the land where they are needed (42% of catchment area). Another 23% of unstable land (13% of catchment area) remains to be planted.

13% of installed measures have been rated as inappropriate or misplaced 37% of installed measures have been rated as appropriate but insufficient in extent. 27% have been rated as appropriate and sufficient.

Bare soil due to natural erosion is 1.6% by area, on unstable land where vegetative soil conservation measures are absent. Bare soil is the same or higher, at 1.6% to 2.7%, amongst soil conservation measures that are inappropriate or mis-placed. It declines to 1.3% amongst soil conservation measures that are appropriate but insufficient in extent, and 0.5% amongst sufficient measures. When all categories are combined (including stable land with no erosion), natural erosion currently affects 0.7% of the catchment's area.

Soil disturbance by land use is currently 5.1% of the catchment's area. 1.6% is farm and forest tracking, a proportion of which is metalled rather than bare soil. 1.1% is soil exposure by stock trampling or heavy grazing. Cultivation and harvest, of crops, hay or silage, occupy 0.9% and 1.2% of the catchment. Other land use-related disturbances - earthworks, drainage, and timber harvest - are currently minor. 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 measureable percentage of catchment area - currently larger than sites bared by natural erosion.

Between 1992 and 2002 natural erosion has declined throughout the catchment, from 2.0% to 0.7% by area. Most of the decline appears due to healing of streambank erosion, gullies and landslide scars - revegetation is visible on the 2002 photographs cf. the 1992.

Soil disturbance by land use was not measured from the 1992 photographs. In 2002 5.1% of the catchment's area had exposed soil; most accounted for by farm or forest tracking, livestock grazing pressure, and cultivation or harvest. This is similar to the percentage measured in another recent survey (Hicks 2005) so may not be elevated relative to other Waikato sub-catchments.

References

Anonymous: 2001 *Project Watershed Planning Report*, Environment Waikato, Hamilton

Hicks, D.L.: 2001 *Soil conservation survey of the Matahuru catchment* Contract Report for Environment Waikato, Hamilton

Hicks, D.L.: 2005 *Soil conservation survey of the Pokaiwhenua catchment.* Technical Report 2005/15. Environment Waikato, Hamilton

Glossary

This section contains brief definitions of data recorded in the survey, and terms used in the report. As many definitions are related, they are listed here in sections rather than alphabetically.

Soil state

Soil state: whether soil is intact, disturbed, eroding, or accumulating. Other changes in soil, notably :

- break-down of structure by machine compaction or animal treading,
- loss of nutrients by removal of produce, leaching to groundwater, or volatilisation to the atmosphere,
- decrease in topsoil depth by oxidation of organic matter, combustion, or shrinkage after draining.

are commonly thought of as declines in soil's condition, quality or "health".

Soil intactness: the concept of soil intactness expresses whether soils are staying in place. A decrease in soil intactness occurs when soil is disturbed.

Soil disturbance: Physical alteration of soil. Manifests itself as:

- changes in thickness,
- change in exposed area,
- movement of soil on-site,
- removal of soil off-site.

Land use-related disturbance: soil disturbance by cultivation or harvest in the course of cropping; livestock grazing pressure; cutting for hay or silage; spraying of vegetation; tree-planting or timber harvest; drain excavation or cleaning; track or road construction; earthworks for building sites, yards, etc.

Natural disturbance: soil erosion or accumulation by geomorphological processes.

Soil erosion: removal of soil particles by wind, overland flow of runoff, rills and gullies, stream bank scour and collapse, and mass movement (landslides, earthflows, slumps and debris avalanches). Part of the eroded soil is deposited on-site, but some - often most - is removed.

Soil accumulation: long-term build-up in soil depth. Occurs by addition of decaying vegetable matter and weathering of regolith; deposition of soil that has been eroded from upslope; deposition of sediment transported from up-river; deposition of wind-blown dust around growing plants; airfall of volcanic ash.

Landform stability

Stable surfaces: show no sign of past erosion, have a smooth appearance and are completely vegetated (unless topsoil is disturbed by land use).

Unstable inactive surfaces: show signs of past erosion but are currently not eroding. On some, erosion scars are no longer recognisable, but have left rounded depressions or mounds where soil has re-formed beneath long-established vegetation. On others, erosion scars have healed though are still visible. Their surface is rough but well vegetated. Erosion has usually occurred at least a decade prior to photography.

Recently disturbed surfaces: erosion scars are clearly visible and still healing. Their surface is broken, with little bare ground and much revegetation. Erosion has usually occurred in the decade prior to photography.

Freshly disturbed surfaces: erosion scars are easily identifiable and active. Their surface is broken, with much bare ground and little revegetation. Erosion has usually occurred in the year prior to photography.

Need for soil conservation measures

Soil conservation: measures undertaken to keep soil intact; to protect it from land use-related or natural disturbance. Soil conservation "treatment", "measures" and "works" are synonymous. Includes engineered structures for runoff control, surface protection and sub-surface stabilisation.

Soil conservation cover: vegetation planted or retained to conserve soil. The definition recognises that natural cover - whether intentionally or inadvertently retained - can function as a soil conservation measure. Likewise induced cover e.g. exotic scrubby weeds and wildling trees. Soil conservation cover is further classified as ground cover, spaced scrub or trees, and close scrub or trees.

Ground cover: herbaceous vegetation i.e. rank grass, tussock or wetland plants, interspersed with primary vegetation.

Spaced scrub: scrub interspersed with primary vegetation (which is visible through an open canopy).

Spaced trees: trees interspersed with primary vegetation (which is visible through an open canopy).

Close scrub: scrub over-topping primary vegetation (which may remain beneath a closed canopy).

Close trees: trees over-topping primary vegetation (which may remain beneath a closed canopy).

Extent of soil conservation cover

Primary vegetation: the main ground cover at a sample point, present on more than half of a surrounding one-hectare square. Usually determined by land use e.g. crop or pasture if farming; planted trees if forestry; natural forest, scrub or wetland if land not in commercial use.

Dense: complete ground cover by primary vegetation.

Sparse: partial ground cover by primary vegetation. Bare soil is visible, either interspersed with primary vegetation, or as discrete patches.

Secondary vegetation: other vegetation at a sample point, present on less than half of a surrounding one hectare square. It may be associated with land use e.g. a shelterbelt; or induced by the use e.g. scrub reversion; or remnant natural vegetation e.g. wetland plants.

Scattered: isolated specimens of secondary vegetation, dispersed so that its canopy and root mass do not occupy a measureable area of the one hectare square surrounding a sample point.

Extensive: secondary vegetation that is clumped or spaced sufficiently close for its canopy and root mass to occupy a measureable area.

Adequacy of soil conservation cover

Not needed: no soil conservation cover is needed within a one hectare square surrounding the sample point, because unstable surfaces are either absent, or have been inactive for a very long time e.g. smooth drainage hollows infilled by volcanic ash.

Absent: unstable surfaces are present on part or all of the one hectare square; either freshly eroded, recently eroded, or inactive within recent decades e.g. drainage hollows containing revegetated gullies. However soil conservation cover is absent.

Inappropriate: soil conservation cover is present, but not a type which could be expected to protect against soil disturbance recorded for the one hectare square. For instance wetland on an earthflow; spaced trees on a steep landslide-prone face; close trees in a riverbed.

Misplaced: soil conservation cover is present, of a type which could be expected to protect against soil disturbance, but it is not on unstable parts of the one hectare square. For instance a farm woodlot, located on a stable spur instead on an unstable hill face.

Insufficient: soil conservation cover is present, of a type which could be expected to protect against soil disturbance, on unstable parts of the one hectare square. However it is scattered, so there is not enough ground cover/root

mass/canopy closure to protect the unstable soil.

Sufficient: soil conservation cover is present, of a type which could be expected to protect against soil disturbance, on unstable parts of the one hectare square. It is extensive, so there is enough ground cover/root mass/canopy closure to protect unstable soil.