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Reviewed by:

Name: Amy Taylor

Position: Project Leader Land

Organisation: Auckland Regional Council

Date: 27 February 2009

Approved for ARC Publication by:

Name: Grant Barnes

Position: Group Manager Monitoring and Research

Organisation: Auckland Regional Council

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Soil State in the Auckland Region 2007

D. L. Hicks
A. J. Thompson

Prepared for
Auckland Regional Council

D. L. Hicks
P O Box 170, Orewa

A. J. Thompson
Thelton Environmental Limited
McNicol Road, Clevedon, RD5, Papakura

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1 Introduction

This report summarises data and discusses results from a survey of soil state (intactness and disturbance) undertaken for Auckland Regional Council (ARC) in the year 2008. The survey has been carried out in accordance with the National Land Monitoring Forum's (NLMF) procedure for point sampling (NLMF, in prep.), and is similar to surveys carried out in the Manawatu-Wanganui, Auckland, Gisborne, Waikato, Wellington, Tasman and Bay of Plenty regions between 1997 and 2005.

Auckland's survey has been carried out primarily to provide information about soil state (intactness and disturbance) for state of environment reporting. Survey data are also expected to be useful for other purposes, such as providing detail about the region's land use and vegetation cover; assessing the extent of vegetative soil conservation measures; and as a source of facts and figures for the Council's policy documents and publications.

The document is the second of four reports:

- Methods Used to Survey Soil State in the Auckland Region 2007,
- Soil State in the Auckland Region 2007,
- Vegetation Associated with Land Uses in the Auckland Region 2007, and
- Vegetative Soil Conservation Cover in the Auckland Region 2007.

1.1 Report structure

Initially the report will focus on region wide results that are presented in a series of key tables (Table 2.1, 2.2 and 2.3).

Table 2.1 summarises the state of Auckland's soil in 2007, the year of aerial photographic survey. It is a regional overview which contains key items for state of environment reporting (SER), specifically:

- what percentage of sample points has stable surfaces (S),
- what percentage has erosion-prone but inactive surfaces (U),
- what percentages have recently eroded (R) and freshly eroding (E) surfaces,
- the percentages disturbed by land use (on S and U surfaces), and
- the percentages disturbed by natural processes (on R and E surfaces).

The report Methods Used to Survey Soil State in the Auckland Region 2007, defines terms used in this report e.g. stable, erosion-prone, eroded and eroding, extensively

disturbed; land use-related disturbance, natural disturbance, intact soil, disturbed soil, vegetated soil, bare soil, rural land use, non-rural land use.

These percentages (with attached confidence limits) are from a region-wide sample of 5277 points, which is sufficiently large to calculate extent of intact and disturbed soil in hectares region-wide.

Due to rounding in the tables, calculated sub-totals and totals differ by 0.1% (point percentages) to 0.01% (area percentages) from the apparent sums of their components. Calculated sub-totals and totals are cited in the report text.

At points where soil disturbance has been recorded, not all the soil is bare. To measure this, cluster sampling has been used to measure areas and calculate percentages of bare soil on one-hectare squares around each sample point. In table 2.2, the summed areas and percentages give region-wide measurements of:

- How much soil is bare due to different kinds of land use-related disturbance,
- How much soil is bare due to natural disturbance by various processes of erosion or deposition.

Table 2.3 contains summary data about land use on Auckland's soil in the year 2007, specifically:

- percentage of sample points in each of nine broad rural land uses (intensive, dairy, drystock, forest plantation, natural forest, natural scrub, exotic scrub, coastal grass and scrub, wetlands and mangrove swamps),
- percentage composition of vegetation cover, for sample points within each rural use, and
- percentage of sample points not in rural use (buildings and yards, urban areas, water bodies and coastal features, points unclassified or lacking aerial photo cover).

Following the region wide results each land use category as listed in Table 2.3 will be reported under the headings of soil state (Tables 2.4-2.20) and disturbance (Tables 2.5 to 2.21). They summarise to what extent Auckland's soil is intact or disturbed under various rural land uses, together with the land uses' respective contributions to bear soil region-wide.

2 Region wide results

2.1 Soil state throughout the Auckland region, 2007

(Table 2.1)

The region's sample points are:

- 30.1% stable surfaces,
- 35.7% erosion-prone but inactive surfaces,
- 15.5% actively eroded and eroding surfaces,
- 17.6% extensively disturbed surfaces, and
- 0.9% unclassifiable (no aerial photographs).

2.1.1 Stable surfaces

Stable surfaces are protected floodplains, drained wetlands, elevated terraces, rolling downlands, parts of hill country and ranges that show no sign of past erosion, and old coastal dunes with weathered soils.

- 30.1% of the region's sample points have stable surfaces,
- two thirds of these stable sample points (19.3% of the region) have intact soil, currently well-vegetated, and
- a third of the stable sample points (10.8% of the region) have soil currently disturbed by land use. Bare soil within this category accounts for 1.06% of the region's area.

2.1.2 Erosion-prone surfaces

Erosion-prone surfaces are unprotected floodplains, undrained or semi-drained wetlands, drainage hollows through terraces and downlands, parts of hill country and ranges that show signs of past erosion but are currently not eroding, and intermediate-age coastal dunes that are fixed by vegetation.

- 35.7% of the region's sample points have erosion-prone surfaces that are currently inactive,
- three quarters of these erosion-prone sample points (26.6% of the region) have intact soil, currently well-vegetated, and

- a quarter of the erosion-prone sample points (9.1% of the region) have soil currently disturbed by land use. Bare soil within this category accounts for 0.54% of the region's area.

2.1.3 Eroded and eroding surfaces

Eroded and eroding surfaces are river and stream banks, wetland margins, under-runners or gullies through terraces and downlands, parts of hill country and ranges that are subject to mass movement erosion (slope failure), scour and deposition of sediment along valley bottoms, and young coastal dunes subject to sandblow.

- 15.5% of the region's sample points have recently active eroded surfaces and freshly active eroding surfaces,
- just over half of these eroded and eroding sample points (8.0% of the region) have soil recently disturbed by natural erosion processes but revegetating, and
- just under half of the eroded and eroding sample points (7.4% of the region) have soil freshly disturbed by natural erosion. Bare soil within this category accounts for 0.84% of the region's area.

2.1.4 Extensively disturbed surfaces

Extensively disturbed surfaces are areas of land where soil has been removed in whole or part, re-contoured, or covered by buildings, pavements or water.

- 17.6% of the region's sample points are extensively disturbed surfaces.

2.9% are rural land in non-agricultural use, where some of the soil is covered by buildings and yards; industrial premises and quarries; or roads, railways and airfields. Much is still vegetated, but extensively disturbed. Here bare soil accounts for 0.30% of the region's area, and has a diversity of causes (construction earthworks, unsealed yards or tracks, quarry excavation, etc.).

11.0% are land in urban use, where much of the soil is covered by buildings and paved surfaces. Some is still vegetated, particularly urban open spaces and residential gardens; while the unvegetated areas, being covered or paved, now have little soil disturbance. Here bare soil accounts for 0.21% of the region's area, mostly subdivision earthworks (though some has other causes e.g. new roading, re surfacing of sports fields).

An additional 3.8% of the region's sample points are water bodies or coastal features, extensively disturbed by natural processes in the absence of any land use. Here bare ground accounts for 0.33% of the region's area: bare rock, soil sheetwash and landslides on cliffs; sandblows amongst dunes; sediment deposits along beaches and tidal creeks.

2.1.5 Unclassifiable surfaces

A final 0.9% of the region's sample points are unclassifiable. Most of these are on the southern Okahukura peninsula (west of Wellsford), where the Council still awaits supply of cloud-free aerial photographs.

Table 2.1

Soil State throughout the Auckland region 2007

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
STABLE SURFACES	1587	30.1	1.2		
S (i) with intact soil	1018	19.3	1.1	0.00	0.00
S (ii) with soil disturbed by land use	569	10.8	0.8	1.06	0.16
EROSION-PRONE SURFACES	1885	35.7	1.3		
U (i) with intact soil	1403	26.6	1.2	0.00	0.00
U (ii) with soil disturbed by land use	482	9.1	0.8	0.54	0.05
ERODED (R) AND ERODING (E) SURFACES	817	15.5	1.0		
R (i) with revegetating soil	424	8.0	0.7	0.00	0.00
E (ii) with soil disturbed by natural processes	393	7.4	0.7	0.84	0.17
EXTENSIVELY DISTURBED SURFACES	939	17.8	1.0		
Water bodies and coastal features	199	3.8	0.5	0.33	0.13
Rural buildings	162	3.1	0.5	0.31	0.11
Urban areas	578	11.0	0.8	0.21	0.08
UNCLASSIFIABLE SURFACES	49	0.9	0.3		
Points with no aerial photos	49	0.9	0.3	[4]	[4]
ALL SURFACES IN REGION total	5277	100.0	0.0	3.29	0.29

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

Note 4: not measured in 2007.

2.2 Soil disturbance throughout the Auckland region, 2007

(Table 2.2)

2.2.1 Disturbance by land use

Land use related disturbance is present on 34% of the region's land. Bare soil equates to 2.12% of the region's area.

- 19.9% of the region's land is currently disturbed by rural land use. This number corresponds with the sum of percentages for S (ii) and U (ii) from Table 2.1.
- Farm or forest tracks are the most widespread disturbance by land use, present on 8.6% of the region's land. Bare track surface equates to 0.49% of the region's area.
- Cultivation, harvest (includes forest harvest) and spraying (includes pasture renewal) are collectively present on 3.7% of the region's land, and responsible for bare soil on 0.61%, 0.11% and 0.05% of the region's area respectively.
- Livestock grazing pressure is present on 3.9% of the region's land, and exposes bare soil on 0.13% of the region's area.
- Earthworks for farm buildings or forest harvest sites occupy 1.5% of the region's land, and account for bare soil on 0.09% of the region's area.
- Unsealed rural roads cross 1.3% of the region's land, and associated bare soil is 0.09% of the region's area.
- Drain excavation or cleaning is present at 0.9% of the region's land, and has bared soil on 0.04% of the region's area.
- Rural uses 3.1% (buildings, yards and roads). An additional 0.31% of the region's area has bare soil due to disturbance associated with rural buildings, yards and roads.
- Finally 11.0% in urban uses, 0.21% of the region's area has bare soil due to disturbance associated with urban use (houses, commercial buildings, urban roads and urban open space).

2.2.2 Disturbance by natural processes

Disturbance by natural processes is present on 11.2% of the region's land and bare soil equates to 1.17% of the region's area.

This includes contributions from:

- 7.4% of the region's land is currently disturbed by natural processes of erosion or deposition. This number corresponds with the percentage for E(ii) from Table 2.1.
- Slope failures are the most widespread disturbance by natural processes of erosion or deposition. Landslides and debris avalanches, slumps and earthflows, are collectively present on 2.7% of the region's land. They cause bare soil on 0.12% of the region's area.
- Surface erosion, although not as widespread, accounts for more bare soil. Sheetwash (0.3% of the region's land), rockfall or rock outcrops (1.0%), and sandblow (0.7%), collectively bare soil on 0.55% of its area.
- Riparian erosion and deposition are present on a similar percentage (2.1%) of the region's land, but deposits of sand, silt or gravel along watercourses together with bank scour and collapse, account for less bare soil, just 0.17% of the region's area.
- Tunnel gullies (under-runners) and open gullies are minor in comparison, present on 0.6% of the region's land, and responsible for bare soil on 0.01% of its area.
- An additional 3.8% of the region is water bodies or coasts, partly exposed as bare ground. Collectively, estuarine flats, beaches and rock platforms expose bare ground on 0.33% of the region's area.

2.2.3 Regional totals (land use related and natural processes)

53.9% of sample points are currently free from soil disturbance in 2007.

Soil disturbance is present on 45.2% of land in Auckland. 34% is land use-related, while 11.2% is caused by natural processes of erosion or deposition. Bare soil amounts to 3.29% of the entire region's area, of which 2.12% is attributable to land use and 1.17% to natural processes.

There is 95% confidence that sample percentages for soil intactness or disturbance are within 1.2% or better of the true regional figures. For bare soil, there is 95% confidence that sample percentages are within 0.29% or better.

Table 2.2 Soil disturbance throughout the Auckland region, 2007.

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as %of area[2]	95% conf. lim.[3]
BY LAND USE					
grazing pressure	206	3.9	0.5	0.13	0.02
cultivation	85	1.6	0.3	0.61	0.16
harvest	78	1.5	0.3	0.10	0.03
spraying	30	0.6	0.2	0.05	0.03
drains	46	0.9	0.3	0.04	0.01
tracks	454	8.6	0.8	0.49	0.05
earthworks	81	1.5	0.3	0.09	0.03
roads	71	1.3	0.3	0.09	0.03
rural land use sub-total	1051	19.9	1.1	1.60	0.18
rural buildings	162	3.1	0.5	0.31	0.11
urban areas	578	11.0	0.8	0.21	0.08
Land use disturbance total	1791	34.0	1.3	2.12	
BY NATURAL PROCESSES					
landslide	93	1.8	0.4	0.08	0.03
debris avalanche	13	0.2	0.1	0.01	0.01
slump or earthflow	35	0.7	0.2	0.03	0.02
tunnel gully	10	0.2	0.1	<0.01	<0.01
gully	22	0.4	0.2	0.01	0.01
streambank scour	49	0.9	0.3	0.03	0.01
streambank deposit	62	1.2	0.3	0.14	0.06
sandblow	38	0.7	0.2	0.33	0.14
sheetwash	16	0.3	0.1	0.02	0.02
rockfall or bare rock	53	1.0	0.3	0.20	0.07
natural processes sub-total	393	7.4	0.7	0.84	0.17
water bodies and coastal features	199	3.8	0.5	0.33	0.13
Natural disturbance total	592	11.2	0.9	1.17	
Disturbed total	2383	45.2	1.3	3.29	0.29
UNCLASSIFIABLE					
undisturbed points	2845	53.9	1.3	0.00	0.00
points with no photos in 2007	49	0.9	0.3	[4]	[4]
Total	5277	100.0		3.29	0.29

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

Note 4: not measured in 2007.

2.3 Land uses in Auckland region

(Table 2.3)

Summary data are presented in this table, excerpted from a report Vegetation Associated with Land Uses in the Auckland Region 2007 (Thompson and Hicks, 2009). The table is replicated here to set the scene for discussions of soil state under each land use.

Table 2.3 Land uses in Auckland region 2007

Land use	Composition	Points	Points as% of sample[1]	95% conf. lim.[2]
Intensive	vineyards incl. kiwifruit	26	0.5	0.2
	orchards incl. avocado	33	0.6	0.2
	market gardens	66	1.3	0.3
	grain crops	34	0.6	0.2
	greenfeed crops	12	0.2	0.1
	sub-total	171	3.2	0.5
Dairy	improved, hard-grazed	133	2.5	0.4
	improved, lax-grazed or spelled	448	8.5	0.8
	improved, harvested	10	0.2	0.1
	sub-total	591	11.2	0.9
Drystock	improved, hard-grazed	422	8.0	0.7
	improved, lax-grazed or spelled	1054	20.0	1.1
	improved, harvested	20	0.4	0.2
	unimproved	146	2.8	0.4
	sub-total	1642	31.1	1.2
Forest plantations	open-canopy pines	132	2.5	0.4
	maturing pines	304	5.8	0.6
	harvested pines	39	0.7	0.2
	broadleaved trees	4	0.1	0.1
	sub-total	479	9.1	0.8
Natural forest	closed canopy	147	2.8	0.4
	with natural scrub	167	3.2	0.5
	with exotic grass, scrub or trees	58	1.1	0.3
	with other, principally houses	11	0.2	0.1
	sub-total	383	7.3	0.7
Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.				

Note 2: confidence limits are not additive.

Cont. Table 2.3

Land uses in Auckland region, 2007

Land use	Composition	Points	Points as% of sample[1]	95% conf. lim.[2]
Natural scrub	closed canopy	220	4.2	0.5
	with forest trees	287	5.4	0.6
	with exotic grass, scrub or trees	221	4.2	0.5
	with other, principally houses	30	0.6	0.2
	sub-total	758	14.4	0.9
Exotic scrub	closed canopy	12	0.2	0.1
	with natural scrub or forest trees	42	0.8	0.2
	with exotic grass or trees	60	1.1	0.3
	with other, principally houses	8	0.2	0.1
	sub-total	122	2.3	0.4
Coastal grass and scrub	undifferentiated	29	0.5	0.2
Wetland and mangrove	wetland	25	0.5	0.2
	mangrove	89	1.7	0.3
	sub-total	114	2.2	0.4
Other	rural buildings	162	3.1	0.5
	urban areas	578	11.0	0.8
	water bodies and coastal features	199	3.8	0.5
	unclassified points	0	0.0	0.0
	points with no photo cover	49	0.9	0.3
All region	total	5277	100.0	0.0

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: confidence limits are not additive.

3 Intensive Uses

3.1 Overview

(Table 2.3)

3.2% of Auckland's sample points are currently under intensive land uses i.e. high-yielding food crops. 0.5% are grape vineyards or other vine crops (mainly kiwifruit), 0.6% fruit orchards, 1.3% market gardens, 0.6% grain crops (mainly maize), and 0.2% greenfeed crops (chou, turnips and similar). The table summarises soil state for these uses collectively because they entail either seasonal cultivation of soil, or seasonal harvest of produce, or both.

3.2 Soil state

(Table 2.4)

3.2.1 Stable surfaces

Stable surfaces under intensive use are mostly elevated terraces and rolling downlands, protected floodplains, or drained wetlands.

- 2.7% of the region's sample points are on stable surfaces under intensive use,
- 1.1% have intact soil, currently well-vegetated (maturing crop, or tree and vine cover), and
- 1.6% have soil currently disturbed by land use. Within this category, bare soil amounts to 0.51% of the sample's area.

3.2.2 Erosion-prone surfaces

The erosion-prone surfaces are drainage hollows on terraces and downlands, or unprotected floodplains, or semi-drained/undrained wetland remnants.

- 0.5% of the region's sample points are on erosion-prone surfaces under intensive use,
- 0.2% have intact soil, currently well-vegetated, and
- 0.3% have soil currently disturbed by land use. Within this category, bare soil amounts to 0.04% of the sample's area.

3.2.3 Eroded and eroding surfaces

Eroded and eroding surfaces are where bank erosion or deposition occurs along the streams that run through terraces and downlands or across floodplains; except for one point where a landslide has occurred on a terrace edge next to a market garden.

- 0.1% of the region's sample points are on eroded and eroding surfaces under intensive use,
- <0.1% have soil recently disturbed by natural erosion processes, but revegetating, and
- 0.1% have soil freshly disturbed. Within this category, bare soil amounts to less than 0.01% of the sample's area.

Table 2.4

Soil State for intensive uses in Auckland region, 2007.

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
STABLE SURFACES (S)					
S (i) with intact soil	57	1.1	0.3	0.00	0.00
S (ii) with soil disturbed by land use	83	1.6	0.3	0.51	0.50
sub-total	140	2.7	0.4		
EROSION_PRONE SURFACES (U)					
U (i) with intact soil	10	0.2	0.1	0.00	0.00
U (ii) with soil disturbed by land use	17	0.3	0.2	0.04	0.02
sub-total	27	0.5	0.2		
ERODED (R) AND ERODING (E) SURFACES					
R (i) with revegetating soil	1	<0.1	<0.1	0.00	0.00
E (ii) with soil disturbed by natural processes	3	0.1	0.1	<0.01	<0.01
sub-total	4	0.1	0.1		
ALL SURFACES IN LAND USE total	171	3.2	0.5	0.55	0.15

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

3.3 Soil disturbance

(Table 2.5)

3.3.1 Disturbance by land use

Numbers in this section are obtained by adding the percentages for S (ii) and U (ii) from Table 2.4. When stable and erosion-prone surfaces are combined, 1.9% of Auckland's land is currently disturbed by intensive uses. On most sites, growing crops, or fruit trees and vines with grass beneath, provide good ground cover. Nevertheless a proportion of sites show topsoil exposed by:

- cultivation 0.49% of the region's soil,
- harvest 0.01%,
- spraying <0.01%,
- drains <0.01%,
- tracks 0.03%,
- earthworks <0.01%, and
- unsealed roads 0.01%,

These sites collectively contribute 0.55% to the region's area of exposed soil at risk of topsoil loss (2.12%, from Table 2.2).

3.3.2 Disturbance by natural processes

Numbers in this section correspond with the percentages for E (ii) in Table 2.4. A further 0.1% of Auckland's land is disturbed by natural processes while under intensive use; mainly streambank scour or deposition. Exposed soil collectively amounts to less than 0.01%, so makes a minimal contribution to the region's area bared by erosion (1.17%, from Table 2.2).

3.3.3 Summary of disturbance

Under intensive uses, soil disturbance affects 2.0% of land in Auckland. 1.9% is land use-related, while 0.1% is caused by natural processes of erosion or deposition. Bare soil amounts to 0.55% of the entire region's area, of which almost all is attributable to land use and less than 0.01% to natural processes.

There is 95% confidence that sample percentages for soil disturbance are within 0.5% or better of the true regional figures. For bare soil, there is 95% confidence that sample percentages are within 0.15% or better.

Table 2.5

Soil disturbance amongst intensive uses in Auckland region, 2007.

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
BY LAND USE					
grazing pressure	2	0.0	0.1	<0.01	<0.01
cultivation	60	1.1	0.3	0.49	0.15
harvest	5	0.1	0.1	0.01	0.02
spraying	4	0.1	0.1	<0.01	0.01
drains	3	0.1	0.1	<0.01	<0.01
tracks	20	0.4	0.2	0.03	0.01
earthworks	2	<0.1	<0.1	<0.01	<0.01
roads	4	0.1	0.1	0.01	0.01
sub-total	100	1.9	0.4	0.55	0.15
BY NATURAL PROCESSES					
landslide	1	<0.1	<0.1	<0.01	<0.01
debris avalanche	0	0.0	0.0		
slump or earthflow	0	0.0	0.0		
tunnel gully	0	0.0	0.0		
gully	0	0.0	0.0		
streambank scour	1	<0.1	<0.1	<0.01	<0.01
streambank deposit	1	<0.1	<0.1	<0.01	<0.01
sandblow	0	0.0	0.0		
sheetwash	0	0.0	0.0		
rockfall or bare rock	0	0.0	0.0		
sub-total	3	0.1	0.1	<0.01	<0.01
OTHER					
undisturbed sub-total	68	1.3	0.3	0.00	0.00
ALL IN LAND USE total	171	3.2	0.5	0.55	0.15

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

4 Dairy Farms

4.1 Overview

(Table 2.3)

11.2% of Auckland's sample points are currently used for dairy farming. They are entirely improved pasture. At the time of photography (mid to late summer 2007) 8.5% have a complete grass cover (lax-grazed or spelled), 2.5% are hard-grazed or sparsely covered, while 0.2% are recently harvested for hay or silage.

4.2 Soil state

(Table 2.6)

4.2.1 Stable surfaces

Stable surfaces in dairy pasture are mostly protected floodplains, well-drained wetlands, elevated terraces or rolling downlands, and easy hill country footslopes.

- 6.2% of the region's sample points are on stable surfaces in dairy pasture,
- 3.3% have intact soil, currently well-vegetated, and
- 2.9% have soil currently disturbed by land use. Bare soil amounts to 0.19% of the sample's area.

4.2.2 Erosion-prone surfaces

The erosion-prone surfaces are unprotected floodplains, poorly-drained wetlands, drainage hollows on terraces and downlands, or unstable footslopes.

- 3.6% of the region's sample points are on erosion-prone surfaces in dairy pasture,
- 1.9% have intact soil, currently well-vegetated, and
- 1.7% have soil currently disturbed by land use. Here bare soil amounts to 0.12% of the sample's area.

Table 2.6

Soil state for dairy farms in the Auckland region, 2007.

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
STABLE SURFACES (S)					
S (i) with intact soil	173	3.3	0.5	0.00	0.00
S (ii) with soil disturbed by land use	155	2.9	0.5	0.19	0.04
sub-total	328	6.2	0.7		
EROSION_PRONE SURFACES (U)					
U (i) with intact soil	98	1.9	0.4	0.00	0.00
U (ii) with soil disturbed by land use	91	1.7	0.4	0.12	0.04
sub-total	189	3.6	0.5		
ERODED (R) AND ERODING (E) SURFACES					
R (i) with revegetating soil	36	0.7	0.2	0.00	0.00
E (ii) with soil disturbed by natural processes	38	0.7	0.2	0.03	0.01
sub-total	74	1.4	0.3		
ALL SURFACES IN LAND USE total	591	11.2	0.9	0.35	0.06

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

4.2.3 Eroded and eroding surfaces

The eroded and eroding surfaces are streambank scour or deposition along watercourses, under-runners or gullies in terraces and downlands, and slumps or earthflows on footslopes. A landslide is recorded at just one sample point.

- 1.4% of the region's sample points are on eroded and eroding surfaces in dairy pasture,
- 0.7% have soil recently disturbed by natural erosion processes, but revegetating, and
- 0.7% have soil freshly disturbed, with bare soil amounting to 0.03% of the sample's area.

4.3 Soil disturbance

(Table 2.7)

4.3.1 Disturbance by land use

Numbers in this section are obtained by adding the percentages for S(ii) and U(ii) from Table 2.6. When stable and erosion-prone surfaces are combined, 4.7% of Auckland's land is currently disturbed by dairy farming. The fairly high percentage is due to farm tracks (2.6%) and grazing pressure (1.1%). Other land use-related disturbances are minor. Not all the disturbed soil is bare, and where it is, the causes are:

- grazing pressure, exposing 0.05% of the region's soil,
- cultivation 0.04%,
- harvest <0.01%,
- spraying 0.01%,
- drains 0.02%,
- tracks 0.18%,
- earthworks 0.01%, and
- unsealed roads 0.01%.

As these amount to 0.32% of the region's area, dairy farming accounts for a sixth of the region's land at risk of topsoil loss (2.12% region-wide, Table 2.2). However it should be noted that topsoil loss does not necessarily occur on all the exposed ground. A high proportion of tracks on dairy farms are surfaced with race rock or similar, and also away from streams - factors which reduce off-site soil loss. Likewise a high proportion of soil bared by grazing pressure is on flat land where any soil removed by runoff is likely to be trapped by adjacent dense pasture before reaching a watercourse.

4.3.2 Disturbance by natural processes

Numbers in this section correspond with the percentages for E (ii) in Table 2.6. Just 0.7% of land in Auckland is disturbed by natural processes occurring on land under dairy pasture. These are bank scour or deposits along watercourses, tunnel gullies or gullies in drainage hollows, and slumps or earthflows on unstable footslopes. Soil bared by natural disturbance is minor; equating to 0.03% of the region's bare ground, its contribution to region-wide soil erosion (1.17%, Table 2.2) is slight.

Table 2.7

Soil disturbance on dairy farms in the Auckland Region, 2007.

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
BY LAND USE					
grazing pressure	57	1.1	0.3	0.05	0.02
cultivation	7	0.1	0.1	0.04	0.04
harvest	1	<0.1	<0.1	<0.01	<0.01
spraying	5	0.1	0.1	0.01	0.02
drains	21	0.4	0.2	0.02	0.01
tracks	139	2.6	0.4	0.18	0.03
earthworks	8	<0.1	<0.1	0.01	0.01
roads	8	0.2	0.1	0.01	0.01
sub-total	246	4.7	0.6	0.32	0.06
BY NATURAL PROCESSES					
landslide	1	<0.1	<0.1	<0.01	<0.01
debris avalanche	0	0.0	0.0		
slump or earthflow	6	0.1	0.1	<0.01	<0.01
tunnel gully	4	0.1	0.1	<0.01	<0.01
gully	6	0.1	0.1	<0.01	<0.01
streambank scour	7	0.1	0.1	<0.01	<0.01
streambank deposit	14	0.3	0.1	0.02	0.01
sandblow	0	0.0	0.0		
sheetwash	0	0.0	0.0		
rockfall or bare rock	0	0.0	0.0		
sub-total	38	0.7	0.2	0.03	0.01
OTHER					
undisturbed sub-total	307	5.8	0.6	0.00	0.00
ALL IN LAND USE total	591	11.2	0.9	0.35	0.06

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

4.3.3 Summary of disturbance

Under dairy pasture, soil disturbance affects 5.4% of land in Auckland. 4.7% is land use-related, while 0.7% is caused by natural processes of erosion or deposition. Bare soil amounts to 0.35% of the entire region's area, of which 0.32% is attributable to land use and 0.03% to natural processes.

There is 95% confidence that sample percentages for soil disturbance are within 0.9% or better of the true regional figures. For bare soil, there is 95% confidence that sample percentages are within 0.06% or better.

5 Drystock Farms

5.1 Overview

(Table 2.3)

31.1% of Auckland's sample points are currently used for drystock farming (beef cattle, deer, sheep, goats). At the time of photography (mid to late summer 2007) 20.0% are improved pasture with a complete grass cover (lax-grazed or spelled), 8.0% with a sparse cover (hard-grazed) and 0.4% recently harvested for hay or silage. The balance of 2.8% is unimproved pasture.

5.2 Soil state

(Table 2.8)

5.2.1 Stable surfaces

Stable surfaces in drystock pasture are mostly elevated terraces, rolling downlands, easy hillslopes, and old coastal dunes with weathered soils.

- 12.7% of the region's sample points are on stable surfaces in drystock pasture,
- 7.8% have intact soil, currently well-vegetated, and
- 4.9% have soil currently disturbed by land use. Bare soil amounts to 0.27% of the sample's area.

5.2.2 Erosion-prone surfaces

Erosion-prone surfaces are drainage hollows on terraces and downlands (including healed under-runners and gullies); moderate hill slopes showing traces of past slope failure, now completely revegetated; and young or intermediate-age coastal dunes fixed by pasture.

- 11.7% of the region's sample points are on erosion-prone surfaces in drystock pasture,
- 7.5% have intact soil, currently well-vegetated, and
- 4.2% have soil currently disturbed by land use. Here bare soil amounts to 0.21% of the sample's area.

5.2.3 Eroded and eroding surfaces

The eroded and eroding surfaces are landslides, slumps and earthflows on moderate hill country; under-runners and gullies there or in drainage hollows on terraces and downlands; and streambank scour or deposition along watercourses. Sandblow on sparsely vegetated dunes, sheetwash on sparsely vegetated hill country spurs or ridges, and rockfall or rock outcrops on coastal cliffs, also put in an appearance.

- 6.8% of the region's sample points are on eroded and eroding surfaces in drystock pasture,
- 3.6% have soil recently disturbed by natural erosion processes, but revegetating, and
- 3.2% have soil freshly disturbed, with bare soil amounting to 0.19% of the sample's area.

Table 2.8

Soil state for drystock farms in Auckland Region, 2007

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
STABLE SURFACES (S)					
S (i) with intact soil	411	7.8	0.7	0.00	0.00
S (ii) with soil disturbed by land use	258	4.9	0.6	0.27	0.05
sub-total	669	12.7	0.9		
EROSION_PRONE SURFACES (U)					
U (i) with intact soil	398	7.5	0.7	0.00	0.00
U (ii) with soil disturbed by land use	219	4.2	0.5	0.21	0.05
sub-total	617	11.7	0.9		
ERODED (R) AND ERODING (E) SURFACES					
R (i) with revegetating soil	189	3.6	0.5	0.00	0.00
E (ii) with soil disturbed by natural processes	167	3.2	0.5	0.19	0.05
sub-total	356	6.7	0.7		
ALL SURFACES IN LAND USE total	1642	31.1	1.2	0.67	0.08

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

5.3 Soil disturbance

(Table 2.9)

5.3.1 Disturbance by land use

Numbers in this section are obtained by adding the percentages for S(ii) and U(ii) from Table 2.8. When stable and erosion-prone surfaces are combined, 9.0% of Auckland's land is currently disturbed by drystock farming. The percentage is twice as much as for dairy farming. Causes are similar though more elevated, with the principal contributors being farm tracks (3.8%) and grazing pressure (2.6%). Other land-use-related disturbances are individually minor; though cumulatively amount to 2.6% of land. Topsoil is exposed by:

- grazing pressure on 0.08% of the region's soil,
- cultivation on 0.07%,
- harvest on 0.01%,
- spraying on 0.03%,
- drains on 0.02%,
- tracks on 0.20%,
- earthworks on 0.05%, and
- roads on 0.03%.

Bare soil equates to 0.48% of the region's area, so makes a greater contribution than dairy farming to the region's land at risk of topsoil loss (2.12%, Table 2.2). Unlike dairy farms, most tracks on drystock farms are bare earth, many are on rolling to moderately steep ground, and some cross streams. A high proportion of soil bared by grazing pressure is on rolling to moderate slopes; though even here some of the soil transported by runoff is more likely to be trapped by dense pasture downslope, than to enter watercourses.

Table 2.9

Soil disturbance on drystock farms in the Auckland region 2007

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
BY LAND USE					
grazing pressure	137	2.6	0.4	0.08	0.02
cultivation	18	0.3	0.2	0.07	0.05
harvest	4	0.1	0.1	0.01	0.01
spraying	16	0.3	0.1	0.03	0.03
drains	22	0.4	0.2	0.02	0.01
tracks	201	3.8	0.5	0.20	0.03
earthworks	55	1.0	0.3	0.05	0.02
roads	24	0.5	0.2	0.03	0.01
sub-total	477	9.0	0.8	0.48	0.07
BY NATURAL PROCESSES					
landslide	50	0.9	0.3	0.03	0.01
debris avalanche	4	0.1	0.1	0.01	0.01
slump or earthflow	28	0.5	0.2	0.03	0.02
tunnel gully	6	0.1	0.1	<0.01	<0.01
gully	14	0.3	0.1	0.01	<0.01
streambank scour	21	0.4	0.2	0.01	0.01
streambank deposit	15	0.3	0.1	0.02	0.01
sandblow	10	0.2	0.1	0.01	0.01
sheetwash	5	0.1	0.1	0.01	0.02
rockfall or bare rock	14	0.3	0.1	0.05	0.04
sub-total	167	3.2	0.5	0.19	0.05
OTHER					
undisturbed sub-total	998	18.9	1.1	0.00	0.00
ALL IN LAND USE total	1642	31.1	1.2	0.67	0.08

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

5.3.2 Disturbance by natural processes

Numbers in this section correspond with the percentages for E(ii) in Table 2.8. A further 3.2% of land in Auckland is disturbed by natural processes occurring on land under drystock pasture. These are earthflows, slumps and large slope failures on moderate hilllslopes; landslides or debris avalanches on steep faces; tunnel gully or open gully erosion in drainage hollows; and streambank scour or deposition along watercourses. At 3.2% of the region, percentage of land disturbed is much higher than for dairy farms (0.7%, Table 2.6). Soil actually bared on drystock farms is:

- by slope failures, 0.07% of the region's area,
- by gullies 0.02%,
- by streambank scour or deposit 0.03%, and
- by surface erosion 0.07%.

Soil bared by natural processes in drystock pasture equates to 0.19% of the region's area, and accounts for a just under a tenth of the region's soil erosion (2.12%, Table 2.2).

5.3.3 Summary of disturbance

Under drystock pasture, soil disturbance affects 12.2% of land in Auckland. 9.0% is land use-related, while 3.2% is caused by natural processes of erosion or deposition. Bare soil amounts to 0.67% of the entire region's area, of which 0.48% is attributable to land use and 0.19% to natural processes.

There is 95% confidence that sample percentages for soil disturbance are within 1.2% or better of the true regional figures. For bare soil, there is 95% confidence that sample percentages are within 0.08% or better.

6 Forest Plantations

6.1 Overview

(Table 2.3)

Forest plantations are growing on 9.1% of Auckland's sample points. 2.5% are young pines (prior to canopy closure), much of them second-rotation. 5.8% are maturing pines (closed canopy). 0.7% are harvested pines, not yet re-planted. 0.1% are broadleaved plantations; mainly eucalypts.

6.2 Soil state

(Table 2.10)

6.2.1 Stable surfaces

Stable surfaces under forest plantation are elevated terraces, rolling downlands, easy hillslopes, and old coastal dunes with weathered soils.

- 1.6% of the region's sample points are on stable surfaces under forest plantations,
- 1.1% have intact soil, currently well-vegetated, and
- 0.5% have soil currently disturbed by land use. Bare soil amounts to 0.04% of the sample's area.

6.2.2 Erosion-prone surfaces

Erosion-prone surfaces are mostly moderate hillslopes or steep rangelands showing traces of past slope failure, now completely revegetated; or coastal dunes of young to intermediate age, now fixed by pine trees. A small proportion are stream banks, drainage hollows on terraces and downlands, or unstable footslopes.

- 6.0% of the region's sample points are on erosion-prone surfaces under forest plantations,
- 4.4% have intact soil, currently well-vegetated, and
- 1.6% have soil currently disturbed by land use. Here bare soil amounts to 0.09% of the sample's area.

6.2.3 Eroded and eroding surfaces

The eroded and eroding surfaces under forest plantation are streambank scour or deposition along watercourses; landslides or debris avalanches on hill faces and steep ranges; and sandblows on young coastal dunes.

- 1.4% of the region's sample points are on eroded and eroding surfaces under forest plantations,
- 0.8% have soil recently disturbed by natural erosion processes, but revegetating, and
- 0.6% have soil freshly disturbed, with bare soil amounting to 0.04% of the sample's area.

Table 2.10

Soil state for forest plantations in Auckland Region, 2007

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
STABLE SURFACES (S)					
S (i) with intact soil	59	1.1	0.3	0.00	0.00
S (ii) with soil disturbed by land use	28	0.5	0.2	0.04	0.02
sub-total	87	1.6	0.3		
EROSION_PRONE SURFACES (U)					
U (i) with intact soil	232	4.4	0.6	0.00	0.00
U (ii) with soil disturbed by land use	85	1.6	0.3	0.09	0.02
sub-total	317	6.0	0.6		
ERODED (R) AND ERODING (E) SURFACES					
R (i) with revegetating soil	42	0.8	0.2	0.00	0.00
E (ii) with soil disturbed by natural processes	33	0.6	0.2	0.04	0.03
sub-total	75	1.4	0.3		
ALL SURFACES IN LAND USE total	479	9.1	0.8	0.17	0.04

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

6.3 Soil disturbance

(Table 2.11)

6.3.1 Disturbance by land use

Numbers in this section are obtained by adding the percentages for S (ii) and U (ii) from Table 2.10. When stable and erosion-prone surfaces are combined, 2.1% of Auckland's land is currently disturbed, out of the 9.1% in forest plantations. Causes of disturbance are very different from intensive uses or pastoral farming. 0.9% of land use-related disturbance is tracking or forest roads - this includes access tracks for planting and silviculture as well as roads for harvest. <0.1% is earthworks associated with forest harvest - landing stages and skid sites which are largely protected by slash. 1.2% is land where soil is exposed by harvest - concentrated along skidder tracks and hauler paths rather than disseminated throughout harvested compartments. Bare soil exposed to risk of topsoil loss by forestry is:

- by harvest, 0.08% of the region's soil,
- by tracks and unsealed roads, 0.05%,
- by earthworks, <0.01%, and
- by miscellaneous disturbances, <0.01%.

These equate to 0.13% of the region's area, so make a lower contribution than dairy or drystock farming to the region's land at risk of topsoil loss (2.12%, Table 2.2). Much of the exposed soil is on upper slopes close to landing stages, where it is unlikely to move towards watercourses. Where it is on lower slopes, off-site soil loss may be mitigated by forest management practices on adjacent ground - metalling of tracks, over-sowing of grasses and legumes on harvest sites, and avoidance of planting or harvest near streams.

Table 2.11

Soil disturbance in forest plantations in Auckland Region, 2007

		points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
BY LAND USE						
grazing pressure		1	<0.1	<0.1	<0.01	<0.01
cultivation		0	0.0	0.0		
harvest		61	1.2	0.3	0.08	0.03
spraying		1	<0.1	<0.1	<0.01	<0.01
drains		0	0.0	0.0		
tracks		37	0.7	0.2	0.03	0.01
earthworks		1	<0.1	<0.1	<0.01	<0.01
roads		12	0.2	0.1	0.02	0.01
	sub-total	113	2.1	0.4	0.13	0.03
BY NATURAL PROCESSES						
landslide		17	0.3	0.2	0.01	0.01
debris avalanche		6	0.1	0.1	<0.01	<0.01
slump or earthflow		0	0.0	0.0		
tunnel gully		0	0.0	0.0		
gully		0	0.0	0.0		
streambank scour		4	0.1	0.1	<0.01	<0.01
streambank deposit		2	<0.1	<0.1	<0.01	<0.01
sandblow		4	0.1	0.1	0.02	0.03
sheetwash		0	0.0	0.0		
rockfall or bare rock		0	0.0	0.0		
	sub-total	33	0.6	0.2	0.04	0.03
OTHER						
undisturbed	sub-total	333	6.3	0.7	0.00	0.00
ALL IN LAND USE	total	479	9.1	0.8	0.17	0.04

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

6.3.2 Disturbance by natural processes

Numbers in this section correspond with the percentages for E(ii) in Table 2.10. A further 0.6% of land in Auckland is disturbed by natural processes occurring on land planted in trees. Bare soil is caused by:

- slope failures on 0.01% of the region's area,
- sandblows on 0.02%, and
- streambank scour and deposit on 0.01%.

In forest plantations natural erosion or deposition of soil, with bare soil amounting to 0.04% of the region's area, is similar to dairy farming and much less than drystock farming. This is a small contribution to regional soil erosion (1.17%, Table 2.2). Given the area in forest plantation (9.1% of the region), proportionately it is much less than might be expected and indicates the stabilising effect of tree roots in soil under maturing forest (5.9%) cf. harvested (0.7%) and replanted trees (2.5%).

6.3.3 Summary of disturbance

Under forest plantations, soil disturbance affects 2.7% of land in Auckland. 2.1% is land use-related, while 0.6% is caused by natural processes of erosion or deposition. Bare soil amounts to 0.17% of the entire region's area, of which 0.13% is attributable to land use and 0.04% to natural processes.

There is 95% confidence that sample percentages for soil disturbance are within 0.8% or better of the true regional figures. For bare soil, there is 95% confidence that sample percentages are within 0.04% or better.

7 Natural Forest

7.1 Overview

(Table 2.3)

Natural forest remains on 7.3% of Auckland's sample points. 2.8% are closed canopy forest. 3.2% are interspersed with woody scrub in canopy gaps due to plant succession after natural disturbance (erosion or windthrow during storms). 1.1% are natural forest with patches of grass, exotic scrub or exotic trees. These are areas adjacent to past or present farms. 0.2% are natural forest with houses, either lifestyle blocks or urban-fringe.

7.2 Soil state

(Table 2.12)

7.2.1 Stable surfaces

Stable surfaces in natural forest are moderate hillslopes, or spurs and ridges in the ranges; apart from a small proportion where forest remains on footslopes, terraces or downlands.

- 1.8% of the region's sample points are on stable surfaces under natural forest,
- 1.7% have intact soil, currently well-vegetated, and
- 0.1% have soil currently disturbed by land use. Bare soil amounts to <0.01% of the sample's area.

7.2.2 Erosion-prone surfaces

Erosion-prone surfaces are moderate hillslopes showing traces of past slope failure (now completely revegetated), or steep slopes in the ranges with similar evidence. A small proportion are forest remnants adjacent to watercourses that run through footslopes, terraces or downlands.

- 4.3% of the region's sample points are on erosion-prone surfaces under natural forest,
- 4.2 have intact soil, currently well-vegetated, and
- 0.1% have soil currently disturbed by land use. Here bare soil amounts to 0.01% of the sample's area.

7.2.3 Eroded and eroding surfaces

The eroded and eroding surfaces are landslides on hill country, debris avalanches and gullied debris flow deposits in the ranges; and streambank scour or deposition along watercourses.

- 1.2% of the region's sample points are on eroded and eroding surfaces under natural forest,
- 0.8% have soil recently disturbed by natural erosion processes, but revegetating, and
- 0.3% have soil freshly disturbed, with bare soil amounting to 0.03% of the sample's area.

Table 2.12

Soil state for natural forest in Auckland Region, 2007

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
STABLE SURFACES (S)					
S (i) with intact soil	89	1.7	0.3	0.00	0.00
S (ii) with soil disturbed by land use	6	0.1	0.1	<0.01	<0.01
sub-total	95	1.8	0.4		
EROSION_PRONE SURFACES (U)					
U (i) with intact soil	221	4.2	0.5	0.00	0.00
U (ii) with soil disturbed by land use	6	0.1	0.1	0.01	<0.01
sub-total	227	4.3	0.5		
ERODED (R) AND ERODING (E) SURFACES					
R (i) with revegetating soil	43	0.8	0.2	0.00	0.00
E (ii) with soil disturbed by natural processes	18	0.3	0.2	0.03	0.03
sub-total	61	1.2	0.3		
ALL SURFACES IN LAND USE total	383	7.3	0.7	0.04	0.03

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

7.3 Soil disturbance

(Table 2.13)

7.3.1 Disturbance by land use

Numbers in this section are obtained by adding the percentages for S(ii) and U(ii) from Table 2.12. When stable and erosion-prone surfaces are combined, just 0.2% of Auckland's land is currently disturbed by land use-related activities within natural forest. These are almost entirely access tracks or unsealed rural roads (earthwork disturbance was recorded at just one sample point). Equating to 0.01% of the region's bare soil, their contribution to land at risk of topsoil loss (2.12%, Table 2.2) is negligible.

7.3.2 Disturbance by natural processes

Numbers in this section correspond with the percentages for E(ii) in Table 2.12. 0.3% of land in Auckland is disturbed by erosion or deposition within natural forest. Bare soil on disturbed surfaces is attributable to:

- slope failures on <0.01% of the region's area,
- stream scour and deposit on 0.03%,
- rockfall or bare rock on <0.01%.

They amount to 0.03% of the region's area, a very small contribution towards the region's total soil bared by erosion or deposition (1.17%, Table 2.2). Although the region's remaining forest is mainly on hill country or steep ranges subject to high rainfall, for the most part it is underlain by stable geology.

7.3.3 Summary of disturbance

Under natural forest, soil disturbance affects 0.5% of land in Auckland. 0.2% is land use-related, while 0.3% is caused by natural processes of erosion or deposition. Bare soil amounts to 0.04% of the entire region's area, of which 0.01% is attributable to land use and 0.03% to natural processes.

There is 95% confidence that sample percentages for soil disturbance are within 0.7% or better of the true regional figures. For bare soil, there is 95% confidence that sample percentages are within 0.03% or better.

Table 2.13

Soil disturbance in natural forest in the Auckland region 2007

	points	points as % of sample	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
BY LAND USE					
grazing pressure	0	0.0	0.0		
cultivation	0	0.0	0.0		
harvest	0	0.0	0.0		
spraying	0	0.0	0.0		
drains	0	0.0	0.0		
tracks	7	0.1	0.1	<0.01	<0.01
earthworks	1	<0.1	<0.1	<0.01	<0.01
roads	4	0.1	0.1	0.01	0.01
sub-total	12	0.2	0.1	0.01	0.01
BY NATURAL PROCESSES					
landslide	2	<0.1	<0.1	<0.01	<0.01
debris avalanche	2	<0.1	<0.1	<0.01	<0.01
slump or earthflow	0	0.0	0.0		
tunnel gully	0	0.0	0.0		
gully	0	0.0	0.0		
streambank scour	3	0.1	0.1	<0.01	<0.01
streambank deposit	8	0.2	0.1	0.03	0.03
sandblow	0	0.0	0.0		
sheetwash	0	0.0	0.0		
rockfall or bare rock	3	0.1	0.1	<0.01	<0.01
sub-total	18	0.3	0.2	0.03	0.03
OTHER					
undisturbed sub-total	353	6.7	0.7	0.00	0.00
ALL IN LAND USE total	383	7.3	0.7	0.04	0.03

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

8 Natural Scrub

8.1 Overview

(Table 2.3)

Natural scrub is present on 14.4% of Auckland's sample points. 4.2% are closed canopy scrub. 5.4% are scrub with emerging forest trees; such areas include forest long since cut-over and long-abandoned pasture. 4.2% are scrub with grass, exotic scrub or exotic trees in canopy gaps; these are areas of recently abandoned or lightly grazed pasture. 0.6% is scrub with houses; either lifestyle blocks or homes on the urban fringe.

8.2 Soil state

(Table 2.14)

8.2.1 Stable surfaces

Stable surfaces in natural scrub are moderate hillslopes, or spurs and ridges in the ranges; apart from a small proportion where scrub remains on footslopes, terraces or downlands.

- 4.4% of the region's sample points are on stable surfaces in natural scrub,
- 3.8% have intact soil, currently well-vegetated, and
- 0.6% have soil currently disturbed by land use. Bare soil amounts to 0.04% of the sample's area.

8.2.2 Erosion-prone surfaces

Erosion-prone surfaces are moderate hillslopes showing traces of past slope failure (now completely revegetated), or steep slopes in the ranges with similar evidence. A small proportion are scrub remnants adjacent to watercourses that run through footslopes, terraces or downlands.

- 7.1% of the region's sample points are on erosion-prone surfaces in natural scrub,
- 6.3% have intact soil, currently well-vegetated, and
- 0.8% have soil currently disturbed by land use. Here bare soil amounts to 0.05% of the sample's area.

8.2.3 Eroded and eroding surfaces

The eroded and eroding surfaces are landslides on hill country; debris avalanches and gullied debris flow deposits in the ranges; and streambank scour or deposition along watercourses.

- 2.8% of the region's sample points are on eroded and eroding surfaces in natural scrub,
- 1.3% have soil recently disturbed by natural erosion processes, but revegetating, and
- 1.5% have soil freshly disturbed, with bare soil amounting to 0.20% of the sample's area.

Table 2.14

Soil state for natural scrub in the Auckland region 2007

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
STABLE SURFACES (S)					
S (i) with intact soil	199	3.8	0.5	0.00	0.00
S (ii) with soil disturbed by land use	32	0.6	0.2	0.04	0.01
sub-total	231	4.4	0.6		
EROSION_PRONE SURFACES (U)					
U (i) with intact soil	335	6.3	0.7	0.00	0.00
U (ii) with soil disturbed by land use	42	0.8	0.2	0.05	0.02
sub-total	377	7.1	0.7		
ERODED (R) AND ERODING (E) SURFACES					
R (i) with revegetating soil	69	1.3	0.3	0.00	0.00
E (ii) with soil disturbed by natural processes	81	1.5	0.3	0.20	0.05
sub-total	150	2.8	0.4		
ALL SURFACES IN LAND USE total	758	14.4	0.9	0.28	0.07

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

8.3 Soil disturbance

(Table 2.15)

8.3.1 Disturbance by land use

Numbers in this section are obtained by adding the percentages for S(ii) and U(ii) from Table 2.14. When stable and erosion-prone surfaces are combined, 1.4% of Auckland's land is currently disturbed by land use-related activities within natural scrub. Most disturbance is access tracks or rural roads remaining within areas formerly harvested for timber or formerly farmed. Grazing pressure was recorded at a few sample points, as was scrub clearance. Equating to 0.08% bare soil by area, land use-related disturbance in natural scrub makes a larger contribution to the region's soil at risk of topsoil loss (2.12%, Table 2.2) than is the case in natural forest. Components of the bare soil are:

- tracks at 0.04%,
- unsealed roads at 0.02%,
- earthworks at 0.01%, and
- grazing pressure and scrub clearance, collectively 0.01%.

8.3.2 Disturbance by natural processes

Numbers in this section correspond with the percentages for E (ii) in Table 2.14. 1.5% of landl is disturbed by erosion or deposition within natural scrub, and bare soil on disturbed surfaces is due to:

- slope failures on 0.03% of the region's area,
- stream scour and deposit on 0.01%, and
- surface erosion on 0.16%.

These equate to 0.20% of the region's area; about a sixth of soil exposed by natural erosion region-wide (1.17%, Table 2.2). Proportionately it is higher than the contribution that might be expected, given that the land occupied by scrub (14.4%) is twice the area in forest (7.3%, Table 2.12) which only contributes 0.03%. The main contributors to high natural erosion amongst scrub are actually rockfalls and bare rock outcrops stripped of soil (0.14% out of the 0.16% surface erosion total). These occur in two situations: coastal cliffs throughout the region, and lava flows on Rangitoto Island.

Table 2.15

Soil disturbance in natural scrub in Auckland Region, 2007

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
BY LAND USE					
grazing pressure	3	0.1	0.1	<0.01	<0.01
cultivation	0	0.0	0.0		
harvest	2	<0.1	<0.1	<0.01	<0.01
spraying	1	<0.1	<0.1	<0.01	<0.01
drains	0	0.0	0.0		
tracks	38	0.7	0.2	0.04	0.01
earthworks	11	0.2	0.1	0.01	0.01
roads	19	0.4	0.2	0.02	0.01
sub-total	74	1.4	0.3	0.08	0.02
BY NATURAL PROCESSES					
landslide	21	0.4	0.2	0.03	0.03
debris avalanche	2	<0.1	<0.1	<0.01	<0.01
slump or earthflow	0	0.0	0.0		
tunnel gully	0	0.0	0.0		
gully	0	0.0	0.0		
streambank scour	8	0.2	0.1	0.01	<0.01
streambank deposit	5	0.1	0.1	<0.01	<0.01
sandblow	3	0.1	0.1	0.01	0.01
sheetwash	5	0.1	0.1	0.01	0.01
rockfall or bare rock	37	0.7	0.2	0.14	0.06
sub-total	81	1.5	0.3	0.20	0.05
OTHER					
undisturbed sub-total	603	11.4	0.9	0.00	0.00
ALL IN LAND USE total	758	14.4	0.9	0.28	0.07

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

8.3.3 Summary of disturbance

Out of 14.4% of land in Auckland in natural scrub, soil disturbance affects 2.9%. 1.4% is land use-related, while 1.5% is caused by natural processes of erosion or deposition. Bare soil amounts to 0.28% of the entire region's area, of which 0.08% is attributable to land use and 0.20% to natural processes.

There is 95% confidence that sample percentages for soil disturbance are within 0.9% or better of the true regional figures. For bare soil, there is 95% confidence that sample percentages are within 0.07% or better.

9 Exotic Scrub

9.1 Overview

(Table 2.3)

Exotic scrub occupies 2.3% of Auckland's sample points. Just 0.2% are young closed-canopy stands; typically gorse though other species e.g. tobacco weed, brush wattle are locally present. 0.8% are mature exotic scrub stands intermingled with native scrub which successively replaces it. Another 1.1% contain remnant pasture or exotic trees, on abandoned or reverting farmland. 0.2% are scrub with houses on lifestyle blocks.

9.2 Soil state

(Table 2.16)

9.2.1 Stable surfaces

Stable surfaces in exotic scrub range from infertile soils on terraces, downlands or footslopes, through spurs and ridges in hill country, to shallow soils on steep but stable faces in the ranges.

- 0.6% of the region's sample points are on stable surfaces in exotic scrub,
- 0.5% have intact soil, currently well-vegetated, and
- 0.1% have soil currently disturbed by land use. Bare soil amounts to 0.01% of the sample's area.

9.2.2 Erosion-prone surfaces

The unstable surfaces are drainage hollows through terraces, downlands or footslopes, and moderate hillslopes or steep ranges showing traces of past slope failure, now completely revegetated.

- 1.1% of the region's sample points are on erosion-prone surfaces in exotic scrub,
- 0.8% have intact soil, currently well-vegetated, and
- 0.3% have soil currently disturbed by land use. Here bare soil amounts to 0.02% of the sample's area.

9.2.3 Eroded and eroding surfaces

The eroded and eroding surfaces are mainly where sheetwash occurs on any of the unstable landforms listed above; though other erosion types are also recorded at individual sample points.

- 0.6% of the region's sample points are on eroded and eroding surfaces in exotic scrub,
- 0.4% have soil recently disturbed by natural erosion processes, but revegetating, and
- 0.2% have soil freshly disturbed, with bare soil amounting to 0.01% of the sample's area.

Table 2.16

Soil state for exotic scrub in the Auckland region 2007

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
STABLE SURFACES (S)					
S (i) with intact soil	29	0.5	0.2	0.00	0.00
S (ii) with soil disturbed by land use	6	0.1	0.1	0.01	0.01
sub-total	35	0.6	0.2		
EROSION_PRONE SURFACES (U)					
U (i) with intact soil	42	0.8	0.2	0.00	0.00
U (ii) with soil disturbed by land use	16	0.3	0.1	0.02	0.01
sub-total	58	1.1	0.3		
ERODED (R) AND ERODING (E) SURFACES					
R (i) with revegetating soil	20	0.4	0.2	0.00	0.00
E (ii) with soil disturbed by natural processes	9	0.2	0.1	0.01	0.01
sub-total	29	0.6	0.2		
ALL SURFACES IN LAND USE total	122	2.3	0.4	0.03	0.01

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

9.3 Soil disturbance

(Table 2.17)

9.3.1 Disturbance by land use

Numbers in this section are obtained by adding the percentages for S(ii) and U(ii) from Table 2.16. When stable and erosion-prone surfaces are combined, 0.4% of Auckland's land is currently disturbed by land use-related activities within exotic scrub. As with natural scrub, most disturbance is access tracks remaining within areas formerly farmed. The balance is scrub clearance or spraying of scrub. Earthworks associated with house-building, and bare soil associated with grazing pressure, were observed at few sample points. Bare soil due to land use disturbance equates to 0.02% of the region's bare soil, a very small contribution to the region's exposed soil at risk of topsoil loss (2.12%, Table 2.2).

9.3.2 Disturbance by natural processes

Numbers in this section correspond with the percentages for E(ii) in Table 2.16. 0.2% of land in Auckland is disturbed by erosion or deposition within exotic scrub. Bare soil on disturbed surfaces is due to:

- slope failures on <0.01% of the region's area,
- gullies on <0.01%,
- stream deposits on <0.01%, and
- sheetwash on <0.01%.

These add to 0.01% of the region's area; much less than the contributions from natural scrub or forest, and a small contribution to the region's total soil bared by natural disturbance (1.17%, Table 2.2). Exotic scrub's contribution is surprisingly low, given that it colonises abandoned or unstable sites following unsuccessful attempts at use or frequent natural disturbance. Such a low figure can only be attributed to the very small area currently in exotic scrub (2.3% of Auckland's land).

9.3.3 Summary of disturbance

Under exotic scrub, soil disturbance affects 0.6% of land in Auckland. 0.4% is land use-related, while 0.2% is caused by natural processes of erosion or deposition. Bare soil amounts to 0.03% of the entire region's area, of which 0.02% is attributable to land use and 0.01% to natural processes.

There is 95% confidence that sample percentages for soil disturbance are within 0.4% or better of the true regional figures. For bare soil, there is 95% confidence that sample percentages are within 0.01% or better.

Table 2.17

Soil disturbance in exotic scrub in Auckland Region, 2007

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
BY LAND USE					
grazing pressure	2	<0.1	<0.1	<0.01	<0.01
cultivation	0	0.0	0.0		
harvest	5	0.1	0.1	0.01	0.01
spraying	3	0.1	0.1	<0.01	<0.01
drains	0	0.0	0.0		
tracks	9	0.2	0.1	0.01	<0.01
earthworks	3	0.1	0.1	<0.01	0.01
roads	0	0.0	0.0		
sub-total	22	0.4	0.2	0.02	0.01
BY NATURAL PROCESSES					
landslide	1	<0.1	<0.1	<0.01	<0.01
debris avalanche		0.0	0.0		
slump or earthflow	1	<0.1	<0.1	<0.01	<0.01
tunnel gully		0.0	0.0		
gully	1	<0.1	<0.1	<0.01	<0.01
streambank scour		0.0	0.0		
streambank deposit	1	<0.1	<0.1	<0.01	<0.01
sandblow		0.0	0.0		
sheetwash	5	0.1	0.1	<0.01	<0.01
rockfall or bare rock		0.0	0.0		
sub-total	9	0.2	0.1	0.01	0.01
OTHER					
undisturbed sub-total	91	1.7	0.4	0.00	0.00
ALL IN LAND USE total	122	2.3	0.4	0.03	0.01

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

10 Coastal Grass and Scrub

10.1 Overview

(Table 2.3)

Coastal grass and scrub occupies just 0.5% of Auckland's sample points. It comprises exotic (marram, kikuyu) and native (matihetihe, pingao) grass species interspersed with scattered scrub, also a mix of exotics (boxthorn, gorse, etc.) and natives (flax, toitoi etc.). These vegetation types are so mixed at coastal sample points, that it is impossible to record them separately.

10.2 Soil state

(Table 2.18)

10.2.1 Stable surfaces

Stable surfaces in coastal grass or scrub are non-existent, due to dynamic nature of coastal landforms. Consequently:

- 0.0% of the region's sample points are on stable surfaces under coastal grass and scrub.

10.2.2 Erosion-prone surfaces

Erosion-prone surfaces in coastal grass and scrub range from fixed dunes, through foredunes behind beaches, to coastal cliffs.

- 0.1% of the region's sample points are on erosion-prone surfaces under coastal grass and scrub, and
- all the 0.1% have intact soil, currently well-vegetated.

10.2.3 Eroded and eroding surfaces

Eroded and eroding surfaces are either devegetated mobile dunes, or sandblows on fixed dunes, or sparsely vegetated foredunes; plus sand-veneered coastal cliffs.

- 0.4% of the region's sample points are on eroded and eroding surfaces under coastal grass and scrub, and

- almost the whole 0.4% have soil freshly disturbed, with bare soil amounting to 0.28% of the sample's area.

Table 2.18

Soil state for coastal grass and scrub in Auckland Region, 2007

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
STABLE SURFACES (S)					
S (i) with intact soil	0	0.0	0.0	0.00	0.00
S (ii) with soil disturbed by land use	0	0.0	0.0	0.00	0.00
sub-total	0	0.0	0.0		
EROSION_PRONE SURFACES (U)					
U (i) with intact soil	5	0.1	0.1	0.00	0.00
U (ii) with soil disturbed by land use	0	0.0	0.0	0.00	0.00
sub-total	5	0.1	0.1		
ERODED (R) AND ERODING (E) SURFACES					
R (i) with revegetating soil	1	<0.1	<0.1	0.00	0.00
E (ii) with soil disturbed by natural processes	23	0.4	0.2	0.28	0.13
sub-total	24	0.4	0.2		
ALL SURFACES IN LAND USE total	29	0.5	0.2	0.28	0.13

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

10.3 Soil disturbance

(Table 2.19)

10.3.1 Disturbance by land use

Numbers in this section are obtained by adding the percentages for S(ii) and U(ii) from Table 2.18. When stable and erosion-prone surfaces are combined, none of Auckland's land is currently disturbed by land use-related activities within coastal grass and scrub. This is because bare soil due to any land use e.g. grazing pressure or track-

cutting, is quickly taken over by sandblow which is then classed as natural disturbance at these exposed sites.

Table 2.19

Soil disturbance amongst coastal grass and scrub in Auckland Region, 2007

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
BY LAND USE					
grazing pressure	0	0.0	0.0		
cultivation	0	0.0	0.0		
harvest	0	0.0	0.0		
spraying	0	0.0	0.0		
drains	0	0.0	0.0		
tracks	0	0.0	0.0		
earthworks	0	0.0	0.0		
roads	0	0.0	0.0		
sub-total	0	0.0	0.0	0.00	0.00
BY NATURAL PROCESSES					
landslide	0	0.0	0.0		
debris avalanche	0	0.0	0.0		
slump or earthflow	0	0.0	0.0		
tunnel gully	0	0.0	0.0		
gully	0	0.0	0.0		
streambank scour	0	0.0	0.0		
streambank deposit	0	0.0	0.0		
sandblow	23	0.4	0.2	0.28	0.13
sheetwash	0	0.0	0.0		
rockfall or bare rock	0	0.0	0.0		
sub-total	23	0.4	0.2	0.28	0.13
OTHER					
undisturbed sub-total	6	0.1	0.1	0.00	0.00
ALL IN LAND USE total	29	0.5	0.2	0.28	0.13

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

10.3.2 Disturbance by natural processes

Numbers in this section correspond with the percentages for E(ii) in Table 2.18. Just 0.4% of land is disturbed by natural erosion or deposition, though bare soil is extensive within this area and is caused by:

- sandblows amounting to 0.28% of the region's area.

This is a substantial contributor to the region's area of bare soil due to natural disturbance (1.17%, Table 2.2). Proportionately it is very high relative to the small area of land in coastal grass and scrub (0.5% of the region).

10.3.3 Summary of disturbance

Under coastal grass and scrub, soil disturbance affects 0.4% of land in Auckland. None is classed as land use-related. While some may have originated in overgrazing or tracking, all is now attributed to a natural process of erosion or deposition - sandblow - in the coastal environment. Bare soil due to sandblow amounts to 0.28% of the entire region's area.

There is 95% confidence that sample percentages for soil disturbance are within 0.2% or better of the true regional figures. For bare soil, there is 95% confidence that sample percentages are within 0.13% or better.

11 Wetlands and Mangroves

11.1 Overview

(Table 2.3)

Freshwater wetlands and mangrove swamps occupy 2.2% of Auckland's sample points. These vegetation types are recorded separately as wetland (0.6%) and mangrove (1.6%), though are grouped for analysis because much of the remaining wetland is on floodplains or coastal flats adjacent to mangroves in estuaries.

11.2 Soil state

(Table 2.20)

11.2.1 Stable surfaces

Stable surfaces are non-existent in freshwater wetlands or mangrove swamps, due to regular flooding of both landforms. Consequently:

- 0.0% of the region's sample points are on stable surfaces under wetland vegetation or mangroves.

11.2.2 Erosion-prone surfaces

The erosion-prone surfaces are undrained or semi-drained swamps (on floodplains and coastal flats); plus intact or partly reclaimed mangrove swamps (in estuaries).

- 1.3% of the region's sample points are on erosion-prone surfaces under wetland vegetation or mangroves,
- 1.2% have intact soil, currently well-vegetated, and
- 0.1% have soil disturbed by land-use-related activities, with exposed soil amounting to 0.01% of the region's area.

11.2.3 Eroded and eroding surfaces

Eroded and eroding surfaces are either banks of watercourses flowing through swamps, or banks of tidal creeks, or sandflats/mudflats within mangrove swamps.

- 0.8% of the region's sample points are on eroded and eroding surfaces under wetland vegetation or mangroves,

- 0.4% have soil recently disturbed by natural erosion processes but revegetating, and
- another 0.4% have soil freshly disturbed, with bare soil amounting to 0.07% of the sample's area.

Table 2.20

Soil state for wetlands and mangroves in the Auckland region, 2007

	points	points as % of sample[1]	95% conf. lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
STABLE SURFACES (S)					
S (i) with intact soil	0	0.0	0.0	0.00	0.00
S (ii) with soil disturbed by land use	0	0.0	0.0	0.00	0.00
sub-total	0	0.0	0.0		
EROSION_PRONE SURFACES (U)					
U (i) with intact soil	63	1.2	0.3	0.00	0.00
U (ii) with soil disturbed by land use	7	0.1	0.1	0.01	0.01
sub-total	70	1.3	0.3		
ERODED (R) AND ERODING (E) SURFACES					
R (i) with revegetating soil	23	0.4	0.2	0.00	0.00
E (ii) with soil disturbed by natural processes	21	0.4	0.2	0.07	0.05
sub-total	44	0.8	0.2		
ALL SURFACES IN LAND USE total	114	2.2	0.4	0.07	0.05

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

11.3 Soil disturbance

(Table 2.21)

11.3.1 Disturbance by land use

Numbers in this section are obtained by adding the percentages for S (ii) and U (ii) from Table 2.20. When stable and erosion-prone surfaces are combined, 0.1% of Auckland's

land is currently disturbed by land use-related activities within wetlands and mangrove swamps. Exposed soil is <0.01% of the region's area, a negligible contribution to the total bared by land use (2.12% region-wide, Table 2.2); and is accounted for by:

- grazing pressure at <0.01%, and
- tracks at <0.01%.

Table 2.21

Soil disturbance amongst wetlands and mangroves in Auckland region, 2007.

	points	points as % of sample[1]	95% conf.lim.[3]	bare soil as % of area[2]	95% conf. lim.[3]
BY LAND USE					
grazing pressure	4	0.1	0.1	<0.01	<0.01
cultivation	0	0.0	0.0		
harvest	0	0.0	0.0		
spraying	0	0.0	0.0		
drains	0	0.0	0.0		
tracks	3	0.1	0.1	<0.01	<0.01
earthworks	0	0.0	0.0		
roads	0	0.0	0.0		
sub-total	7	0.1	0.1	<0.01	0.01
BY NATURAL PROCESSES					
landslide	0	0.0	0.0		
debris avalanche	0	0.0	0.0		
slump or earthflow	0	0.0	0.0		
tunnel gully	0	0.0	0.0		
gully	0	0.0	0.0		
streambank scour	5	0.1	0.1	<0.01	<0.01
streambank deposit	16	0.3	0.1	0.07	0.05
sandblow	0	0.0	0.0		
sheetwash	0	0.0	0.0		
rockfall or bare rock	0	0.0	0.0		
sub-total	21	0.4	0.2	0.07	0.05
OTHER					
undisturbed sub-total	86	1.6	0.3	0.00	0.00
ALL IN LAND USE total	114	2.2	0.4	0.07	0.05

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

Note 3: confidence limits are not additive.

11.3.2 Disturbance by natural processes

Numbers in this section correspond with the percentages for E (ii) in Table 2.20. 0.4% of Auckland's land is disturbed by natural erosion or deposition within wetlands and mangrove swamps. Bare soil is extensive at these sites, amounting to 0.07% of the region's area. It is caused by:

- streambank scour or tidal creek bank scour at <0.01%, and
- streambank or estuarine deposits (mainly the latter) at 0.07%.

This is a measureable contribution to the region's area of bare soil due to natural disturbance (1.17%, Table 2.2). Proportionately it is quite high relative to the area of land in wetlands and mangrove swamps (2.2% of the region).

11.3.3 Summary of disturbance

In wetlands and mangrove swamps, soil disturbance affects 0.5% of land in Auckland. Less than 0.1% is classed as land use-related; a mix of grazing pressure and access tracks at partly drained sites. The rest is classed as natural erosion or deposition of sediment; a little in swamps, and most in estuaries. Bare soil (or bare sediment) amounts to 0.07% of the region's area.

There is 95% confidence that sample percentages for soil disturbance are within 0.4% or better of the true regional figures. For bare soil, there is 95% confidence that sample percentages are within 0.05% or better.

12 Summary

This section summarises key points from the preceding results. The conclusions are for Auckland's soil in 2007, the year of new aerial photographic coverage. They are based on a sample of one-hectare areas at 5277 points, taken from the coverage at one kilometre spacings throughout the region. The sample represents true regional figures to +- 1.2% or better.

12.1 Soil state, soil disturbance and bare soil region-wide

(Table 2.22, summarising Table 2.1)

Table 2.22

Soil state, disturbance and bare soil region wide

		points as % of sample[1]	bare soil as % of area[2]
Stable	intact	19.3	0.00
	disturbed by land use	10.8	1.06
Erosion-prone	intact	26.6	0.00
	disturbed by land use	9.1	0.54
Eroded and eroding	recently disturbed by natural erosion	8.0	0.00
	freshly disturbed by natural erosion	7.4	0.84
Extensively disturbed	water bodies and coastal features	3.8	0.33
	rural buildings	3.1	0.31
	urban areas	11.0	0.21
Other	no photos or unclassified	0.9	Not measureable
Totals	as % of region	100.0	3.29

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

12.1.1 On stable and erosion-prone land

45.9% of land in the Auckland region has intact soil. Of this:

- 19.3% is on stable land that shows no signs of past erosion and is currently well-vegetated. Such land includes drained wetlands, protected floodplains, elevated terraces, and rolling downlands, together with footslopes spurs or ridges in the hill country and ranges, and
- 26.6% is on erosion-prone land that is currently inactive and well-vegetated. This land includes hill faces or steep faces with healed erosion scars; inactive gullies, drainage hollows or watercourses that run through footslopes, downlands, and terraces; flood-prone river flats, undrained wetlands and stabilised sand dunes. Here vegetation cover - whether crops, pasture, plantations, scrub or forest - is at present sufficiently dense to protect soil against disturbance.

19.9% of the region's land has soil currently disturbed by rural land use. Of this:

- 10.8% is on stable land. 1.06% has bare soil, and
- 9.1% is on erosion-prone land. 0.56% has bare soil.

12.1.2 On eroded and eroding land

15.4% of Auckland's land has eroded or eroding soil - soil that has recently been, or still is, on the move. This land includes hill faces and steep faces with revegetating or fresh mass movement scars (debris avalanches, slips, slumps and earthflows); footslopes, downlands and terraces that have gullies of all types (under-runners, open gullies, gullied debris flow deposits), or scour and deposition along streambanks; areas within coastal dunes where sand is blown away or accumulates; sheetwash of soil on ridges, spurs or coastal cliffs; and rockfalls or rock outcrops where soil is absent from cliffs, bluffs, gorges or lava flows. Of this:

- 8.0% is eroded - it has been disturbed in recent years but is now revegetating, and
- the other 7.4% is eroding - it is freshly disturbed by natural processes of erosion and deposition. 0.84% has bare soil.

12.1.3 On extensively disturbed surfaces

On another 3.8% of the region's land which is water bodies and coastal features, soil is exposed or absent. This area includes rock platforms, beaches, tidal creeks, and estuarine sandflats or mudflats. Here exposed bare soil, rock or sediment amounts to 0.33% of the region's area.

2.9% of the region is partly covered by rural buildings and yards. Bare soil associated with these features is 0.31% of the region's area.

A final 11.0% of the region's soil is covered by urban uses - residential buildings and gardens, commercial buildings and yards, urban roads, railways and airfields, open spaces with planted vegetation or retained vegetation. Here bare soil is 0.21% of the region's area.

12.2 Soil disturbance region wide

(Table 2.23, summarizing Table 2.2)

45.2% of the regions land has fresh soil disturbance. 34% is land use related:

- The main land use-related disturbance is by farm tracks and logging roads (present on 8.6% of Auckland's land), together with unsealed roads passing through land in rural use (1.4%). Grazing pressure in pasture is next most extensive (3.9%). Collectively, cultivation, harvest and spraying of cropland and pasture affect almost as much soil (3.6%). Drain or pond excavation is not particularly extensive (0.9%), and exceeded by earthworks on farm building sites or forest operations sites (1.5%).
- Soil actually bare within these disturbed areas amounts to 1.60% of the region's land; of which 1.51% is attributed to rural land use and 0.09% to rural roads.
- On extensively disturbed surfaces, another 0.52% of the regions land is bared by land use related disturbance. 0.31% is amongst rural buildings and yards, while 0.21% is within urban areas.

11.2% of the disturbance is due to natural processes:

- The main natural disturbance is by slope failure (mass movement) scars, collectively present on 2.7%. Sediment deposition and bank scour along watercourses are next most extensive, together 2.1%. Various forms of gully erosion at 0.6% are not widespread. Surface erosion processes (sandblow, sheetwash, rockfall, rock outcrops) are 2.0% in extent.
- This fresh natural disturbance amounts to 0.84% of the region's area; of which 0.64% is bare soil amongst rural land uses; and 0.20% bare rock.
- On extensively disturbed surfaces another 0.33% of the regions land is bared by natural disturbance, almost entirely along coastal features.

Table 2.23

Soil disturbance and bare soil region-wide

Disturbance cause :	Disturbance type :	% of points sampled[1]	bare soil as % of region[2]
Land use	grazing pressure	3.9	0.13
	cultivation	1.6	0.61
	harvest	1.4	0.10
	spraying	0.6	0.05
	drains	0.9	0.04
	tracks	8.6	0.49
	earthworks	1.5	0.09
	rural roads	1.4	0.09
	rural buildings and yards	3.1	0.31
	urban areas	11.0	0.21
Land use sub total		34.0	2.12
Natural processes	landslide	1.8	0.08
	debris avalanche	0.2	0.01
	slump or earthflow	0.7	0.03
	tunnel gully	0.2	<0.01
	gully	0.4	0.01
	streambank scour	0.9	0.03
	streambank deposit	1.2	0.14
	sandblow	0.7	0.33
	sheetwash	0.3	0.02
	rockfall or rock outcrop	1.0	0.20
	water bodies and coastal features	3.8	0.33
Natural processes sub total		11.2	1.17
Totals	as % of region	45.2	3.29

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

12.3 Pressure on soil - impacts of land use

(Table 2.24, summarising Tables 2.4 to 2.21)

12.3.1 On land in rural use

54.5% of land in Auckland is currently in rural uses, and 17.7% of the land is disturbed by those uses.

- They have exposed 1.48% of the region's soil to topsoil loss. All land uses contribute: orchards and cropland (cultivation and harvest), dairy farms (tracks and races), drystock pasture (grazing pressure and tracks), forestry (logging tracks and landing stages).
- As a percentage of land in each use, bare topsoil falls from 16.83% amongst intensive uses, through 2.84% in dairy pasture and 1.53% in drystock pasture, to 1.45% in forest plantations.

12.3.2 On land in conservation use

26.7% of the region's land is in conservation uses, and 2.1% is disturbed by activities associated with those uses.

- They have exposed 0.11% of the region's soil to topsoil loss. The bulk is in natural and exotic scrub (unsealed roads or access tracks).
- As a percentage of land in each use, bare topsoil rises from 0.14% in natural forest, through 0.56% in natural scrub to 0.99% in exotic scrub. It is 0% amongst coastal grass and scrub, but only because land use-related disturbance rapidly converts to sandblow. The figure is 0.25% amongst wetlands and mangroves (drains, tracks and grazing pressure).

12.3.3 On land in other use

2.9% of Auckland's land has been extensively disturbed by erection of rural buildings and yards, though just 1.7% is currently disturbed. Here an additional 0.31% of the region's soil is exposed to topsoil loss, mainly by unsealed yards, tracks and earthworks.

11.0% of the region's land has been extensively disturbed by urbanisation, though just 1.3% shows signs of current disturbance. Here 0.21% of the region's soil is exposed to topsoil loss, mainly by housing subdivision and road construction.

Table 2.24

Impacts of land use on soil

	Impacts of Land Use on Soil			
	Area in use	Area of land disturbed by use	Bare soil within disturbed area	
	% of region	as % of region[1]	as % of region[2]	as % of land in use
Rural uses :				
Intensive uses	3.2	1.9	0.55	16.83
Dairy pasture	11.1	4.6	0.32	2.84
Drystock pasture	31.1	9.1	0.48	1.53
Forest plantation	9.1	2.1	0.13	1.45
sub-total	54.5	17.7	1.48	
Conservation uses :				
Natural forest	7.3	0.2	0.01	0.14
Natural scrub	14.4	1.4	0.08	0.56
Exotic scrub	2.3	0.4	0.02	0.99
Coastal grass and scrub	0.5	0.0	0.00	0.00
Wetland and mangrove	2.2	0.1	<0.01	0.25
sub-total	26.7	2.1	0.11	
Other :				
Rural buildings	2.9	1.7	0.31	1.03
Urban areas	11.0	1.3	0.21	1.55
Water bodies and coastal features	3.8	0.0	0.00	0.00
No photos or unclassified	1.1	Not measureable	Not measureable	
sub-total	18.8	3.0	0.52	
Regional total	100.0	22.8	2.12	

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.

12.4 Pressure on soil -impacts of natural processes

(Table 2.25, summarising Tables 2.4 to 2.21)

12.4.1 On land in rural use

4.6% of the region is freshly disturbed by natural processes of erosion or deposition amongst rural land uses.

- Here these processes have exposed 0.26% of the region's subsoil. Most of the fresh disturbance is in drystock pasture (mass movement, gullying, streambank scour and deposition), though there is also measureable disturbance in dairy pasture and forest plantations.
- As a percentage of land in each use, bare subsoil rises from 0.06% amongst intensive uses, through 0.29% in dairy pasture, to 0.61% in drystock pasture. It falls to 0.48% in forest plantations.

12.4.2 On land in conservation use

2.8% of the region is freshly disturbed by natural processes on land in conservation use.

- Here erosion or depostion have exposed 0.59% of the region's subsoil. Half is sandblow amongst coastal grass and scrub. Most of the rest is within scrub on hill country or in the ranges (debris avalanches, gullied debris flow deposits, streambank erosion and deposition). There is a lesser contribution from sediment deposition amongst wetlands and mangroves. Contributions from natural disturbance in forest and exotic scrub are minor.
- As a percentage of land in each use, bare subsoil rises from 0.44% in natural forest, to 1.37% in natural scrub. The figure for exotic scrub is low at 0.23%. Amongst coastal grass and scrub, 51.34% of land has bare subsoil or exposed sand. Amongst wetlands and mangroves, bare subsoil or exposed sediment is 3.11% by area.

12.4.3 On land in other use

Disturbance by natural processes is minor on most land in other uses (rural buildings and yards, urban areas). However out of the 3.8% of Auckland's land along water bodies and coastal features, 1.6% is currently disturbed. Here an additional 0.33% of the region's area is bare soil, sediment or rock due to extensive disturbance by coastal processes. This is 8.68% of the area occupied by water bodies and coastal features.

Table 2.25

Impacts of natural processes on soil

	Impacts of Natural Processes on Soil			
	Area in use	Area of land disturbed by erosion	Bare soil within disturbed area	
	% of region	as % of region[1]	as % of region[2]	as % of land in use
Rural uses :				
Intensive uses	3.2	0.1	<0.01	0.06
Dairy pasture	11.1	0.7	0.03	0.29
Drystock pasture	31.1	3.2	0.19	0.61
Forest plantation	9.1	0.6	0.04	0.48
sub-total	54.5	4.6	0.26	
Conservation uses :				
Natural forest	7.3	0.3	0.03	0.44
Natural scrub	14.4	1.5	0.20	1.37
Exotic scrub	2.3	0.2	0.01	0.23
Coastal grass and scrub	0.5	0.4	0.28	51.34
Wetland and mangrove	2.2	0.4	0.07	3.11
sub-total	26.7	2.8	0.59	
Other :				
Rural buildings	2.9	0.0	0.00	0.00
Urban areas	11.0	0.0	0.00	0.00
Water bodies and coastal features	3.8	1.6	0.33	8.68
No photos or unclassified	1.1	Not measureable	Not measureable	
sub-total	18.8	1.6	0.33	
Total	100.0	9.0	1.17	

Note 1: "% of sample" sub-totals/totals may differ by 0.1% due to rounding.

Note 2: "% of area" sub-totals/totals may differ by 0.01% due to rounding.