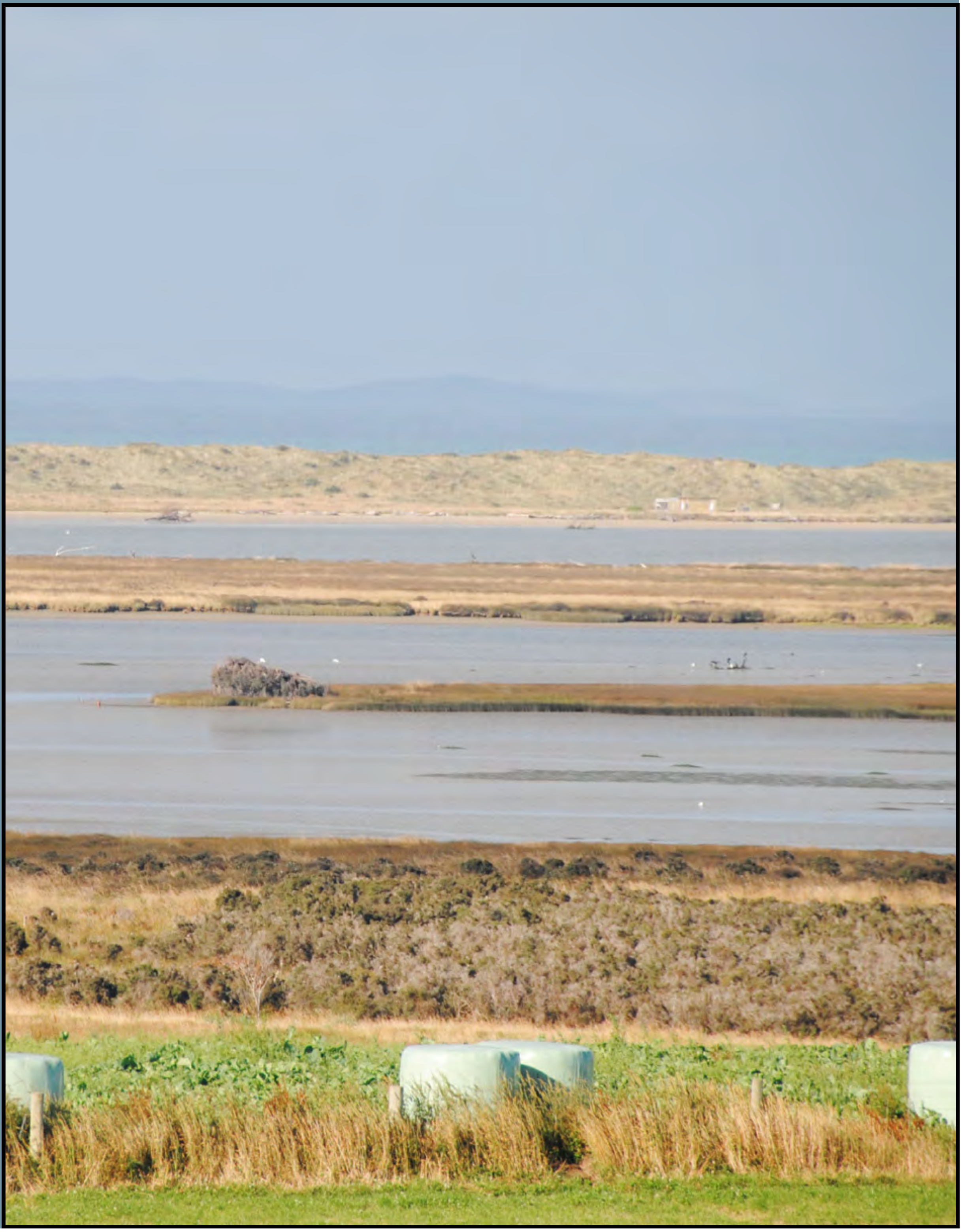
coastalmanagement

Fortrose (Toetoes) Estuary

Broad Scale Habitat Mapping 2012/13



Prepared for

Environment Southland

October 2013

Cover Photo: Fortrose (Toetoes) Estuary, February 2013.


Central basin area of Fortrose (Toetoes) Estuary, February 2013

Fortrose (Toetoes) Estuary

Broad Scale Habitat Mapping 2012/13

Prepared for
Environment Southland

By

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All photos by Wriggle except where noted otherwise.

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FORTROSE ESTUARY - EXECUTIVE SUMMARY

This report summarises the results of the 2013 broad scale intertidal habitat mapping of Fortrose (Toetoes) Estuary, a medium-sized "tidal lagoon" type estuary (area 500ha) that discharges to Toetoes Beach at the mouth of the Mataura River and Titiroa Stream. It drains a large and primarily high productivity agricultural catchment, and has a large freshwater influence because the estuary is small in relation to the freshwater input. It is one of the key estuaries in Environment Southland's long-term coastal monitoring programme. The following sections summarise broad scale monitoring results (from the current report and previous studies), condition ratings, overall estuary condition, and monitoring and management recommendations.

BROAD SCALE RESULTS

- Sandy substrate dominated the estuary (75%, 242ha), with sandiest areas primarily located in the central and lower estuary.
- Soft and very soft mud cover had increased significantly since 2003 (from 24ha to 60ha - 8% to 19%), mostly on the intertidal flats where Titiroa Stream and Mataura River discharge to the central basin of the estuary.
- Dense nuisance macroalgae (>50%) covered 8% (23ha) of the intertidal area, with highest densities on the eastern side of the estuary. Remaining intertidal areas supported widespread low density growths that have shown a trend of increase since 2003.
- Gross eutrophic conditions were not a prominent feature within the estuary.
- Dense seagrass cover (>50%) was very scarce (0.5ha, <1%).
- Saltmarsh cover was 84ha (17%), of which 68% was dominated by rushland (jointed wire rush) and 12% by tussockland (flax and salt grass). Saltmarsh cover was rated high despite being only a remnant of the historically extensive wetland and saltmarsh surrounding the estuary. Saltmarsh had declined slightly since 2003 due to recent land drainage and localised shoreline erosion.
- Densely vegetated 200m terrestrial margin (scrub and forest) cover was low (4%), with grassland (63%) dominant, greatly limiting natural buffering of the estuary from sediment and nutrient inputs. No significant change in cover was apparent since 2003.

RATINGS		CONDITION RATINGS		CHANGE RATINGS
Major Issue	Indicator	2003	2013	Change from 2003 Baseline
Sediment	Soft mud area	FAIR	POOR	VERY LARGE INCREASE
Eutrophication	Low density macroalgal cover	VERY LOW	MODERATE	TRENDING UP = WARNING
	High density macroalgal cover	VERY LOW	MODERATE	VERY LARGE INCREASE
	Gross eutrophic condition area	VERY GOOD	VERY GOOD	NO SIGNIFICANT CHANGE
Habitat Modification	Seagrass Coefficient/area	POOR	POOR	NO DECREASE
	Saltmarsh area	HIGH	HIGH	SLIGHT DECREASE
	Densely vegetated margin area	POOR	POOR	NO SIGNIFICANT CHANGE

ESTUARY CONDITION AND ISSUES

In relation to the key issues addressed by the broad scale monitoring (i.e. sediment, eutrophication, and habitat modification), the 2013 broad scale mapping results show that both sediment and eutrophication are ongoing issues within the estuary. Although large sections of the estuary remain in good condition, the decline in estuary quality evident since 2003, specifically increased muddiness and macroalgal growth, indicate that current inputs of fine sediment and nutrients to the estuary are too high. The cause of low seagrass coverage is uncertain but may well relate to elevated nutrient inputs exceeding levels known to be toxic to seagrass. Secondary stressors are also likely to be from macroalgal smothering and increased muddiness contributing to reduced sediment oxygenation and poor water clarity. Consequently, nutrient and sediment inputs need to be reduced to levels the estuary can assimilate to achieve a more moderately enriched estuary and to protect it from further degradation.

RECOMMENDED MONITORING AND MANAGEMENT

To monitor the key issues of nutrient enrichment and sediment muddiness it is recommended that:

- Broad scale habitat mapping be repeated every 10 years (next due in 2023).
- Fine scale intertidal monitoring be repeated on a 5 yearly cycle (next due in 2014).
- Sedimentation rate and macroalgal monitoring continue annually.
- Key changes in catchment landuse be tracked and mapped 5 yearly, particularly where activities have the potential to release sediments or increase nutrient loads to the estuary.

For management, it is recommended that catchment nutrient and sediment guideline criteria be developed for the estuary as a priority, and the current catchment nutrient and sediment loads be estimated. If catchment loads exceed the estuary's guidelines then it is recommended that sources of elevated loads in the catchment be identified, and management undertaken to minimise their adverse effects on estuary uses and values.

In addition, identify saltmarsh areas on private land, and encourage landowners to protect remaining, but vulnerable stands and identify areas for the managed retreat of saltmarsh in future.

1. INTRODUCTION

FORTROSE (TOETOES) ESTUARY

Vulnerability Assessment
Identifies issues and recommends monitoring and management. Completed in 2008 (Robertson and Stevens 2008)

Fortrose Estuary Issues
Moderate eutrophication
Moderate sedimentation
Habitat Loss (saltmarsh, dune and terrestrial margin)

Monitoring

Broad Scale Mapping
Sediment type
Saltmarsh
Seagrass
Macroalgae
Land margin

5 -10 yearly
First undertaken in 2003. Macroalgae annually since 2009.

Fine Scale Monitoring
Grain size, RPD, Organic Content
Nutrients, Metals, Invertebrates, Macroalgae, Sedimentation

4yr Baseline then 5 yearly
Baseline completed 2009.
Next survey 2014.

Condition Ratings
Area soft mud, Area saltmarsh, Area seagrass, Area terrestrial margin, RPD depth, Benthic Community, Organic content, N and P, Toxicity, Sedimentation rate.

Other Information
Previous reports, Observations, Expert opinion

ESTUARY CONDITION
Eutrophication
Sedimentation
Toxicity
Habitat (saltmarsh, terrestrial margin)

Recommended Management
- Limit intensive landuse.
- Set nutrient guidelines.
- Margin vegetation enhancement.
- Manage for sea level rise.
- Enhance saltmarsh.
- Manage weeds and pests.

Environment Southland (ES) has an established long-term coastal monitoring programme that contributes to the information necessary to make effective management decisions. An outline of the monitoring and management process used for Fortrose (Toetoes) Estuary is summarised in the margin flow diagram, and below. It consists of three components developed from the National Estuary Monitoring Protocol (NEMP) (Robertson et al. 2002):

1. **Ecological Vulnerability Assessment** (EVA) of the estuary to major issues (Table 1) and appropriate monitoring design. A preliminary EVA has been completed for Fortrose Estuary and is reported on in Robertson and Stevens (2008).
2. **Broad Scale Habitat Mapping** (NEMP approach). This component, which documents the key habitats within the estuary (Table 2), and changes to these habitats over time, was undertaken in 2003 (Robertson et al. 2003). The second survey is the focus of the current report. Annual monitoring of macroalgal growth has been undertaken since 2009 (e.g. Stevens and Robertson 2012).
3. **Fine Scale Monitoring** (NEMP approach). Monitoring of physical, chemical and biological indicators (Table 2) including sedimentation rate monitoring. This component, which provides detailed information on the condition of Fortrose Estuary, has been undertaken in 2004, 2005, 2006, and 2009 and is summarised in Robertson and Stevens (2006 and 2009).

To help evaluate overall estuary condition and decide on appropriate monitoring and management actions, a series of condition ratings has also been developed and is described in Section 2.

The current report describes the following work undertaken in February 2013:

- Broad scale mapping of estuary sediment types.
- Broad scale mapping of macroalgal beds (i.e. *Ulva* (sea lettuce), *Gracilaria*).
- Broad scale mapping of gross eutrophic areas.
- Broad scale mapping of seagrass (*Zostera muelleri*) beds.
- Broad scale mapping of saltmarsh vegetation.
- Broad scale mapping of the 200m terrestrial margin surrounding the estuary.

Fortrose (Toetoes) Estuary is a medium-sized (500ha) "tidal lagoon" type estuary that discharges to Toetoes Beach at Fortrose. Situated at the mouth of the Mataura River and Titiroa Stream, it drains a large and primarily high productivity agricultural catchment. The shallow estuary (mean depth ~2m) has a large freshwater influence because the estuary is small in relation to the freshwater input. It has a wide range of habitats (extensive mudflats and saltmarsh areas, very small patches of seagrass) but has historically lost large areas of saltmarsh (estimated loss of ~75% (250ha), while virtually all the surrounding wetland has been lost through drainage and reclamation and conversion to pasture (see inset photo below and Figure 3). This has greatly reduced the estuary's ability to filter, dilute, and assimilate nutrient and sediment inputs.

In addition to these historical changes, the estuary has several ongoing issues:

Figure 1. Estimated historical extent of Fortrose Estuary.

- Water quality is moderately degraded (reduced clarity, elevated faecal coliforms, elevated nutrients), particularly in high river flows.
- Localised macroalgal blooms are common and are driven by elevated nutrient inputs.
- Sediment type is mixed with areas of firm muddy sands and gravels but with increasing areas of soft muds - some localised areas poor in oxygen with elevated sulphide concentrations.

A recent vulnerability assessment (Robertson and Stevens 2008) identified eutrophication, sedimentation and habitat loss as moderate vulnerabilities within the estuary and recommended ongoing monitoring and management to address these issues.

1. INTRODUCTION (CONTINUED)

Table 1. Summary of the major issues affecting most NZ estuaries.

Major Estuary Issues	
Sedimentation	Because estuaries are a sink for sediments, their natural cycle is to slowly infill with fine muds and clays. Prior to European settlement they were dominated by sandy sediments and had low sedimentation rates (<1 mm/year). In the last 150 years, with catchment clearance, wetland drainage, and land development for agriculture and settlements, New Zealand's estuaries have begun to infill rapidly. Today, average sedimentation rates in our estuaries are typically 10 times or more higher than before humans arrived.
Eutrophication (Nutrients)	Increased nutrient richness of estuarine ecosystems stimulates the production and abundance of fast-growing algae, such as phytoplankton, and short-lived macroalgae (e.g. sea lettuce). Fortunately, because most New Zealand estuaries are well flushed, phytoplankton blooms are generally not a major problem. Of greater concern is the mass blooms of green and red macroalgae, mainly of the genera *Cladophora, Ulva,* and *Gracilaria* which are now widespread on intertidal flats and shallow subtidal areas of nutrient-enriched New Zealand estuaries. They present a significant nuisance problem, especially when loose mats accumulate on shorelines and decompose. Blooms also have major ecological impacts on water and sediment quality (e.g. reduced clarity, physical smothering, lack of oxygen), affecting or displacing the animals that live there.
Disease Risk	Runoff from farmland and human wastewater often carries a variety of disease-causing organisms or pathogens (including viruses, bacteria and protozoans) that, once discharged into the estuarine environment, can survive for some time. Every time humans come into contact with seawater that has been contaminated with human and animal faeces, we expose ourselves to these organisms and risk getting sick. Aside from serious health risks posed to humans through recreational contact and shellfish consumption, pathogen contamination can also cause economic losses due to closed commercial shellfish beds. Diseases linked to pathogens include gastroenteritis, salmonellosis, hepatitis A, and noroviruses.
Toxic Contamination	In the last 60 years, New Zealand has seen a huge range of synthetic chemicals introduced to estuaries through urban and agricultural stormwater runoff, industrial discharges and air pollution. Many of them are toxic in minute concentrations. Of particular concern are polycyclic aromatic hydrocarbons (PAHs), heavy metals, polychlorinated biphenyls (PCBs), and pesticides. These chemicals collect in sediments and bio-accumulate in fish and shellfish, causing health risks to people and marine life.
Habitat Loss	Estuaries have many different types of habitats including shellfish beds, seagrass meadows, saltmarshes (rushlands, herbfields, reedlands etc.), forested wetlands, beaches, river deltas, and rocky shores. The continued health and biodiversity of estuarine systems depends on the maintenance of high-quality habitat. Loss of habitat negatively affects fisheries, animal populations, filtering of water pollutants, and the ability of shorelines to resist storm-related erosion. Within New Zealand, habitat degradation or loss is commonplace with the major causes cited as sea level rise, population pressures on margins, dredging, drainage, reclamation, pest and weed invasion, reduced flows (damming and irrigation), over-fishing, polluted runoff and wastewater discharges.

Table 2. Summary of broad and fine scale NEMP indicators (shading signifies indicators used in the broad scale monitoring assessments)**.**

Issue	Indicator	Method
Sedimentation	Soft Mud Area	Broad scale mapping - estimates the area and change in soft mud habitat over time.
Sedimentation	Sedimentation Rate	Fine scale measurement of sediment deposition.
Sedimentation	Grain Size	Fine scale measurement of sediment type.
Eutrophication	Nuisance Macroalgal Cover	Broad scale mapping - estimates the change in the area of nuisance macroalgal growth (e.g. sea lettuce (*Ulva*), *Gracilaria* and *Enteromorpha*) over time.
Eutrophication	Organic and Nutrient Enrichment	Chemical analysis of total nitrogen, total phosphorus, and total organic carbon in replicate samples from the upper 2cm of sediment.
Eutrophication	Redox Profile	Measurement of depth of redox potential discontinuity profile (RPD) in sediment estimates likely presence of deoxygenated, reducing conditions.
Toxins	Contamination in Bottom Sediments	Chemical analysis of indicator metals (total recoverable cadmium, chromium, copper, nickel, lead and zinc) in replicate samples from the upper 2cm of sediment.
Toxins, Eutrophication, Sedimentation	Biodiversity of Bottom Dwelling Animals	Type and number of animals living in the upper 15cm of sediments (infauna in $0.0133m^2$ replicate cores), and on the sediment surface (epifauna in $0.25m^2$ replicate quadrats).
Habitat Loss	Saltmarsh Area	Broad scale mapping - estimates the area and change in saltmarsh habitat over time.
Habitat Loss	Seagrass Area	Broad scale mapping - estimates the area and change in seagrass habitat over time.
Habitat Loss	Vegetated Terrestrial Buffer	Broad scale mapping - estimates the area and change in buffer habitat over time.

1. INTRODUCTION (CONTINUED)

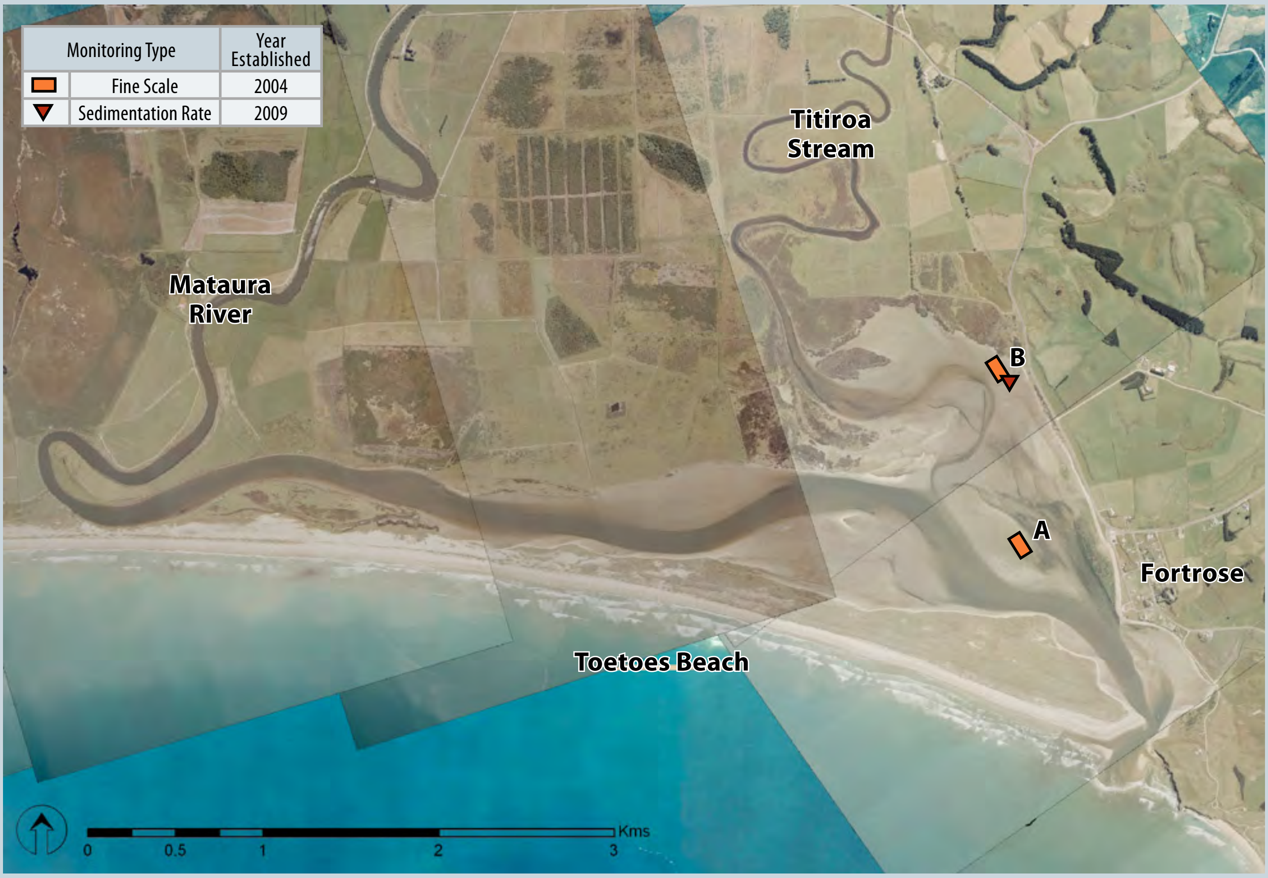


Figure 2. Fortrose (Toetoes) Estuary showing the location of fine scale sites established in 2004 and buried sediment plates established in 2009.

Figure 3. Toetoes Estuary Survey District Plan, circa 1900 (source: Maling 1996) showing the consistency of the Mataura River and Titiroa Stream channels over the past century.

2. METHODS

BROAD SCALE HABITAT MAPPING

Broad-scale mapping is a method for describing habitat types based on the dominant surface features present (e.g. substrate: mud, sand, cobble, rock; or vegetation: macrophyte, macroalgae, rushland, etc). It follows the NEMP approach originally described for use in NZ estuaries by Robertson et al. (2002) with a combination of aerial photography, detailed ground-truthing, and GIS-based digital mapping used to record the primary habitat features present. Very simply, the method involves three key steps:

- Obtaining laminated aerial photos for recording dominant habitat features.
- Carrying out field identification and mapping (i.e. ground-truthing).
- Digitising the field data into GIS layers (e.g. ArcMap).

Rectified ~0.3m/pixel resolution colour aerial photos flown in 2008 were supplied by ES. Photos at a scale of 1:3,000 were laminated, and experienced scientists ground-truthed the spatial extent of dominant habitat and substrate types between 12-18 February 2013 by walking the area and recording features directly on the laminated aerial photos.

Field notes and photographs were subsequently combined to produce GIS-based habitat maps showing dominant cover of: substrate, macroalgae (e.g. *Ulva*, *Gracilaria*), gross eutrophic conditions, seagrass (*Zostera*), saltmarsh vegetation, and the 200m wide terrestrial margin vegetation/land use.

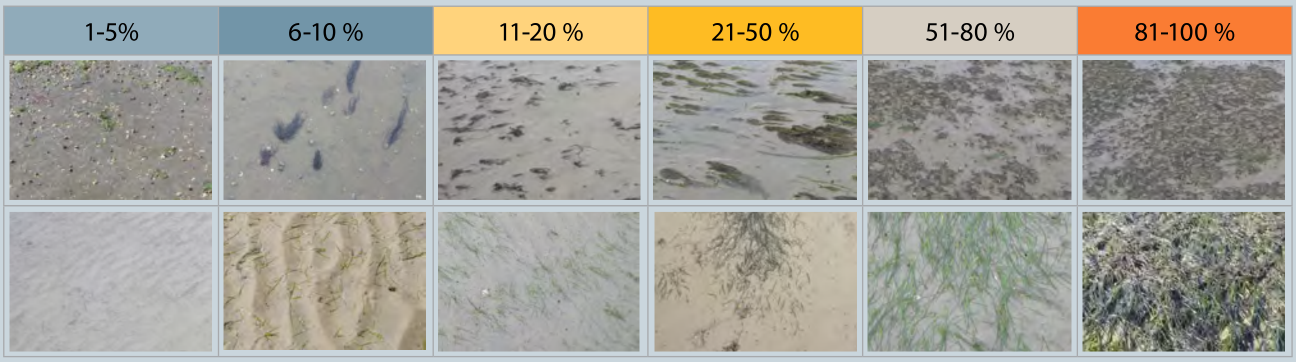
Appendix 2 lists the definitions used to classify substrate and vegetation. The composition of vegetation was classified using an interpretation of the Atkinson (1985) system, where the dominant plant species were coded by using the two first letters of their Latin genus and species names e.g. marram grass, *Ammophila arenaria*, was coded as Amar. Dominance was indicated by the order of codes and the use of ( ) to distinguish subdominant species e.g. Amar(Caed) indicates that marram grass was dominant over ice plant (*Carpobrotus edulis*). A measure of vegetation height can be derived from its structural class (e.g. rushland, scrub, forest).

When present, macroalgae and seagrass were mapped using a 6 category percent cover rating scale (see Figure 4 below) to describe density.

Broad scale habitat features were subsequently digitised from aerial photos into ArcMap 9.3 shapefiles using a Wacom Cintiq21UX drawing tablet. The broad scale results are summarised in Section 3, with the supporting GIS files (supplied on a separate CD) providing a much more detailed data set designed for easy interrogation to address specific monitoring and management questions.

The georeferenced spatial habitat maps allow the 2013 results to be compared to changes from the 2003 survey (Robertson et al. 2003). In a few minor instances, changes were made to the 2003 shapefiles to correct minor inconsistencies in classification or coverage. The updated 2003 GIS data are included as part of the supporting information provided on CD.

Figure 4. Visual rating scale for percentage cover estimates of macroalgae (top) and seagrass (bottom).



2. METHODS (CONTINUED)

CONDITION AND CHANGE RATINGS

A series of broad scale estuary "condition and change ratings" (below) have been proposed for Fortrose Estuary based on ratings developed for NZ's estuaries - e.g. Robertson & Stevens 2006, 2007, 2008, 2012 and a recent review of NZ monitoring data (Robertson and Stevens, in prep). As more NZ data becomes available, and the understanding of estuary condition improves, condition ratings will continue to be revised and updated.

The ratings are designed to be used in combination with each other, along with other important condition indices, and expert input, when evaluating overall estuary condition and deciding on appropriate management. Some condition ratings include an "early warning trigger" to highlight rapid or unexpected change, and each rating has a recommended monitoring and management response. In most cases initial management is to further assess an issue and consider what response actions may be appropriate (e.g. develop an Evaluation and Response Plan - ERP).

SOFT MUD (PERCENT COVER)

Estuaries are a sink for sediments. Where large areas of soft mud are present, they are likely to lead to major and detrimental ecological changes that could be very difficult to reverse, and indicate where changes in land management may be needed.

SOFT MUD PERCENT COVER CONDITION RATING

CONDITION RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	<2% of estuary substrate is soft mud	Monitor at 5 year intervals after baseline established
Good	2%-5% of estuary substrate is soft mud	Monitor at 5 year intervals after baseline established
Fair	6%-15% of estuary substrate is soft mud	Post baseline, monitor 5 yearly. Initiate ERP
Poor	>15% of estuary substrate is soft mud	Post baseline, monitor 5 yearly. Initiate ERP
Early Warning Trigger	>5% of estuary substrate is soft mud	Initiate ERP (Evaluation and Response Plan)

SOFT MUD (CHANGE IN AREA)

Soft mud in estuaries decreases water clarity, lowers biodiversity and affects aesthetics and access. Increases in the area of soft mud indicate where changes in catchment land use management may be needed.

SOFT MUD AREA CHANGE RATING

CHANGE RATING	DEFINITION	RECOMMENDED RESPONSE
No Increase	Area of cover (ha) not increasing, or is decreasing	Monitor at 10 year intervals after baseline established
Small Increase	Increase in area of cover (ha) <5% from baseline	Monitor at 5 year intervals after baseline established
Moderate Increase	Increase in area of cover (ha) 5-15% from baseline	Post baseline, monitor 5 yearly. Initiate ERP
Large Increase	Increase in area of cover (ha) 16-50% from baseline	Post baseline, monitor 5 yearly. Initiate ERP
Very Large Increase	Increase in area of cover (ha) >50% from baseline	Post baseline, monitor 5 yearly. Initiate ERP

LOW DENSITY MACROALGAL COVER

A two part macroalgae condition rating has been developed: 1. for low density (<50%) macroalgal cover throughout the estuary, and 2. a warning indicator for hotspots of high density (>50%) cover (see following rating). Low density macroalgal condition is rated using a continuous index (the macroalgae coefficient - MC) based on the percentage cover of macroalgae in defined categories in the estuary where cover is <50%. The equation used is: ***MC=((0 x %macroalgal cover <1%)+(0.5 x %cover 1-5%)+(1.5 x %cover 5-10%)+(4.5 x %cover 10-20%)+(7.5 x %cover 20-50%))/100.***

LOW DENSITY MACROALGAL COVER CONDITION RATING

CONDITION RATING	DEFINITION	MC	RECOMMENDED RESPONSE
Very Low	Very Low	0.0 - 0.2	Monitor at 5 year intervals after baseline established
Low	Low	>0.2 - 0.8	Monitor at 5 year intervals after baseline established
	Low Low-Moderate	>0.8 - 1.5	Monitor at 5 year intervals after baseline established
Moderate	Low-Moderate	>1.5 - 2.2	Monitor yearly. Initiate ERP
	Moderate	>2.2 - 4.5	Monitor yearly. Initiate ERP
High	High	>4.5 - 7.0	Monitor yearly. Initiate ERP
	Very High	>7.0	Monitor yearly. Initiate ERP
Early Warning Trigger	Trend of increasing Macroalgae Coefficient		Initiate ERP (Evaluation and Response Plan)

2. METHODS (CONTINUED)

HIGH DENSITY MACROALGAL COVER

The high density macroalgae condition rating targets areas of high density growth and is applied to the percentage of the estuary where the cover of intertidal macroalgae exceeds 50%. While this may not necessarily be combined with the presence of nuisance conditions, dense growths are an early warning of the estuary potentially exceeding its assimilative capacity and developing gross eutrophic conditions. A trend of an increasing dense macroalgal cover, or an increasing Macroalgal Coefficient for low density cover, provides an "early warning trigger" for initiating management action.

HIGH DENSITY MACROALGAL COVER CONDITION RATING

CONDITION RATING	>50% MACROALGAL COVER OVER:	RECOMMENDED RESPONSE
Very Low	<1% of estuary	Monitor at 5 year intervals after baseline established
Low	1-5% of estuary	Post baseline, monitor 5 yearly. Initiate ERP
Moderate	6-10% of estuary	Monitor yearly. Initiate Evaluation & Response Plan
High	11-30% of estuary	Monitor yearly. Initiate Evaluation & Response Plan
Very High	>30% of estuary	Monitor yearly. Initiate Evaluation & Response Plan

HIGH DENSITY MACROALGAL COVER (CHANGE IN AREA)

Increases in the area of dense macroalgal cover indicate changes in catchment land use management are likely to be needed. Because extensive cover of dense macroalgae is commonly associated with gross eutrophic conditions that can be very difficult to reverse, even relatively small changes from baseline conditions should be evaluated as a priority.

HIGH DENSITY MACROALGAL COVER, AREA CHANGE RATING

CHANGE RATING	DEFINITION	RECOMMENDED RESPONSE
No increase	Area of cover (ha) not increasing, or is decreasing	Monitor at 5 year intervals after baseline established
Small Increase	Increase in area of cover (ha) <5% from baseline	Post baseline, monitor 5 yearly. Initiate ERP
Moderate Increase	Increase in area of cover (ha) 5-15% from baseline	Post baseline, monitor annually. Initiate ERP
Large Increase	Increase in area of cover (ha) 16-50% from baseline	Post baseline, monitor annually. Initiate ERP
Very Large Increase	Increase in area of cover (ha) >50% from baseline	Post baseline, monitor annually. Initiate ERP

GROSS EUTROPHIC CONDITIONS (AREA)

Gross eutrophic conditions occur when sediments exhibit combined symptoms of: a high mud content, a shallow Redox Potential Discontinuity (RPD) depth, elevated nutrient and total organic carbon concentrations, displacement of invertebrates sensitive to organic enrichment, and high macroalgal growth (>50% cover).

Persistent and extensive areas of gross nuisance conditions should not be present in short residence time estuaries, and their presence provides a clear signal that the assimilative capacity of the estuary is being exceeded. Consequently, the actual area exhibiting nuisance conditions, rather than the % of an estuary affected, is the primary condition indicator. Natural deposition and settlement areas, often in the upper estuary where flocculation at the freshwater/saltwater interface occurs, are commonly first affected. The gross eutrophic condition rating is based on the area affected by the combined presence of poorly oxygenated and muddy sediments, and a dense (>50%) macroalgal cover, as follows:

GROSS EUTROPHIC CONDITION RATING

CONDITION RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	No nuisance conditions	Monitor at 5 year intervals after baseline established
Low	Area of nuisance conditions <0.5ha	Monitor at 5 year intervals after baseline established
Fair	Area of nuisance conditions 0.5-5ha	Post baseline, monitor 5 yearly. Initiate ERP
Poor	Area of nuisance conditions 6-20ha	Post baseline, monitor annually. Initiate ERP
Very Poor	Area of nuisance conditions >20ha	Post baseline, monitor annually. Initiate ERP
Early Warning Trigger	Area of nuisance conditions >0.5ha or increasing	Initiate ERP (Evaluation and Response Plan)

GROSS EUTROPHIC CONDITIONS (CHANGE IN AREA)

Increases in the area of gross eutrophic conditions indicate changes in catchment land use management are likely to be needed. Because of the highly undesirable and often rapidly escalating decline in estuary quality associated with gross eutrophic conditions, even relatively small changes from baseline conditions should be evaluated as a priority.

GROSS EUTROPHIC AREA CHANGE RATING

CHANGE RATING	DEFINITION	RECOMMENDED RESPONSE
No increase	Area of cover (ha) not increasing, or is decreasing	Monitor at 5 year intervals after baseline established
Small Increase	Increase in area of cover (ha) <5% from baseline	Post baseline, monitor 5 yearly. Initiate ERP
Moderate Increase	Increase in area of cover (ha) 5-15% from baseline	Post baseline, monitor annually. Initiate ERP
Large Increase	Increase in area of cover (ha) 16-50% from baseline	Post baseline, monitor annually. Initiate ERP
Very Large Increase	Increase in area of cover (ha) >50% from baseline	Post baseline, monitor annually. Initiate ERP

SEAGRASS INDEX

Seagrass (*Zostera muelleri*) grows in soft sediments in NZ estuaries where its presence enhances estuary biodiversity. Though tolerant of a wide range of conditions, it is vulnerable to fine sediments and excessive nutrients in the water column, and sediment quality (particularly if there is a lack of oxygen and production of sulphide).

A continuous index (the seagrass coefficient - SC) has been developed to rate seagrass condition based on the percentage cover of seagrass in defined categories using the following equation: ***SC=((0 x %seagrass cover <1%)+(1 x %cover 1-5%)+(3 x %cover 5-10%)+(6 x %cover 10-20%)+(9 x %cover 20-50%)+(12 x %cover 50-80%)+(15 x %cover >80%))/100.***

The “early warning trigger” for initiating management action is a trend of a decreasing Seagrass Coefficient.

SEAGRASS CONDITION RATING

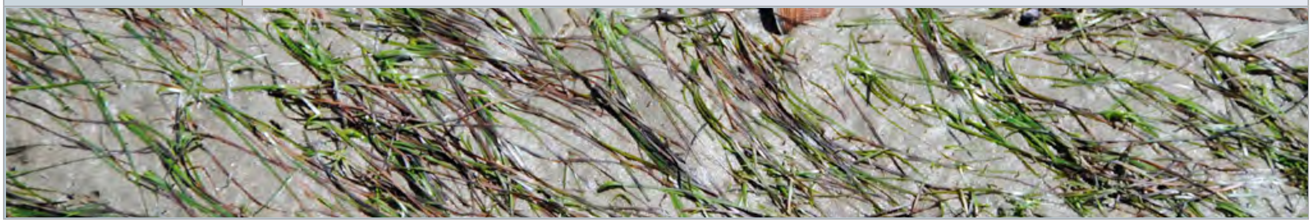
CONDITION RATING	DEFINITION	SC	RECOMMENDED RESPONSE
Poor	Very Low	0.0 - 0.2	Post baseline, monitor 5 yearly. Initiate ERP
Fair	Low	>0.2 - 0.8	Post baseline, monitor 5 yearly. Initiate ERP
	Low Low-Moderate	>0.8 - 1.5	Post baseline, monitor 5 yearly. Initiate ERP
Good	Low-Moderate	>1.5 - 2.2	Monitor at 5 year intervals after baseline established
	Moderate)	>2.2 - 4.5	Monitor at 5 year intervals after baseline established
Very Good	High	>4.5 - 7.0	Monitor at 5 year intervals after baseline established
	Very High	>7.0	Monitor at 5 year intervals after baseline established
Early Warning Trigger	Trend of decreasing Seagrass Coefficient		Initiate ERP (Evaluation and Response Plan)

SEAGRASS (CHANGE IN AREA)

Seagrass is vulnerable to fine sediments in the water column, rapid sediment deposition, poor sediment quality (particularly reduced oxygen or production of sulphide), excessive macroalgal growth, high nutrient concentrations, and reclamation. Decrease in seagrass extent is likely to indicate an increase in these types of pressures.

SEAGRASS AREA CHANGE RATING

CHANGE RATING	DEFINITION	RECOMMENDED RESPONSE
No Decrease	Area of cover (ha) not decreasing, or is increasing	Monitor at 5 year intervals after baseline established
Small Decrease	Decrease in area of cover (ha) <5% from baseline	Monitor at 5 year intervals after baseline established
Moderate Decrease	Decrease in area of cover (ha) 5-15% from baseline	Post baseline, monitor 5 yearly. Initiate ERP
Large Decrease	Decrease in area of cover (ha) 16-50% from baseline	Post baseline, monitor annually. Initiate ERP
Very Large Decrease	Decrease in area of cover (ha) >50% from baseline	Post baseline, monitor annually. Initiate ERP



2. METHODS (CONTINUED)

SALTMARSH (PERCENT COVER)

A variety of saltmarsh species (commonly dominated by rushland but including scrub, sedge, tussock, grass, reed, and herb fields) grow in the upper margins of most NZ estuaries where vegetation stabilises fine sediment transported by tidal flows. Saltmarshes have high biodiversity, are amongst the most productive habitats on earth, and have strong aesthetic appeal. Where saltmarsh cover is limited, these values are decreased. The "early warning trigger" for initiating management action is <5% of the estuary as saltmarsh.

SALTMARSH PERCENT COVER CONDITION RATING

CONDITION RATING	DEFINITION	RECOMMENDED RESPONSE
Very High	>20% of estuary area is saltmarsh	Monitor at 10 year intervals after baseline established
High	11%-20% of estuary area is saltmarsh	Monitor at 5 year intervals after baseline established
Moderate	6%-10% of estuary area is saltmarsh	Monitor at 5 year intervals after baseline established
Low	2%-5% of estuary area is saltmarsh	Post baseline, monitor 5 yearly. Initiate ERP
Very Low	<2% of estuary area is saltmarsh	Post baseline, monitor 5 yearly. Initiate ERP
Early Warning Trigger	<5% of estuary area is saltmarsh	Initiate ERP (Evaluation and Response Plan)

SALTMARSH (CHANGE IN AREA)

Saltmarshes are sensitive to a wide range of pressures including land reclamation, margin development, flow regulation, sea level rise, grazing, wastewater contaminants, and weed invasion. Decrease in saltmarsh extent is likely to indicate an increase in these types of pressures.

SALTMARSH AREA CHANGE RATING

CHANGE RATING	DEFINITION	RECOMMENDED RESPONSE
No Decrease	Area of cover (ha) not decreasing, or is increasing	Monitor at 10 year intervals after baseline established
Small Decrease	Decline in area of cover (ha) <5% from baseline	Monitor at 5 year intervals after baseline established
Moderate Decrease	Decline in area of cover (ha) 5-10% from baseline	Post baseline, monitor 5 yearly. Initiate ERP
Large Decrease	Decline in area of cover (ha) 11-50% from baseline	Post baseline, monitor 5 yearly. Initiate ERP
Very Large Decrease	Decline in area of cover (ha) >50% from baseline	Post baseline, monitor annually. Initiate ERP

TERRESTRIAL VEGETATED BUFFER (PERCENT COVER)

The presence of a terrestrial margin dominated by a dense assemblage of scrub/shrub and forest vegetation acts as an important buffer between developed areas and the saltmarsh and estuary. This buffer protects against introduced weeds and grasses, naturally filters sediments and nutrients, and provides valuable ecological habitat. The "early warning trigger" for initiating management action is <50% of the estuary with a densely vegetated margin.

TERRESTRIAL VEGETATED BUFFER PERCENT COVER CONDITION RATING

CONDITION RATING	DEFINITION	RECOMMENDED RESPONSE
Very High	81%-100% cover of terrestrial vegetated buffer	Monitor at 10 year intervals after baseline established
High	51%-80% cover of terrestrial vegetated buffer	Monitor at 5 year intervals after baseline established
Fair	26%-50% cover of terrestrial vegetated buffer	Post baseline, monitor 5 yearly. Initiate ERP
Poor	5%-25% cover of terrestrial vegetated buffer	Post baseline, monitor 5 yearly. Initiate ERP
Early Warning Trigger	<50% cover of terrestrial vegetated buffer	Initiate ERP (Evaluation and Response Plan)

TERRESTRIAL VEGETATED BUFFER (CHANGE IN AREA)

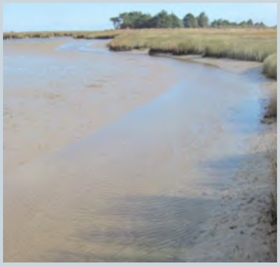
Estuaries are sensitive to a wide range of pressures including land reclamation, margin development, flow regulation, sea level rise, grazing, wastewater contaminants, and weed invasion. Reduction in the vegetated buffer around the estuary is likely to result in a decline in estuary quality.

TERRESTRIAL VEGETATED BUFFER AREA CHANGE RATING

CHANGE RATING	DEFINITION	RECOMMENDED RESPONSE
No Decrease	Vegetated buffer not decreasing, or is increasing	Monitor at 10 year intervals after baseline established
Small Decrease	Decline in vegetated buffer (ha) <5% from baseline	Monitor at 5 year intervals after baseline established
Moderate Decrease	Decline in vegetated buffer (ha) 5-10% from baseline	Post baseline, monitor 5 yearly. Initiate ERP
Large Decrease	Decline in vegetated buffer (ha) 11-50% from baseline	Post baseline, monitor 5 yearly. Initiate ERP
Very Large Decrease	Decline in vegetated buffer (ha) >50% from baseline	Post baseline, monitor annually. Initiate ERP

3. RESULTS AND DISCUSSION

BROAD SCALE MAPPING



Top to bottom - firm muddy sand near fine scale site B, eroding rushland exposing firm mud on the eastern edge of the estuary, and soft mud in a stream channel draining adjacent pasture in the northern arm.

Broad scale habitat mapping uses measures of the area of soft mud, macroalgal cover, gross eutrophic zones, seagrass, saltmarsh, and the densely vegetated 200m terrestrial margin to apply condition ratings to assess key estuary issues of sedimentation, eutrophication, and habitat modification. The results of the February 2013 broad scale assessment are presented in the following sections.

In 2013, a total of 496ha of estuary was mapped, comprising 174ha covered by water at low tide, 238ha unvegetated intertidal flats, 84ha tidal saltmarsh, and 0.5ha seagrass (Table 3). The mapping extent mirrored as much as possible that presented in Robertson et al. (2003) to facilitate the comparison of results for key condition ratings (Table 3). Improvements were made to the 2003 classification with some intertidal saltmarsh reclassified as terrestrial margin in 2013, and these changes are included in the summary tables below, and in the GIS files supporting this work.

Table 3. Summary of dominant broad scale features, Fortrose (Toetoes) Estuary, 2003 and 2013.

Dominant estuary feature	2003		2013	
	Ha	%	Ha	%
Saltmarsh	84.9	17.1%	83.7	16.9%
Seagrass (>50% cover)	0.2	0.0%	0.5	0.1%
Unvegetated	238.6	48.0%	238.3	48.0%
Water	173.8	34.9%	173.8	35.0%
TOTAL	**498**	**100**	**496**	**100**

SUBSTRATE MAPPING

Where soil erosion from catchment development exceeds the assimilative capacity of an estuary, impacts such as increased muddiness and turbidity, shallowing, increased nutrients, changes in saltmarsh and seagrass habitats, reduced sediment oxygenation, increased organic matter degradation by anoxic processes (e.g. sulphide production), and alterations to fish and invertebrate communities can result. Also, because contaminants are most commonly associated with finer sediment particles, extensive areas of fine soft muds provide a sink which concentrate catchment contaminants. The primary indicator of sediment impacts is the area of the estuary dominated by soft and very soft muds, with estuaries with an area >5% mud exceeding the early warning trigger for management action.

Figure 5 and Table 4 summarise the unvegetated intertidal substrate of Fortrose Estuary. Soft mud was a dominant feature over 19% of the estuary, a condition rating of 'poor'. Outside of these muddy areas the estuary was dominated by firm muddy sands (68%) located mostly on intertidal flats in the central basin. Firm sand and mobile sand (6%) was prominent around intertidal sand bars and in areas with high current flows near the entrance where large gravel beds (6%) were also located. All of the non-muddy habitats appeared to be in good (healthy) ecological condition.

Table 4. Summary of dominant intertidal substrate, Fortrose (Toetoes) Estuary, February 2013.

Dominant Substrate	Area Ha	Percentage	Comments
Rock field	0.2	0.1	Predominantly steep faced rock and earth margins of reclaimed land and roads.
Gravel field	19.7	6.1	Extensive near the estuary entrance, also beds by Titiroa Stream.
Mobile sand	12.5	3.9	In high flow areas near river discharges and at the estuary entrance.
Firm sand	9.2	2.9	Most extensive near the estuary entrance, and along high tide shorelines.
Firm muddy sand	219.9	68.1	Most common as raised tidal flats in the central basin and among saltmarsh.
Firm mud	0.3	0.1	Most common near rushland margins and along the edge of the Mataura River.
Soft mud	60.3	18.7	Most common near channel margins and along the eastern shoreline.
Very soft mud	0.3	0.1	Concentrated in deposition zones in the central basin, and by channel margins.
TOTAL	**323**	**100**	

3. RESULTS AND DISCUSSION (CONTINUED)

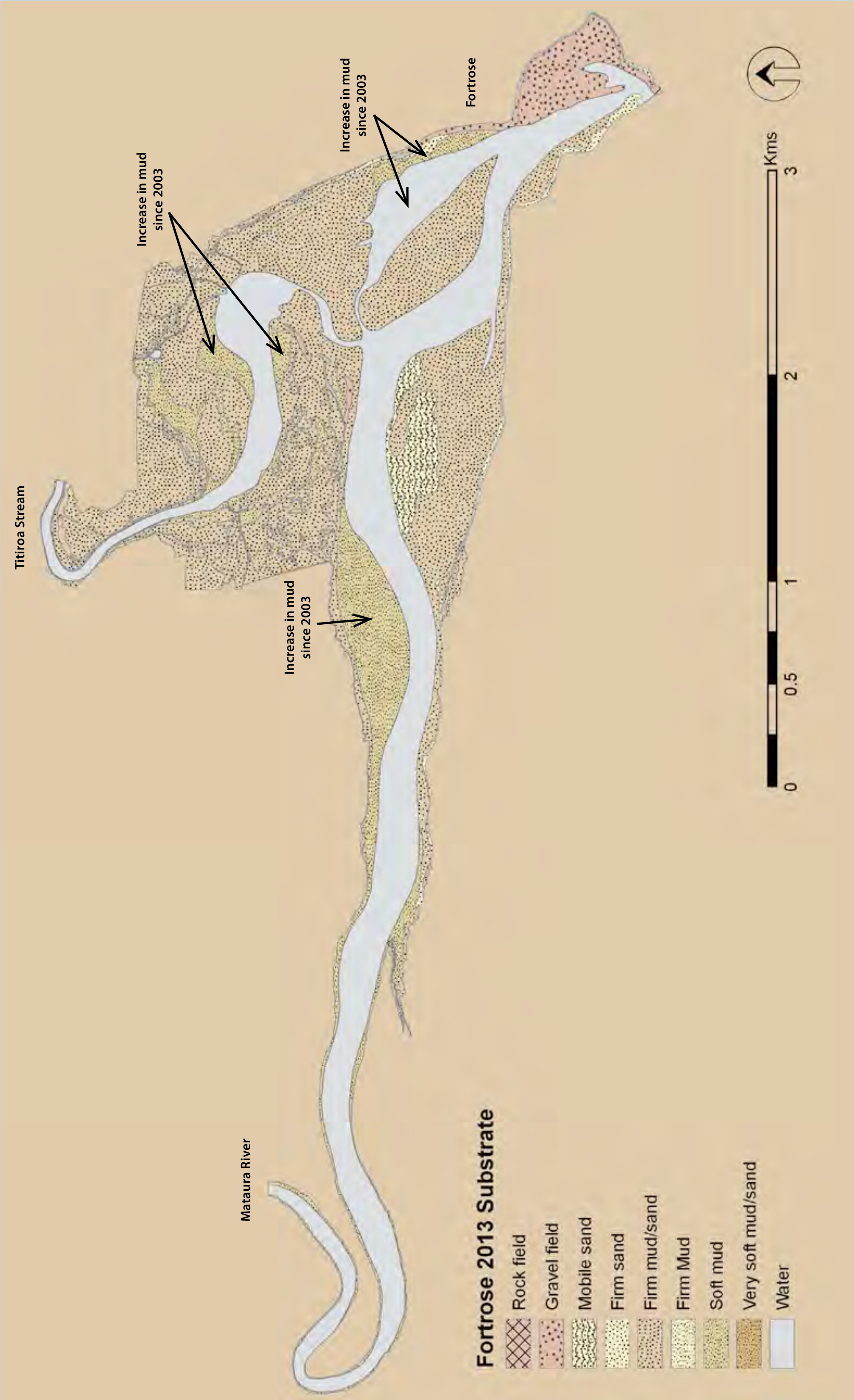


Figure 5. Map of dominant intertidal substrate types - Fortrose (Toetoes) Estuary, February 2013.

BROAD SCALE MAPPING (CONT.)

SOFT MUD % COVER CONDITION RATING
2003 FAIR (8%)
2013 POOR (19%)

SOFT MUD AREA CHANGE RATING
2003-2013 VERY LARGE INCREASE

Firm sand near the estuary entrance.

Soft muds on previously sandy tidal flats in the east of the estuary.

CHANGES IN ESTUARY SOFT MUD 2003-2013

The percent cover of major substrate classes in Fortrose Estuary in 2003 and 2013 is summarised in Table 5. There was no appreciable change in hard (rock/boulder/gravel) habitat types in the estuary. However, the area dominated by firm sand had declined and had changed to firm muddy sand, while firm muddy sand and firm mud had reduced and was replaced by soft mud. The increase in soft mud from 2003 to 2013 (25ha to 60ha - Figure 5) was significant, with the most obvious changes occurring over the last two years (pers. ob.). The changes to mud-dominated areas predominantly occurred on intertidal flats on the true left of the Mataura River, near the Titiroa Stream mouth, and on the eastern foreshore by Fortrose where a large increase in mud in the shallow subtidal basin was also evident (see Figure 5).

Table 5. Broad substrate categories, Fortrose (Toetoes) Estuary, 2003 and 2013.

Substrate Class	2003		2013	
	Area (ha)	Percent	Area (ha)	Percent
Rock field	0.2	0.1	0.2	0.1
Gravel field	19.7	6.2	19.7	6.1
Mobile sand	10.2	3.2	12.5	3.9
Firm sand	28.0	8.7	9.2	2.9
Firm muddy sand	215.4	67.1	219.9	68.1
Firm mud	22.9	7.1	0.3	0.1
Soft mud	24.4	7.6	60.3	18.7
Very soft mud	0.3	0.1	0.3	0.1
TOTAL	**321**	**100**	**323**	**100**

The broad scale condition rating for soft mud has changed from 'fair' in 2003, to 'poor' in 2013, with the overall soft mud change condition rating a "very large increase" (>50% from the 2003 baseline). As any large increase in mud within the estuary is a cause for significant concern, potential sources of sediment inputs to the estuary between 2003 and 2013 should be investigated to determine whether the increase is a likely response to inputs from development of the surrounding catchment, from flood deposition, or from reworking of sediment within the estuary.

Sedimentation rate measurements at fine scale Site B (established in 2009) indicate slight erosion of sediments since that time (average of -1.4mm/year - see Appendix 1 for details), suggesting that a large build up of sediment has not occurred in the estuary. Monitoring at the two fine scale sites, scheduled to be reassessed in 2014, will therefore indicate whether the increase in soft mud area is reflected in increased muddiness of sediments through grain size analyses.

BROAD SCALE MAPPING (CONT.)

LOW DENSITY MACROALGAL CONDITION RATING
2013 MODERATE

HIGH DENSITY MACROALGAL CONDITION RATING
2013 MODERATE

GROSS EUTROPHIC AREA CONDITION RATING
2013 VERY GOOD

Wind blown accumulation of *Ulva* in front of rushland on the eastern shoreline.

MACROALGAL COVER

Macroalgal blooms are a symptom of estuary eutrophication. These can deprive seagrass beds of light causing their decline, while decaying macroalgae can accumulate subtidally and on shorelines causing oxygen depletion and nuisance odours. The results of the 2013 intertidal macroalgal survey (Table 6 and Figure 6) showed:

- A large portion of the intertidal area (67%) had a low/very low percentage cover.
- High-very high (>50%) dense nuisance macroalgal cover was present - 22.5ha (8.1%).
- Dense macroalgal cover commonly coincided with the presence of soft, moderately-oxygenated muds, however gross nuisance conditions were not evident.
- The red alga *Gracilaria chilensis* was the dominant macroalgae growing throughout the intertidal area with a sub-dominant cover of the green alga *Ulva lactuca*. The species dominance reversed when macroalgal cover exceeded 80%. *Gracilaria* sp. is well known as a strong "habitat modifier" in that it successfully traps fine sediment from the water column and thereby increases the sediment mud content.
- The most extensive macroalgal growths were located in subtidal areas and tidal channels wherever substrate allowed macroalgae to gain a foothold.

Table 6. Summary of macroalgal cover, Fortrose (Toetoes) Estuary, Feb. 2013.

MACROALGAE	Fortrose (Toetoes) Estuary		
Percentage Cover	Ha	%	Dominant species
<1%	118	42.6	-
1-5%	68	24.5	*Gracilaria chilensis, Ulva intestinalis*
5-10%	22	7.9	*Gracilaria chilensis, Ulva intestinalis*
10-20%	9	3.2	*Gracilaria chilensis, Ulva intestinalis*
20-50%	38	13.7	*Gracilaria chilensis, Ulva intestinalis*
50-80%	12.0	4.3	*Gracilaria chilensis, Ulva intestinalis*
>80%	10.5	3.8	*Ulva intestinalis, Gracilaria chilensis*
TOTAL	**277**	**100**	

The condition ratings for macroalgal cover were revised in 2013 following a review of the extensive NZ estuary data set compiled by Wriggle since 2007. The revised ratings better characterise the distribution of low density macroalgal growths in the estuary (which generally do not cause significant nuisance conditions), and distinguish these from areas of high density macroalgal growths that are commonly associated with nuisance conditions and sediment deterioration, particularly when they combine with excessive soft muds.

The Macroalgal Coefficient (MC) for low density cover within the estuary in 2013 was 1.5 (Table 7). This fits a condition rating of "moderate", reflecting widespread low growth across much of the estuary. The high density macroalgal cover was rated as "moderate" with 8% of the estuary experiencing dense (>50%) macroalgal growths.

Extensive dense macroalgal cover on the lower intertidal flats near the eastern shoreline.

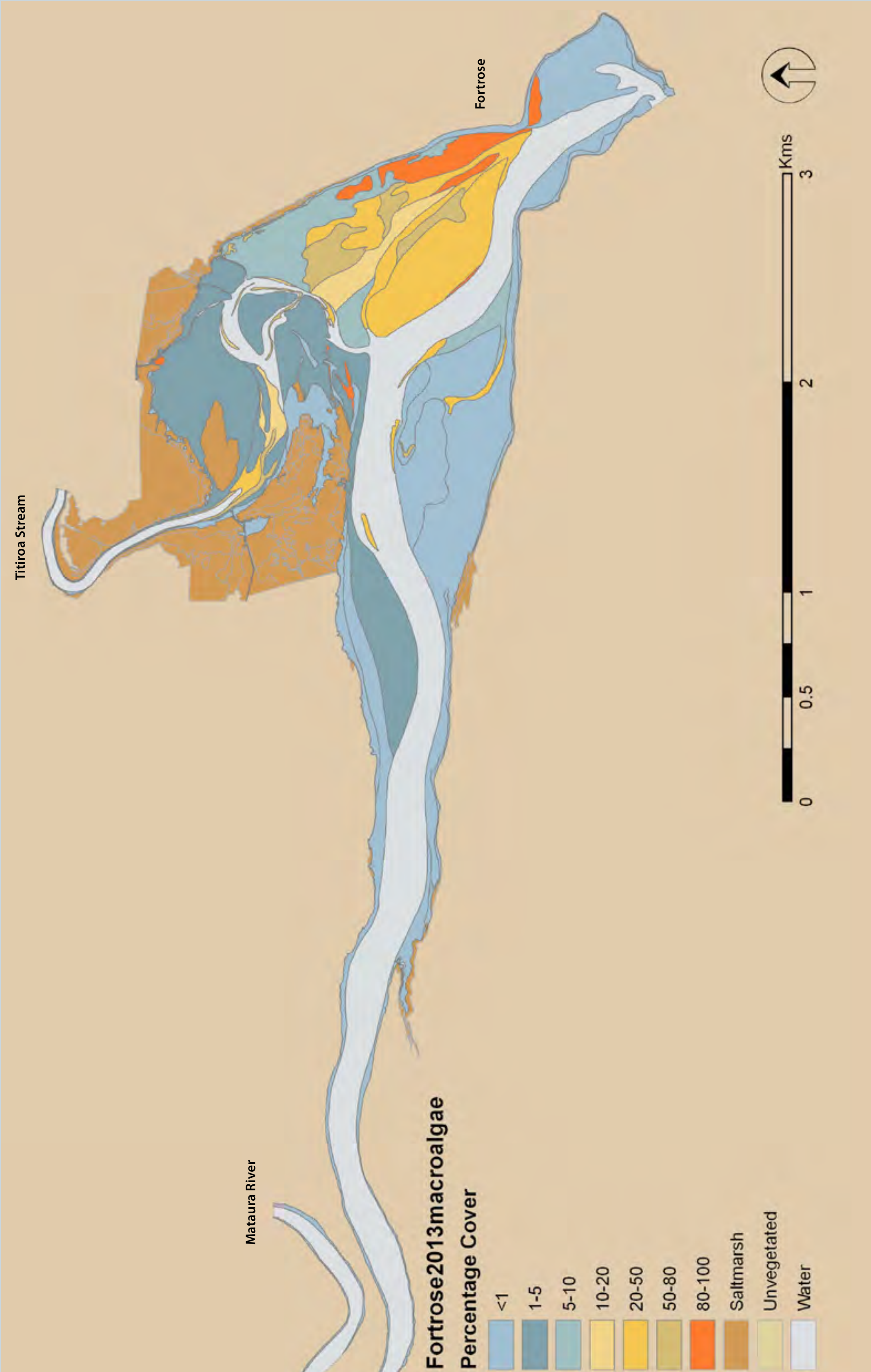


Figure 6. Map of macroalgal cover - Fortrose (Toetoes) Estuary, February 2013.

BROAD SCALE MAPPING (CONT.)

LOW DENSITY MACROALGAL COVER CHANGE RATING
2003 to 2013 WARNING (TREND OF INCREASE)

HIGH DENSITY MACROALGAL COVER CHANGE RATING
2003 to 2013 VERY LARGE INCREASE

CHANGES IN MACROALGAL COVER 2003, 2009-2013

Table 7 summarises both low and high density macroalgal growth from 2003, and 2009-2013 with values recalculated using the condition ratings as revised in 2013. Since 2009, dense intertidal macroalgal growth has been in the "moderate" or "low" categories. The variable 4-9% cover most likely reflects fluctuations in observed cover as a consequence of river flows and wind-generated wave action redepositing macroalgae from subtidal areas onto intertidal flats, or the scouring of macroalgae from intertidal areas under flood conditions. Compared to the 2003 baseline, there has been a significant increase in the extent and density of intertidal macroalgal growths in the estuary, and these appear to be on the cusp of causing nuisance conditions. Combined with the very prolific subtidal growths, this trend of increase throughout the estuary since 2003 activates the "trigger warning" and highlights that care needs to be taken to ensure the assimilative capacity of the estuary is not exceeded.

This extensive subtidal growth present in the estuary is driven by the very high nutrient loads entering the estuary (estimated N load based on NIWA's CLUES model with 2002 land cover is 2,450 tonnes N year^{-1}, therefore based on current land use is likely to be >4,000 tonnes N year^{-1}). Because the estuary is relatively small in comparison to the very large freshwater inflow (mean flow 76m^3.s^{-1}), most of the N inflow is rapidly flushed out to sea. However, the high N inputs support excessive growths of nuisance macroalgae in areas exposed to elevated nutrient concentrations and low salinity conditions. The nuisance macroalgae is usually *Ulva,* which is very tolerant of low salinity, and these growths can break away and be transported to other areas of the estuary through wind and current action. However, prolific growths of *Gracilaria* are also widespread in the shallow subtidal channels of the estuary,

Consequently, setting limits on nutrient inputs, and the identification and management of nutrient sources, is considered a priority. It is therefore recommended that annual macroalgal monitoring be continued, that appropriate catchment nutrient guideline criteria be developed, and that the extent to which catchment loads meet these guidelines be assessed. The key steps in such an approach are as follows:

- Assign catchment nutrient load guideline criteria to the estuary based on available catchment load/estuary response information from other relevant estuaries.
- Estimate catchment nutrient loads to the estuary using available catchment models and stream monitoring data.
- Determine the extent to which the estuary meets guideline catchment load criteria.
- Assess the potential for requiring more detailed assessments of priority catchments (e.g. estuary response modelling, stream and tributary monitoring, catchment load modelling).
- Develop plans for targeted management or restoration of priority catchments.

However, because the estuary is currently in a low to moderate state of enrichment, the estuary does not have the same high urgency as New River or Jacobs River estuaries.

Table 7. Summary of macroalgal cover, Fortrose Estuary, 2003 and 2009-2013.

Year	Low Density (MC) Rating	High Density (%) Rating	Result
2003	VERY LOW 0.0	VERY LOW (<1%)	Very little macroalgal growth present in the estuary.
2009	MODERATE 1.9	MODERATE (9%)	Widespread growth in central basin and eastern side of estuary. Little growth in the west and across the lower estuary, but localised concentrations of windblown algae.
2010	LOW 0.9	MODERATE (9%)	Most macroalgal growth and localised concentrations of windblown algae located on the Eastern Flats. Little growth across the north, west or lower estuary flats.
2011	LOW 0.6	LOW (6%)	Most extensive as windblown deposits on the Eastern Flats. Little growth across the north, west or lower estuary flats. Reduced cover in central basin.
2012	LOW 0.6	LOW (4%)	Little growth across the north, west or lower estuary flats. Low cover in central basin. Most extensive growths near river channel margins.
2013	MODERATE 1.5	MODERATE (8%)	Widespread growth in central basin and eastern side of estuary. Little growth in the west and across the lower estuary. Most extensive growths near river channel margins.

BROAD SCALE MAPPING (CONT.)

SEAGRASS COEFFICIENT CONDITION RATING
2003 POOR
2013 POOR

SEAGRASS COVER

Seagrass (*Zostera muelleri*) beds are important ecologically because they enhance primary production and nutrient cycling, stabilise sediments, elevate biodiversity, and provide nursery and feeding grounds for a range of invertebrates and fish. Though tolerant of a wide range of conditions, seagrass is vulnerable to excessive nutrients, fine sediments in the water column, and sediment quality (particularly if there is a lack of oxygen and the production of toxic sulphide).

The results of the 2013 intertidal seagrass survey (Table 8 and Figure 7) showed:

- Overall, 99% of the intertidal area (excluding that covered by saltmarsh) had no seagrass cover.
- Less than 1% of the estuary had dense (>50%) seagrass cover.
- Seagrass beds were scarce and located relatively high in the tidal range away from the main river flows, with the largest beds in the northern arm.

The 2013 Seagrass Coefficient (SC) was "very low" (0.03), and had a condition rating of "poor", the same rating as in 2003.

Table 8. Summary of seagrass *(Z. muelleri)* cover, Fortrose (Toetoes) Estuary, February 2013.

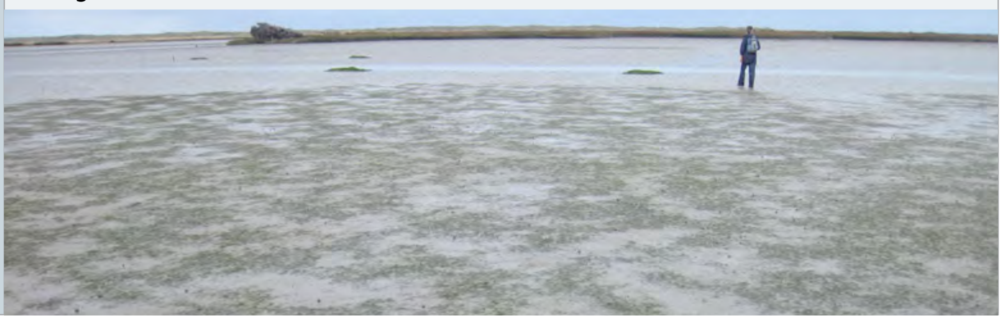
Percentage Cover	Area (ha)	Percentage
<1%	238.3	99.8
1-5%	0	0.0
5-10%	0	0.0
10-20%	0	0.0
20-50%	0	0.0
50-80%	0	0.0
>80%	0.5	0.2
Total	**238.8**	**100**

CHANGES IN SEAGRASS COVER 2003-2013

Intertidal seagrass was historically abundant in most NZ estuaries, but has substantially reduced over time as a consequence of reclamation, increasing fine sediment muddiness (and related effects e.g. reduced water clarity, smothering, reduced sediment oxygenation), and excessive nutrient loads (macroalgal smothering and toxicity). While there are no available estimates of historical seagrass cover in Fortrose Estuary, it is almost certain that seagrass was once much more plentiful than at present, and that there has been a significant loss of this important habitat over time.

Since 2003 there has been little observed change in seagrass. The 2013 habitat mapping indicates a slight increase in seagrass cover (0.3ha) from that mapped in 2003 (Table 3). However, this change is almost certainly due to more accurate mapping of seagrass in 2013 made possible by higher resolution aerial photos, rather than any real change is seagrass extent. Consequently, the 2003-2013 seagrass area change rating is rated as "no decrease".

SEAGRASS AREA CHANGE RATING
2003-2013 NO DECREASE



Seagrass bed in the northern arm near Titiroa Stream.

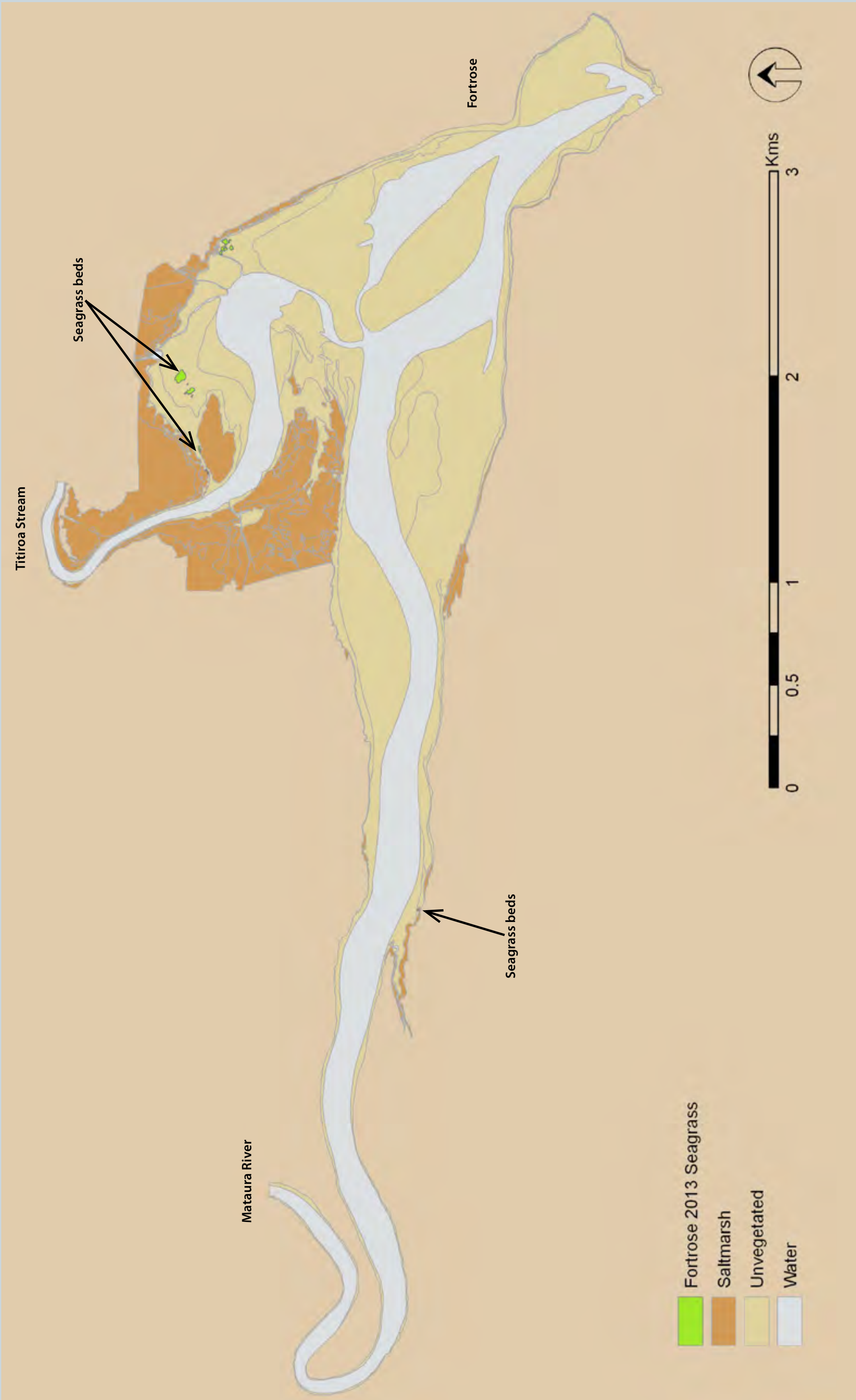
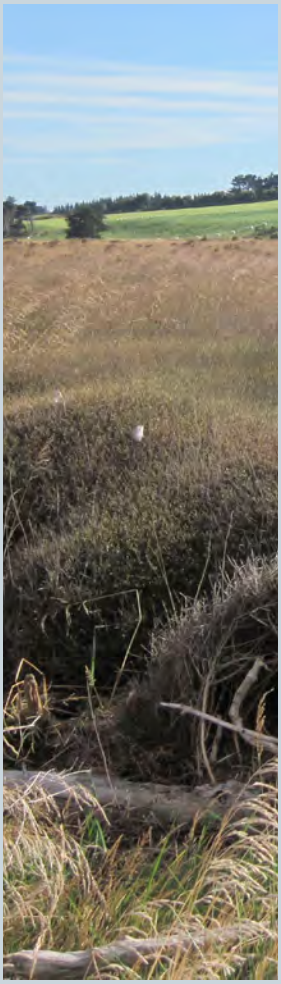


Figure 7. Map of seagrass cover - Fortrose (Toetoes) Estuary, February 2013.

BROAD SCALE MAPPING (CONT.)

SALTMARSH % COVER CONDITION RATING
2003 HIGH
2013 HIGH



Saltmarsh ribbonwood and tall fescue between the estuary and surrounding pasture near Titiroa Stream.

SALTMARSH MAPPING

Saltmarsh (vegetation able to tolerate saline conditions where terrestrial plants are unable to survive) is important as it is highly productive, naturally filters and assimilates sediment and nutrients, acts as a buffer that protects against introduced grasses and weeds, and provides important habitat for a variety of species including fish and birds. Table 9 and Figure 8 summarise the 2013 saltmarsh mapping results. Overall, 17% of the estuary (84ha) is saltmarsh, a condition rating of "high". Key findings were:

- The most extensive areas of remaining saltmarsh were located near Titiroa Stream.
- The dominant saltmarsh cover was jointed wire rush (68%), and tussockland (12%).
- Introduced grass and weeds were a common subdominant cover near the terrestrial margin.

Table 9. Summary of saltmarsh cover, Fortrose (Toetoes) Estuary, 2003, 2013.

Class	Dominant Vegetation	2003		2013	
		Area (ha)	%	Area (ha)	%
Scrub		0.8	0.9	0.1	0.2
	Ulex europaeus (Gorse)	0.8	0.9	0.1	0.2
Estuarine Shrub		2.7	3.2	2.5	3.0
	Plagianthus divaricatus (Saltmarsh ribbonwood)	2.7	3.2	2.5	3.0
Tussockland		10.1	11.9	9.9	11.9
	Phormium tenax (New Zealand flax)	6.3	7.5	6.3	7.6
	Puccinella stricta (Salt grass)	3.8	4.5	3.6	4.3
Sedgeland		0.0	0.0	0.03	0.01
	Schoenoplectus pungens (Three square)	0.0	0.0	0.03	0.03
Grassland		11.6	13.7	11.1	13.3
	Festuca arundinacea (Tall fescue)	11.3	13.3	11.1	13.3
	Pasture	0.4	0.4		
Duneland		1.6	1.9	1.6	2.0
	Ammophila arenaria (Marram grass)	1.6	1.9	1.6	2.0
Rushland		56.9	67.0	57.2	68.3
	Apodasmia similis (Jointed wirerush)	56.9	67.0	57.2	68.3
Herbfield		1.1	1.3	1.1	1.3
	Samolus repens (Primrose)	0.8	1.0	0.8	1.0
	Selliera radicans (Remuremu)	0.3	0.3	0.3	0.3
TOTAL		**84.9**	**100**	**83.7**	**100**

The largest remnant of an historically much broader cover of saltmarsh was located near Titiroa Stream and was dominated by wide beds of rushland (mostly jointed wire rush) which, as the terrestrial influence increased, transitioned through areas dominated by saltmarsh ribbonwood (*Plagianthus divaricatus*) and grassland (mostly tall fescue - *Festuca arundinacea*). Introduced weeds were a common subdominant cover, particularly among the grassland. In several places the seaward edge of rush beds were eroding leaving a relatively steep bank and exposing firm muds (photo below left). Small beds of three-square were present along the eastern estuary (photo below right), while herbfields were uncommon in the estuary.

Eroding rushland (left) and sedge beds (right) along the east side of the estuary.

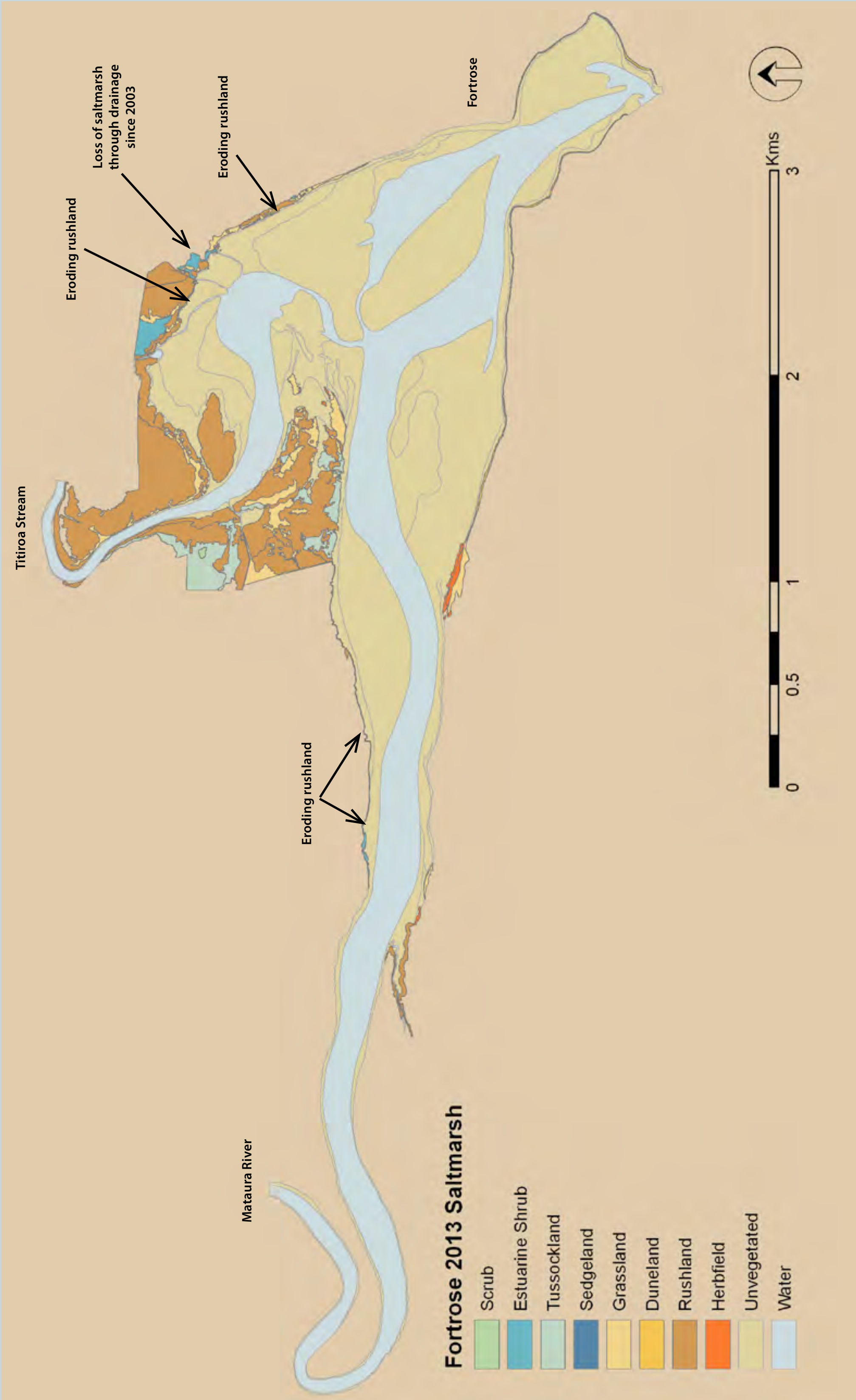


Figure 8. Map of saltmarsh vegetation - Fortrose (Toetoes) Estuary, February 2013.

BROAD SCALE MAPPING (CONT.)

SALTMARSH AREA CHANGE RATING
2003-2013 SMALL DECREASE

CHANGES IN SALTMARSH COVER 2003-2013

The condition rating for saltmarsh measures a percentage change from an established baseline. Based on the summary information in Table 9, and using 2003 data as a baseline, the 2013 saltmarsh condition rating is rated as "small decrease". This reflects a small reduction in saltmarsh cover as a consequence of drainage in the north east of the estuary, and minor shoreline erosion (Figure 8, photos below).

Bank erosion in the east (above left) and west (above right) contributing to minor saltmarsh losses.

Elsewhere the changes evident in the 2003 and 2013 results presented in Table 9 relate to changes in the extent and interpretation of mapped features, rather than changes in the area of saltmarsh itself. In particular, there has been a reclassification of 2003 saltmarsh in the west and south of the estuary to terrestrial margin, and inclusion of saltmarsh near Titiroa Stream that was not included in the 2003 mapping.

Grassland containing herbfield in the west of the estuary adjacent to the Mataura River re-classified from intertidal saltmarsh in 2003 to terrestrial margin grassland in 2013 as it is not tidally inundated.

Saltmarsh in the north of the estuary representative of similar areas adjacent to Titiroa Stream added in the 2013 mapping.

3. RESULTS AND DISCUSSION (CONTINUED)

BROAD SCALE MAPPING (CONT.)

VEGETATED MARGIN % COVER CONDITION RATING
2003 POOR
2013 POOR

VEGETATED MARGIN CHANGE RATING
2003-2013 NO SIGNIFICANT CHANGE

TERRESTRIAL MARGIN COVER

Like saltmarsh, a densely vegetated terrestrial margin filters and assimilates sediment and nutrients, acts as an important buffer that protects against introduced grasses and weeds, is an important habitat for a variety of species, provides shade to help moderate stream temperature fluctuations, and improves estuary biodiversity. The results of the 200m terrestrial margin survey (Table 10 and Figure 9) showed:

- Much of the immediate terrestrial estuary margin had been modified through conversion to pasture following wetland clearance, drainage and reclamation.
- The coastal margin (between the estuary and Toetoes Beach) was dominated by duneland (primarily introduced marram grass, but with some important native cushion field and pingao habitat remaining).
- Densely vegetated terrestrial margin cover (scrub and forest) was scarce (4%).

The extent of the densely vegetated terrestrial buffer (4%) fits the condition rating of "poor". Although not reported on in 2003, the 2003 aerial photographs indicate that the terrestrial margin has not changed significantly over the past decade.

Table 10. Summary of the 200m terrestrial margin, Fortrose (Toetoes) Estuary, February 2013.

Class	Dominant Feature	Percentage Cover
Scrub/Forest	Mixed native and exotic scrub/forest	1%
Scrub	Mixed native and exotic scrub	3%
Grassland	Grassed pasture	63%
Rushland	Jointed wire rush	2%
Duneland	Marram grass	23%
Firm sand	Beach areas by the estuary mouth	1%
Water	Pond, river, sea	3%
Built feature	Roading	1%
Residential	Housing	3%
TOTAL		**100**

Grazing to the estuary channel edge along much of the northwestern part of the estuary means there is very little capacity to filter sediment and nutrients, and very limited natural habitat remaining for whitebait spawning, wildlife, and the natural protection of stream banks from erosion. The drainage and loss of most of the lowland wetland also means the vulnerability of the estuary to sediment and nutrient inputs is much greater than in the past, while the ecological values have been significantly compromised. The few remaining areas therefore have high values and efforts to protect and restore such habitat is strongly encouraged.

To the east of the estuary, margin vegetation contained a range of introduced weeds while the road breaks the natural sequence of estuarine to terrestrial vegetation and is a significant barrier to the estuary responding naturally to predicted sea level rise.

Overall, the terrestrial margin is highly developed and retains very few habitat features that are unmodified and in their natural state.

3. RESULTS AND DISCUSSION (CONTINUED)

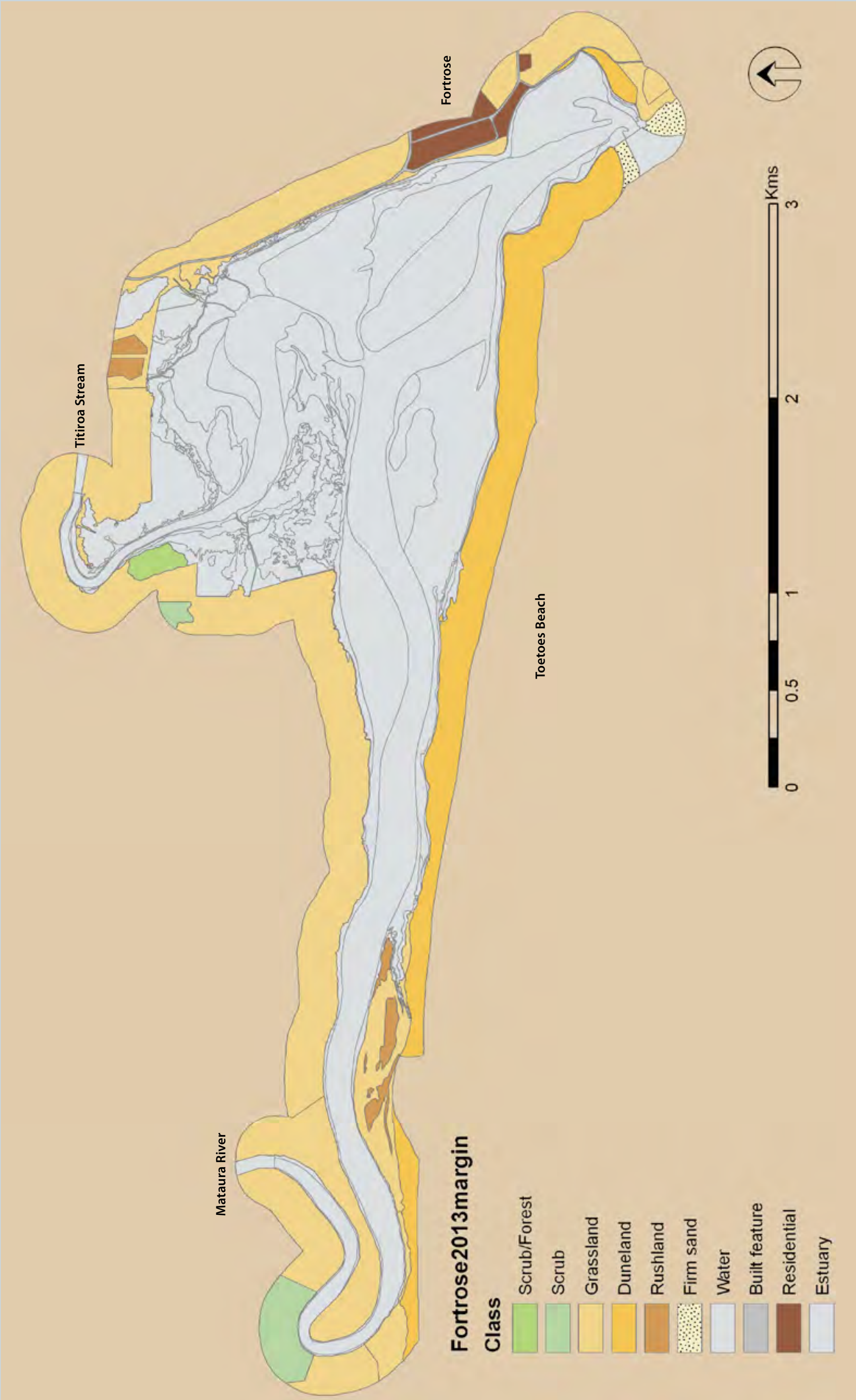


Figure 9. Map of 200m terrestrial margin vegetation - Fortrose (Toetoes) Estuary, February 2013.

4. SUMMARY AND CONCLUSIONS

Table 11 summarises condition ratings in relation to the key issues addressed by the broad scale monitoring (i.e. sediment, eutrophication and habitat modification).

Table 11. Summary of broad scale condition ratings for Fortrose (Toetoes) Estuary 2003, 2013.

Major Issue	Indicator	2003	2013	Change from 2003 Baseline
Sediment	Soft mud area	FAIR	POOR	VERY LARGE INCREASE
Eutrophication	Low density macroalgal cover	VERY LOW	MODERATE	TRENDING UP = WARNING
	High density macroalgal cover	VERY LOW	MODERATE	VERY LARGE INCREASE
	Gross eutrophic condition area	VERY GOOD	VERY GOOD	NO SIGNIFICANT CHANGE
Habitat Modification	Seagrass area	POOR	POOR	NO DECREASE
	Saltmarsh area	HIGH	HIGH	SLIGHT DECREASE
	Densely vegetated margin area	POOR	POOR	NO SIGNIFICANT CHANGE

Overall, the majority of the intertidal area was characterised by unvegetated sands (75%) and soft muds (19%), with small areas of gravel and rock (6%). Saltmarsh was relatively extensive (84ha) and predominantly located near Titiroa Stream. Otherwise the majority of the estuary's terrestrial margin was dominated by grassland, a consequence of extensive historical drainage and reclamation.

Although the estuary remained dominated by sand, the soft mud cover had significantly increased since 2003, from 8% to 19% (24ha to 60ha). Most of this change had occurred on the intertidal flats where the Titiroa Stream and Mataura River discharge into the central basin of the estuary. The increase in mud has not resulted in a visible decline in sediment oxygenation, but increasing sediment mud is a major estuary stressor and the change is of significant concern.

Macroalgal growth (dominated by *Gracilaria* and *Ulva*) was at moderate levels, with a widespread low density cover, particularly near low tide channels fed by nutrient-rich river flows. High density growths were moderate. Macroalgal cover has been relatively variable since annual monitoring began in 2009, but has increased significantly since it was first assessed in 2003 and appears on the cusp of causing nuisance conditions. While no large zones of gross eutrophic conditions were present, based on increased macroalgal cover and high catchment nutrient loads entering the estuary, developing nutrient load guideline criteria for the estuary to ensure its assimilative capacity is not exceeded is strongly recommended.

Seagrass (*Zostera*) beds were scarce with only 0.5ha (<1%) in the estuary. The cause of the low coverage is uncertain but may well relate to the elevated nutrient inputs which exceed levels known to be toxic to seagrass. Secondary stressors are likely to be from macroalgal smothering and increased muddiness contributing to reduced sediment oxygenation and poor water clarity.

Although only a small remnant of the historically very extensive wetland and saltmarsh cover surrounding the estuary remains, saltmarsh cover (17%, 84ha) was rated high. It was dominated by rushland (jointed wire rush) and 12% tussockland (flax and salt grass), but had declined slightly since 2003 due to recent land drainage and localised shoreline erosion.

The estuary 200m terrestrial margin remained unchanged from 2003 and was dominated by grassland (63%) with very little dense vegetation remaining (4%), greatly limiting its role in the natural buffering of the estuary from sediment and nutrient inputs.

Overall, there has been a change in several key condition indicators over the past decade indicating a decline in estuary health. The primary drivers of the changes identified are almost certainly related to elevated catchment inputs of nutrients and fine sediments, and nutrient inputs in particular need to be reduced below current levels to achieve a more moderately enriched estuary and to protect it from further degradation.

5. MONITORING

Fortrose (Toetoes) Estuary has been identified by ES as a priority for monitoring, and is a key part of ES's coastal monitoring programme being undertaken in a staged manner throughout the region. This arises because the estuary is large, has moderate ecological and human use values (particularly whitebaiting) and is rated as of outstanding importance in the "Wetlands of National Significance to Fisheries Database". The estuary is moderately vulnerable to sediment muddiness, eutrophication and disease risk, with the vulnerability mitigated somewhat by the high rate of flushing and consequent export of a large portion of the elevated catchment sediment and nutrient load to the surrounding coastline. Based on the 2013 monitoring results and condition ratings, and changes since 2003, it is recommended that monitoring continue as follows:

Broad Scale Habitat Mapping
Repeat broad scale intertidal habitat mapping on a 10 yearly cycle. Next monitoring is therefore due in February 2023.

Fine Scale Monitoring
Repeat fine scale intertidal monitoring at 5 yearly intervals (next scheduled for February 2014).

Sediment Monitoring
Because sedimentation is an issue in the estuary it is recommended that sediment plate depths be measured annually, and consideration be given to deploying additional plates if sediment is rapidly accumulating in obvious intertidal deposition areas.

Macroalgal Monitoring
Based on the widespread cover of macroalgae, and the trend of increase, annual monitoring of macroalgal cover is recommended (next scheduled for February 2014).

Catchment Landuse
Track and map key changes in catchment landuse, particularly where activities have the potential to release sediments or increase nutrient loads to the estuary (5 yearly).

6. MANAGEMENT

Previous recommendations (e.g. Robertson and Stevens 2009, Stevens and Robertson 2011, 2012) are reiterated for the development of catchment nutrient and sediment guideline criteria for each estuary type in Southland to derive thresholds protecting against adverse sediment and nutrient impacts. Fortrose (Toetoes) Estuary has been identified as a priority for this work, behind assessments for New River and Jacobs River estuaries, as follows:

Set Limits on Nutrient Inputs

The presence of increasing macroalgal growth in Fortrose Estuary (widespread throughout the central basin and eastern side of the estuary in 2009, 2010 and 2013) indicates catchment nutrient loads to the estuary exceed the ability of the estuary to assimilate these loads (Robertson and Stevens 2008). To address this issue and set an appropriate upper limit on macroalgal growth for the estuary, it is recommended that nutrient and sediment load guidelines be developed for the estuary.

Identify and Manage Major Nutrient Sources

- The identification of nutrient sources to the estuary is seen as a priority given the very significant nature of both point and non-point discharges. Once identified, a plan should be developed to prioritise and reduce the key inputs.

Assessment of the extent to which catchment loads meet guideline criteria will enable ES to sustainably manage the estuary and its surroundings. If catchment inputs can be assimilated by the estuary, it will flourish and provide sustainable human use and ecological values in the long term. If catchment loads exceed the estuary's assimilative capacity, it will continue to degrade.

In addition, because of the potential for ongoing margin development, it is recommended that saltmarsh areas located on private land be identified, and landowners be encouraged to i. protect these remaining, but vulnerable, stands and ii. identify areas most likely to be influenced by sea level rise to assist in planning for the managed retreat of saltmarsh in future.

7. ACKNOWLEDGEMENTS

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APPENDIX 1. SEDIMENT PLATE DATA 2009-2013.

Fortrose (Toetoes) Estuary Fine Scale Site B Sediment Plate Depths							
Plate	NZMG East	NZMG North	17/02/2009	18/02/2010	19/02/2011	20/02/2012	12/02/2013
1	2186888	5396709	220	not measured	207	203	210
2	2186884	5396705	183	not measured	173	180	180
3	2186878	5396697	191	not measured	190	190	191
4	2186875	5396693	212	not measured	214	205	203
Mean Change/Plate (mm)				0	-5.5	-1.5	1.5
Mean Annual Change from 2009 baseline (mm)							-1.4

APPENDIX 2. BROAD SCALE HABITAT CLASSIFICATION DEFINITIONS.

Vegetation was classified using an interpretation of the Atkinson (1985) system, whereby dominant plant species were coded by using the two first letters of their Latin genus and species names e.g. marram grass, *Ammophila arenaria*, was coded as Amar. An indication of dominance is provided by the use of ( ) to distinguish subdominant species e.g. Amar(Caed) indicates that marram grass was dominant over ice plant (*Carpobrotus edulis*). The use of ( ) is not always based on percentage cover, but the subjective observation of which vegetation is the dominant or subdominant species within the patch. A measure of vegetation height can be derived from its structural class (e.g. rushland, scrub, forest).

Forest: Woody vegetation in which the cover of trees and shrubs in the canopy is >80% and in which tree cover exceeds that of shrubs. Trees are woody plants ≥10 cm diameter at breast height (dbh). Tree ferns ≥10cm dbh are treated as trees. Commonly sub-grouped into native, exotic or mixed forest.

Treeland: Cover of trees in the canopy is 20-80%. Trees are woody plants >10cm dbh. Commonly sub-grouped into native, exotic or mixed treeland.

Scrub: Cover of shrubs and trees in the canopy is >80% and in which shrub cover exceeds that of trees (c.f. Forest). Shrubs are woody plants <10 cm dbh. Commonly sub-grouped into native, exotic or mixed scrub.

Shrubland: Cover of shrubs in the canopy is 20-80%. Shrubs are woody plants <10 cm dbh. Commonly sub-grouped into native, exotic or mixed shrubland.

Tussockland: Vegetation in which the cover of tussock in the canopy is 20-100% and in which the tussock cover exceeds that of any other growth form or bare ground. Tussock includes all grasses, sedges, rushes, and other herbaceous plants with linear leaves (or linear non-woody stems) that are densely clumped and >100 cm height. Examples of the growth form occur in all species of *Cortaderia, Gahnia,* and *Phormium*, and in some species of *Chionochloa, Poa, Festuca, Rytidosperma, Cyperus, Carex, Uncinia, Juncus, Astelia, Aciphylla,* and *Celmisia*.

Duneland: Vegetated sand dunes in which the cover of vegetation in the canopy (commonly Spinifex, Pingao or Marram grass) is 20-100% and in which the vegetation cover exceeds that of any other growth form or bare ground.

Grassland: Vegetation in which the cover of grass (excluding tussock-grasses) in the canopy is 20-100%, and in which the grass cover exceeds that of any other growth form or bare ground.

Sedgeland: Vegetation in which the cover of sedges (excluding tussock-sedges and reed-forming sedges) in the canopy is 20-100% and in which the sedge cover exceeds that of any other growth form or bare ground. "Sedges have edges." Sedges vary from grass by feeling the stem. If the stem is flat or rounded, it's probably a grass or a reed, if the stem is clearly triangular, it's a sedge. Sedges include many species of *Carex, Uncinia,* and *Scirpus*.

Rushland: Vegetation in which the cover of rushes (excluding tussock-rushes) in the canopy is 20-100% and where rush cover exceeds that of any other growth form or bare ground. A tall grasslike, often hollow-stemmed plant, included in rushland are some species of *Juncus* and all species of *Leptocarpus*.

Reedland: Vegetation in which the cover of reeds in the canopy is 20-100% and in which the reed cover exceeds that of any other growth form or open water. Reeds are herbaceous plants growing in standing or slowly-running water that have tall, slender, erect, unbranched leaves or culms that are either round and hollow – somewhat like a soda straw, or have a very spongy pith. Unlike grasses or sedges, reed flowers will each bear six tiny petal-like structures. Examples include *Typha, Bolboschoenus, Scirpus lacutris, Eleocharis sphacelata,* and *Baumea articulata*.

Cushionfield: Vegetation in which the cover of cushion plants in the canopy is 20-100% and in which the cushion-plant cover exceeds that of any other growth form or bare ground. Cushion plants include herbaceous, semi-woody and woody plants with short densely packed branches and closely spaced leaves that together form dense hemispherical cushions.

Herbfield: Vegetation in which the cover of herbs in the canopy is 20-100% and where herb cover exceeds that of any other growth form or bare ground. Herbs include all herbaceous and low-growing semi-woody plants that are not separated as ferns, tussocks, grasses, sedges, rushes, reeds, cushion plants, mosses or lichens.

Lichenfield: Vegetation in which the cover of lichens in the canopy is 20-100% and where lichen cover exceeds that of any other growth form or bare ground.

Introduced weeds: Vegetation in which the cover of introduced weeds in the canopy is 20-100% and in which the weed cover exceeds that of any other growth form or bare ground.

Seagrass meadows: Seagrasses are the sole marine representatives of the Angiospermae. They all belong to the order Helobiae, in two families: Potamogetonaceae and Hydrocharitaceae. Although they may occasionally be exposed to the air, they are predominantly submerged, and their flowers are usually pollinated underwater. A notable feature of all seagrass plants is the extensive underground root/rhizome system which anchors them to their substrate. Seagrasses are commonly found in shallow coastal marine locations, salt-marshes and estuaries.

Macroalgal bed: Algae are relatively simple plants that live in freshwater or saltwater environments. In the marine environment, they are often called seaweeds. Although they contain cholorophyll, they differ from many other plants by their lack of vascular tissues (roots, stems, and leaves). Many familiar algae fall into three major divisions: Chlorophyta (green algae), Rhodophyta (red algae), and Phaeophyta (brown algae). Macroalgae are algae observable without using a microscope.

Cliff: A steep face of land which exceeds the area covered by any one class of plant growth-form. Cliffs are named from the dominant substrate type when unvegetated or the leading plant species when plant cover is ≥1%.

Rock field: Land in which the area of residual rock exceeds the area covered by any one class of plant growth-form. They are named from the leading plant species when plant cover is ≥1%.

Boulder field: Land in which the area of unconsolidated boulders (>200mm diam.) exceeds the area covered by any one class of plant growth-form. Boulder fields are named from the leading plant species when plant cover is ≥1%.

Cobble field: Land in which the area of unconsolidated cobbles (20-200 mm diam.) exceeds the area covered by any one class of plant growth-form. Cobble fields are named from the leading plant species when plant cover is ≥1%.

Gravel field: Land in which the area of unconsolidated gravel (2-20 mm diameter) exceeds the area covered by any one class of plant growth-form. Gravel fields are named from the leading plant species when plant cover is ≥1%.

Mobile sand: The substrate is clearly recognised by the granular beach sand appearance and the often rippled surface layer. Mobile sand is continually being moved by strong tidal or wind-generated currents and often forms bars and beaches. When walking on the substrate you'll sink <1 cm.

Firm sand: Firm sand flats may be mud-like in appearance but are granular when rubbed between the fingers, and solid enough to support an adult's weight without sinking more than 1-2 cm. Firm sand may have a thin layer of silt on the surface making identification from a distance difficult.

Soft sand: Substrate containing greater than 99% sand. When walking on the substrate you'll sink >2 cm.

Firm mud/sand: A mixture of mud and sand, the surface appears brown, and may have a black anaerobic layer below. When walking you'll sink 0-2 cm.

Soft mud/sand: A mixture of mud and sand, the surface appears brown, and many have a black anaerobic layer below. When you'll sink 2-5 cm.

Very soft mud/sand: A mixture of mud and sand, the surface appears brown, and many have a black anaerobic layer below. When walking you'll sink >5 cm.

Cockle bed /Mussel reef/ Oyster reef: Area that is dominated by both live and dead cockle shells, or one or more mussel or oyster species respectively.

Sabellid field: Area that is dominated by raised beds of sabellid polychaete tubes.

Shell bank: Area that is dominated by dead shells.

Artificial structures: Introduced natural or man-made materials that modify the environment. Includes rip-rap, rock walls, wharf piles, bridge supports, walkways, boat ramps, sand replenishment, groynes, flood control banks, stopgates.