coastalmanagement

Motupipi Estuary 2007

Broad Scale Habitat Mapping

Prepared for

Tasman District Council

March 2008

Cover Photo: Motupipi Estuary mouth

Motupipi Estuary 2007

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By

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All photos by Wriggle except where noted otherwise.

Contents

List of Figures

List of Tables

EXECUTIVE SUMMARY

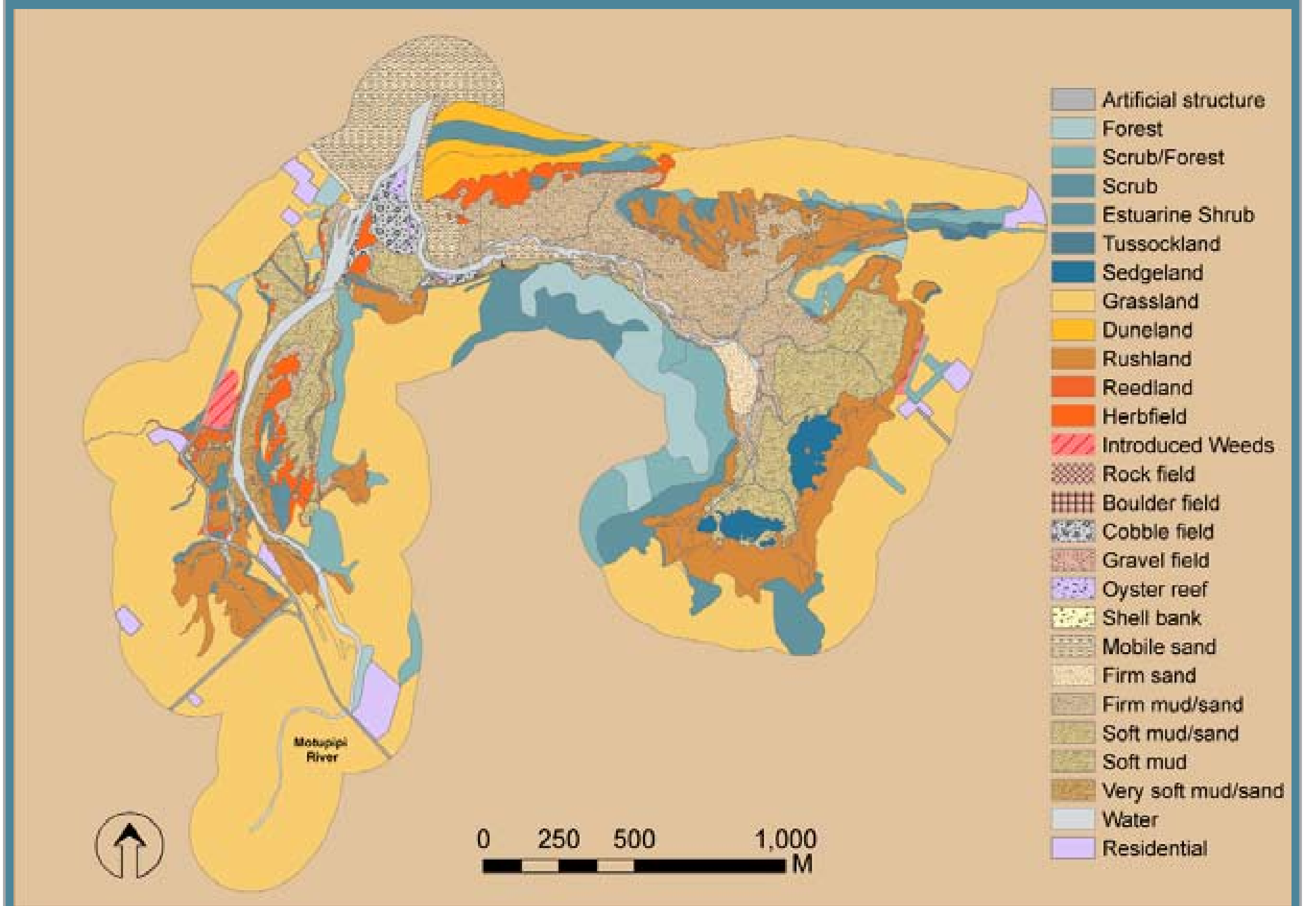
Since 2000, Tasman District Council (TDC) has been developing a long-term monitoring programme to assess the condition of key estuaries in its region using the National Estuary Monitoring Protocol (EMP) (Robertson et al. 2002). To date this has included the Ruataniwha, Waimea and Moutere Inlets and the Motueka Estuary. In 2007, TDC added the Motupipi Estuary in Golden Bay, to the estuary programme. The Motupipi programme consists of three components which are each reported separately: ecological vulnerability assessment, broad scale habitat mapping and fine scale physical, chemical and biological monitoring.

The current report describes the broad scale habitat mapping undertaken in September 2007. It includes:

- Broad scale mapping of estuary sediment types.
- Broad scale mapping of saltmarsh vegetation.
- Broad scale mapping of macroalgal beds (i.e. *Ulva* (sea lettuce), *Gracilaria, Enteromorpha*).
- Broad scale mapping of seagrass (*Zostera*) beds.
- Broad scale mapping of the 200m terrestrial margin surrounding the estuary.
- Broad scale mapping of historical estuary vegetation using 1943 and 1984 aerial photos.

The methods used are based on the tools included in the EMP, and a number of extensions to the EMP developed by Wriggle Coastal Management (see Robertson & Stevens 2006, 2007, Stevens & Robertson 2007) to assess the key issues of sedimentation, eutrophication and habitat loss. The figure below summarises the broad scale features of the estuary in 2007, with the results summarised and compared to condition ratings in the table on the following page. Monitoring and management recommendations are made at the end of the executive summary.

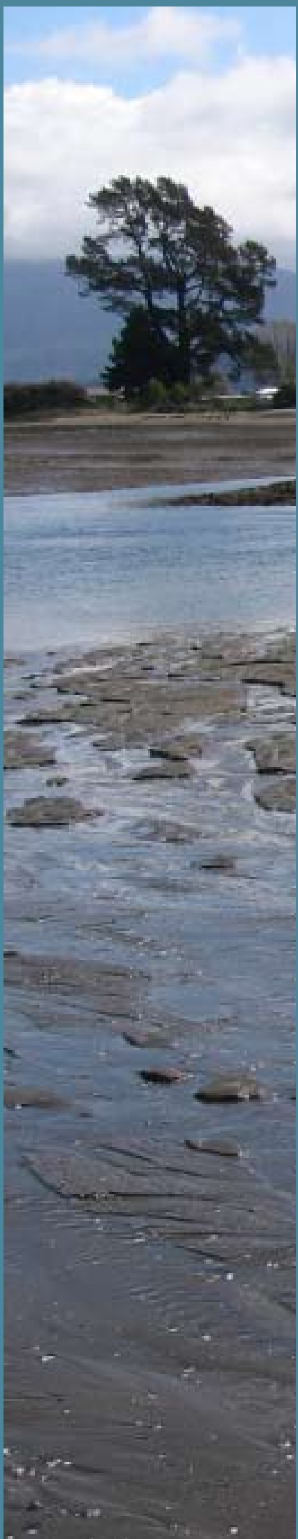
Summary of the broad scale features of the estuary, September, 2007.



EXECUTIVE SUMMARY (CONTINUED)

Issue	Indicator	Rating	Result
Sedimentation	Soft Mud Percent Cover	High	The broad scale mapping showed that 43% of the estuary was soft or very soft mud, rating sedimentation as a "high" issue overall which requires further investigation and evaluation. In terms of sediment associated problems, the western arm is the most affected, where muds are widespread, deep, poorly oxygenated, and close to nutrient and contaminant sources. Sand was the dominant substrate in the rest of the estuary (51%), with large tidal flats a dominant feature of the eastern arm and lower reaches of the estuary. The lower estuary and mouth areas also had a mixed cover of oyster reef, rock, gravel, cobble and mobile sand. While small in area, seawalls were a feature of the upper tidal reaches of the lower western arm.
	Soft Mud Area	Baseline established	The baseline area of soft mud established in 2007 will be used to measure change in area over time.
Eutrophication	Macroalgal Percent Cover	Fair	The extent of macroalgal growth in the Motupipi Estuary was low to moderate ("good" category), however because there were significant areas of localised nuisance conditions in the western arm, it was given an overall "fair" category triggering annual monitoring and further investigation and evaluation. *Gracilaria* and *Enteromorpha* were dominant in the low tide channels at the edge of the Motupipi River, while *Enteromorpha* was dominant in the upper estuary commonly covering rocks and cobbles in riffle zones, and in narrow bands along the edge of the river. Sea lettuce (*Ulva*) was present only in the lower estuary at low densities.
Habitat Loss	Seagrass Area	Baseline established	The baseline area of seagrass established in 2007 will be used to measure changes in area over time. Seagrass growth was most widespread in the subtidal reaches of the Motupipi River in the western arm of the estuary. Such extensive beds are not commonly found in the upper reaches of NZ estuaries, and are most likely present in the Motupipi because of its spring fed flows that maintain a relatively clear and constant base flow in the upper reaches.
	Saltmarsh Percent Cover	Very High	Saltmarsh (estuarine vegetation able to tolerate saline conditions and where terrestrial plants are unable to survive) covered 39% of the Motupipi Estuary which places it in the "very high" category. Rushland was dominant (43ha) - mainly searush *Juncus kraussii* and, to a lesser extent, jointed wire rush *Leptocarpus (Apodasmia) similis* - followed by herbfield (9ha), sedge (5ha), and estuarine shrub (4ha). The majority of the eastern arm was well vegetated. In the western arm, the lower sections had only small and narrow areas of herbfield dominated saltmarsh. The losses are attributable to past draining and reclamation of rushland habitat and hardfill/rockwalls flanking much of the road, and surrounding the closed Rototai landfill. Further up the western arm, saltmarsh was well established in a sequence from herbfield through rushland to estuarine shrubs, then grazed pasture. The upper estuary was river dominated with little saltmarsh present.
	Saltmarsh Area	Baseline established	The baseline area of saltmarsh established in 2007 will be used to measure changes in area over time. The change in saltmarsh area estimated from historical aerial photographs showed a 3.3% reduction between 1984 and 2007, placing it in the "good" category, and a 29% reduction between 1943 and 1984 placing it in the "poor" category. Modifications to the estuary margin visible in the 1943 aerial photo indicate saltmarsh reduction is also likely to have been in the "poor" category prior to 1943. A small expansion of the seaward edge of rushland means most reduction has been in the upper tidal reaches of the estuary. These losses have reduced the significant wildlife habitat and recreational and aesthetic value such areas provide, while also adversely impacting on their role in flood and erosion protection, contaminant mitigation, sediment stabilisation, and nutrient cycling.
	Terrestrial Vegetated Buffer Percent Cover	Poor	Terrestrial buffer vegetation (a dense assemblage of scrub/shrub and forest vegetation) was in the "poor" category, with most of the estuary surrounded by grazed pasture, and the remaining vegetated areas often in relatively poor condition consisting mostly gorse and pine trees on the steep hillsides in the central southern area between the east and west arms, along with a few patches of native scrub dotted throughout the estuary margin and as duneland on the historically intertidal barrier spit. Introduced weeds were present in most areas around the estuary.
	Terrestrial Vegetated Buffer Area	Baseline established	The baseline area of the terrestrial vegetated buffer established in 2007 will be used to measure changes in area over time.

EXECUTIVE SUMMARY (CONTINUED)



MONITORING

Motupipi Estuary has been identified by TDC as a priority for monitoring, and is a key part of TDC's existing estuary monitoring programme being undertaken in a staged manner throughout the Nelson/Golden Bay region. Under this long term programme, TDC will undertake broad scale monitoring on a 5 yearly cycle (next scheduled for September 2012) to monitor and assess ongoing changes in broad scale substrate and vegetation in the Motupipi.

RECOMMENDED MANAGEMENT

Both the broad and fine scale monitoring results have reinforced the need for management of fine sediment and nutrient sources entering the estuary. In addition, the absence of a densely vegetated terrestrial buffer means the buffering function provided previously by the bush-covered margin has largely been lost, and, in conjunction with modification of the estuary margins, the capacity for the estuary to respond to key pressures such as sea level rise is greatly diminished. It is recommended that options be considered for the following (as identified in the estuary vulnerability assessment - Robertson & Stevens 2008):

Identify and Implement Catchment BMPs

- Catchment runoff was identified as one of the major stressors in the Motupipi with the likely ecological response one of lowered biodiversity and lowered aesthetic and human use values. To prevent avoidable inputs, best management practices (BMPs) should be identified and implemented to reduce sediment, nutrient and pathogen runoff from catchment "hotspots".

TDC and Landcare Research are currently working with farmers in the catchment to identify catchment nutrient sources and "hotspots", and to implement BMPs for reducing nutrient mobilisation and runoff to surface and groundwater.

Set Limits on Nutrient Inputs

- An increase in nuisance growths of macroalgae will result in reduced public amenity values, reduced biodiversity and increased sediment enrichment in the estuary. Because nutrient input was both high and strongly related to the eutrophication symptoms, it is recommended that catchment nutrient inputs be reduced and Total Daily Maximum Loads (TDMLs) set.

Reinstate Margin Buffer

- Historical clearance of bush around the terrestrial margin of the estuary means it is now dominated by grazed pasture. Additionally, there have been significant areas of saltmarsh drained and reclaimed for pastoral use, roading and the now closed Rototai landfill. This has almost certainly contributed to reduced biodiversity and increased sedimentation in the estuary. Many areas are also adversely affected by nuisance weeds. Because of the importance of a natural vegetated margin around the estuary, it is recommended that a management plan be developed to encourage its re-establishment.

Coastal Squeeze

- Sea level rise is a key estuary stressor. The ability of estuary vegetation to respond to sea level rise relies to a large extent on saltmarsh and terrestrial margin vegetation being able to migrate landward to maintain suitable growing conditions. In the Motupipi, migration is limited by reclamations, seawalls, causeways, flood controls, and by drainage of low-lying land (now mostly converted to pasture) resulting in coastal squeeze. Areas where coastal squeeze is likely to occur should be identified and used to guide existing revegetation efforts, and identify where future estuary expansion may need to be allowed for as a consequence of sea level rise.

1. INTRODUCTION

OVERVIEW

Developing an understanding of the condition and risks to coastal and estuarine habitats is critical to the management of biological resources. Since 2000, Tasman District Council (TDC) has been developing a long-term monitoring programme to assess the condition of key estuaries in its region using the National Estuary Monitoring Protocol (EMP) (Robertson et al. 2002). To date this has included the Ruataniwha, Waimea and Moutere Inlets and the Motueka Estuary.

More recently, the EMP approach has been extended (Table 1) to include various other components including an Ecological Vulnerability Assessment (Robertson & Stevens 2007a,b, Stevens & Robertson 2007a) to provide Councils with a better understanding of how estuary condition relates to monitoring and management requirements. The Ecological Vulnerability Assessment is a tool for identifying the vulnerability of an estuary to problems (Table 2), and priorities for monitoring and management.

In 2007, TDC added the Motupipi Estuary (Figure 1) in Golden Bay, to the estuary programme. The Motupipi programme consists of three components:

1. **Ecological Vulnerability Assessment** of the Motupipi Estuary to major issues and appropriate monitoring design with particular emphasis on:
   * upper estuary areas (including phytoplankton blooms) and,
   * nutrient and pathogen distributions throughout the estuary.

This component has been completed and is reported on in Robertson & Stevens (2008).

2. **Broad scale habitat mapping,** including historical comparisons (EMP approach). This component, which documents the key habitats within the estuary and establishes a baseline to assess changes to these habitats over time, is the subject of the current report.

3. **Fine scale physical, chemical and biological monitoring**, (EMP approach) including sedimentation plate deployment. This component, which provides detailed information on estuary condition, is reported separately in Robertson & Stevens (2008a)

The approach used for the 2007 broad scale habitat mapping focuses on documenting the location and type of dominant vegetation (e.g. saltmarsh, seagrass, macroalgae) and substrate (e.g. mud, sand, gravel) to provide baseline information on the key issues of habitat loss (saltmarsh and buffer vegetation), sedimentation (extent of soft mud), and eutrophication (macroalgal percent cover). It includes:

- Broad scale mapping of estuary sediment types.
- Broad scale mapping of saltmarsh vegetation.
- Broad scale mapping of macroalgal beds (i.e. *Ulva* (sea lettuce), *Gracilaria, Enteromorpha*).
- Broad scale mapping of seagrass (*Zostera*) beds.
- Broad scale mapping of the 200m terrestrial margin surrounding the estuary.
- Broad scale mapping of historical estuary vegetation using 1943 and 1984 aerial photos.

In addition, interim condition ratings described in Section 2 (see Robertson & Stevens, 2006, 2007), have been developed to evaluate the monitoring results.

Eastern arm of Motupipi Estuary

1. INTRODUCTION (CONTINUED)

Table 1. Extensions to the EMP (developed by Wriggle Coastal Management)

Extensions to Estuary Monitoring Protocol
Estuary Vulnerability Matrix.
Sedimentation rate measures (using plates buried in sediment).
Historical sedimentation rate measures (using radio-isotope ageing of sediment cores).
Percentage cover of macroalgae and seagrass (reported as separate GIS layers).
Broad scale mapping of the 200m terrestrial margin surrounding the estuary.
Condition ratings for key indicators.
Georeferenced digital photos (as a GIS layer).
Upper Estuary Monitoring and Assessment Protocol.

Table 2. Summary of the major issues affecting most NZ estuaries.

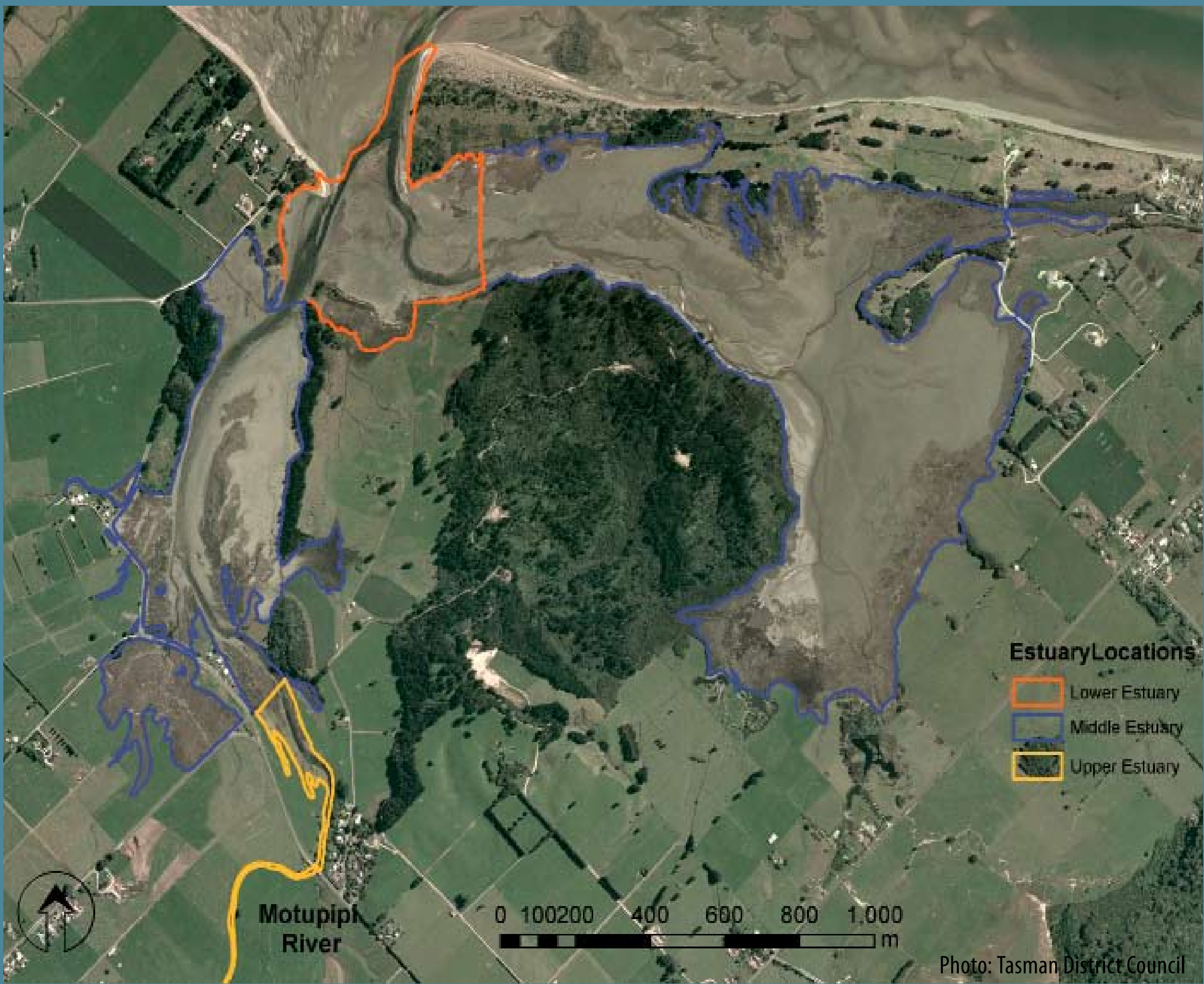
Issue	Impact
Sedimentation	If sediment inputs are excessive, they infill quickly with muds, reducing biodiversity and human values and uses.
Eutrophication	Eutrophication is an increase in the rate of supply of organic matter to an ecosystem. If nutrient inputs are excessive, they experience macroalgal and/or phytoplankton blooms, anoxic sediments, lowered biodiversity and nuisance effects for local residents.
Disease Risk	If pathogen inputs are excessive, the disease risk from bathing, wading or eating shellfish increases to unacceptable levels.
Toxins	If potentially toxic contaminant inputs (e.g. heavy metals, pesticides) are excessive, estuary biodiversity is threatened and shellfish and fish may be unsuitable for eating.
Habitat Loss	If habitats (such as saltmarsh) are lost or damaged through drainage, reclamation, building of structures, stock grazing or vehicle access, biodiversity and estuary productivity declines.
	If the natural terrestrial margin around the estuary is modified by forest clearance or degraded through such actions as roading, stormwater outfalls, property development and weed growth, the natural character is diminished and biodiversity reduced.

Table 3. Summary of the broad and fine scale EMP indicators.

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.
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 (calculated from ash free dry weight) in replicate samples from the upper 2cm of sediment.
Toxins	Contamination in Bottom Sediments	Chemical analysis of indicator metals (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.

REPORT STRUCTURE	The report is structured as follows: **Section 1** Introduction to the scope and structure of the study. **Section 2** Methods - broad scale mapping (substrate, saltmarsh, macroalgae, seagrass, terrestrial margin, historical aerial photos), and estuary condition ratings. **Section 3** Results and Discussion. **Section 4** Monitoring. **Section 5** Recommended Management. **Section 6** Acknowledgements. **Section 7** References. **Appendix 1:** Substrate and vegetation classification. ArcMap 9.2 GIS shapefiles summarised in the current report are provided on a separate CD.

Figure 1. Motupipi Estuary showing the location of the upper, middle and lower estuary areas.

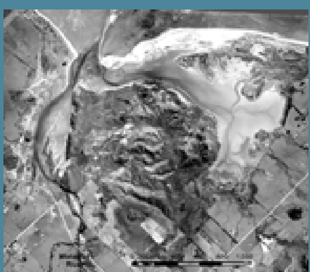


2. METHODS

BROAD SCALE HABITAT MAPPING

Bands of percentage cover used to classify macroalgae and seagrass.

>1 %
1-5%
5-10 %
10-20 %
20-50 %
50-80 %
80-100 %



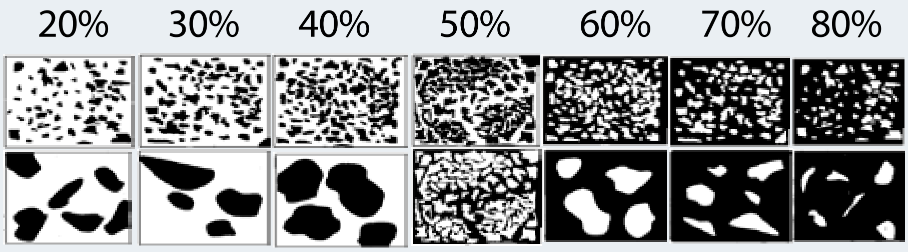
Broad-scale mapping is a method for describing habitat types based on the dominant surface features present (e.g. substrate: mud, sand, cobble, rock; or vegetation: seagrass, macroalgae, rushland, etc). It follows the EMP approach originally described for use in NZ estuaries by Robertson et al. (2002) 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 (ArcMap 9.2).

For the 2007 study, TDC supplied rectified 0.5m/pixel resolution colour aerial photos flown in 2004. Photos covering the estuary at a scale of 1:5,000 were laminated, and two scientists ground-truthed the spatial extent of dominant habitat and substrate types by walking the extent of the estuary recording features directly on the laminated aerial photos over two days (Sept. 26/27, 2007).

The percentage cover of intertidal macroalgae and seagrass within the estuary was visually classified into seven bands of percentage cover using a visual rating scale (see examples below and left) to describe macroalgae and seagrass density and distribution within the estuary.

Visual rating scale for percentage cover estimates



Sampling positions and photographs were georeferenced and the information collected was used to produce GIS-based habitat maps showing the following:

- Dominant substrate.
- Percent cover of dominant macroalgae (e.g. *Gracilaria, Enteromorpha*).
- Percent cover of dominant seagrass (*Zostera*).
- Dominant estuary vegetation.
- 200m wide terrestrial margin vegetation/landuse.
- Historical changes in dominant estuary vegetation.

Broad scale historical changes in estuary vegetation were assessed using 0.4m/pixel resolution black and white aerial photographs flown in 1984 and 1943. Historical mapping is limited to vegetation because it is not possible to reliably distinguish substrate types from the photographs, and relies on present day ground-truthed habitat features as a starting point to classify the dominant vegetation visible in the historic aerial photos.

2. METHODS (CONTINUED)

BROAD SCALE HABITAT MAPPING (CONTINUED)

Appendix 1 lists the class definitions used to classify substrate and vegetation. Vegetation was further 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).

Digital mapping

Results were entered by digitising features directly off aerial photos in the GIS using a Wacom Intuos3 electronic drawing tablet within ArcMap 9.2.

The spatial location, size, and type of broad scale habitat features in the lagoon are provided as ArcMap 9.2 GIS shapefiles on a separate CD. Georeferenced digital field photos (GPS-Photolink) are also supplied as a GIS layer.

As the GIS structure allows data to be easily managed, and contains a much greater level of detail than can be concisely presented in a summary report, the GIS should be used as the primary resource for assessing broad scale data. Results are summarised in the current report in Section 3.

CONDITION RATINGS

RATING
Very Good
Good
Fair
Poor
Early Warning Trigger

At present, there are no formal criteria for rating the overall condition of estuaries in NZ, and development of scientifically robust and nationally applicable condition ratings requires a significant investment in research and is unlikely to produce immediate answers.

Therefore, to help TDC interpret monitoring data, a series of interim broad scale estuary condition ratings have been proposed for the Motupipi Estuary (based on the ratings developed for Southland's estuaries - Robertson & Stevens 2006, 2007). The condition ratings are based on a review of monitoring data elsewhere in NZ, and expert opinion. They indicate whether monitoring results reflect healthy or degraded conditions, and also include an "early warning trigger" as an alert to any rapid or unexpected change. The condition ratings are designed to be used collectively rather than individually to evaluate estuary condition, with expert judgement used to determine overall estuary condition.

For each of the condition ratings, a recommended monitoring frequency is proposed and a recommended management response is suggested. This usually corresponds to 5 yearly monitoring using the EMP where estuary conditions are good, and initiation of an evaluation and response plan to further evaluate an issue and consider what response actions may be appropriate if conditions are degraded.

At this stage, the interim condition ratings reflect the best guidance able to be provided with the available information and budget. It is expected that the proposed ratings will continue to be revised and updated as better information becomes available. The interim broad scale condition ratings for Motupipi Estuary, are presented below along with a brief rationale for their use.

2. METHODS (CONTINUED)

Soft Mud Percent Cover

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

SOFT MUD PERCENT COVER CONDITION RATING		
RATING	DEFINITION	RECOMMENDED RESPONSE
Very Low	<2% of estuary substrate is soft mud	Monitor at 5 year intervals after baseline established
Low	2%-5% of estuary substrate is soft mud	Monitor at 5 year intervals after baseline established
Moderate	5%-15% of estuary substrate is soft mud	Monitor 5 yearly. Initiate Evaluation & Response Plan
High	>15% of estuary substrate is soft mud	Monitor 5 yearly. Initiate Evaluation & Response Plan
Early Warning Trigger	>5% of estuary substrate is soft mud	Initiate Evaluation and Response Plan

Soft Mud 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 CONDITION RATING		
RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	Area of cover (ha) not increasing	Monitor at 5 year intervals after baseline established
Good	Increase in area of cover (ha) <5% from baseline	Monitor at 5 year intervals after baseline established
Fair	Increase in area of cover (ha) 5-15% from baseline	Monitor 5 yearly. Initiate Evaluation & Response Plan
Poor	Increase in area of cover (ha) >15% from baseline	Monitor 5 yearly. Initiate Evaluation & Response Plan
Early Warning Trigger	Trend of increase in area of cover (ha)	Initiate Evaluation and Response Plan

Macroalgae Percent Cover

Certain types of macroalgae can grow to nuisance levels in nutrient-enriched estuaries causing sediment deterioration, oxygen depletion, bad odours and adverse impacts to biota.

MACROALGAE PERCENT COVER CONDITION RATING		
RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	%cover <1%. No nuisance conditions	Monitor at 5 year intervals after baseline established
Good	%cover 1-10%. No nuisance conditions	Monitor at 5 year intervals after baseline established
Fair	%cover 10-50%. Isolated nuisance conditions	Monitor yearly. Initiate Evaluation & Response Plan
Poor	%cover >50%. Widespread nuisance conditions	Monitor yearly. Initiate Evaluation & Response Plan
Early Warning Trigger	Trend of % cover increasing	Initiate Evaluation and Response Plan

Seagrass Percent Cover

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

SEAGRASS PERCENT COVER CONDITION RATING		
RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	Area of cover (ha) not declining	Monitor at 5 year intervals after baseline established
Good	Decline in area of cover (ha) <5% from baseline	Monitor at 5 year intervals after baseline established
Fair	Decline in area of cover (ha) 5-20% from baseline	Monitor 5 yearly. Initiate Evaluation & Response Plan
Poor	Decline in area of cover (ha) >20% from baseline	Monitor 5 yearly. Initiate Evaluation & Response Plan
Early Warning Trigger	Trend of decline in area of cover (ha)	Initiate Evaluation and Response Plan

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.

SALTMARSH PERCENT COVER CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very High	>20% of estuary area is saltmarsh	Monitor at 5 year intervals after baseline established
High	10%-20% of estuary area is saltmarsh	Monitor at 5 year intervals after baseline established
Moderate	5%-10% of estuary area is saltmarsh	Monitor at 5 year intervals after baseline established
Low	2%-5% of estuary area is saltmarsh	Monitor 5 yearly. Initiate Evaluation & Response Plan
Very Low	<2% of estuary area is saltmarsh	Monitor 5 yearly. Initiate Evaluation & Response Plan
Early Warning Trigger	<5% of estuary area is saltmarsh	Initiate Evaluation and Response Plan

Saltmarsh 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. Decreases in saltmarsh extent is likely to indicate an increase in these types of pressures.

SALTMARSH AREA CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	Area of cover (ha) not decreasing	Monitor at 5 year intervals after baseline established
Good	Decline in area of cover (ha) <5% from baseline	Monitor at 5 year intervals after baseline established
Fair	Decline in area of cover (ha) 5-20% from baseline	Monitor 5 yearly. Initiate Evaluation & Response Plan
Poor	Decline in area of cover (ha) >20% from baseline	Monitor 5 yearly. Initiate Evaluation & Response Plan
Early Warning Trigger	Trend of decrease in area of cover (ha)	Initiate Evaluation and Response Plan

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.

TERRESTRIAL VEGETATED BUFFER PERCENT COVER CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very High	80%-100% cover of terrestrial vegetated buffer	Monitor at 5 year intervals after baseline established
High	50%-80% cover of terrestrial vegetated buffer	Monitor at 5 year intervals after baseline established
Fair	25%-50% cover of terrestrial vegetated buffer	Monitor 5 yearly. Initiate Evaluation & Response Plan
Poor	5%-25% cover of terrestrial vegetated buffer	Monitor 5 yearly. Initiate Evaluation & Response Plan
Early Warning Trigger	<50% cover of terrestrial vegetated buffer	Initiate Evaluation and Response Plan

Terrestrial Vegetated Buffer 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 CONDITION RATING

RATING	DEFINITION	RECOMMENDED RESPONSE
Very Good	Terrestrial buffer is 100% dense vegetation	Monitor at 5 year intervals after baseline established
Good	Decline in vegetated buffer (ha) <5% from baseline	Monitor at 5 year intervals after baseline established
Fair	Decline in vegetated buffer (ha) 5-10% from baseline	Monitor 5 yearly. Initiate Evaluation & Response Plan
Poor	Decline in vegetated buffer (ha) >10% from baseline	Monitor 5 yearly. Initiate Evaluation & Response Plan
Early Warning Trigger	Trend of decrease in area of vegetated buffer (ha)	Initiate Evaluation and Response Plan

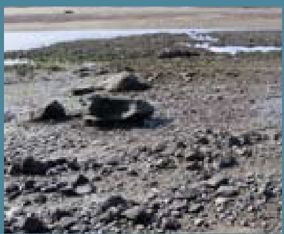
3. RESULTS AND DISCUSSION

OVERVIEW

This results and discussion section is subdivided into summaries of the different broad scale GIS layers that have been mapped: substrate, seagrass, macroalgae, vegetation (including historical changes from 1943 and 1984), and the 200m terrestrial margin. In addition, summary information has been reported for the upper, middle and lower parts of the of Motupipi Estuary to enable spatial differences to be discussed. Following the general overview of results, condition ratings are used to assess the key estuary issues being addressed by the broad scale monitoring (sedimentation, eutrophication, and habitat loss).

SUBSTRATE

Broad sand flats in the eastern arm.



Mixed substrate in the lower estuary.

Very soft mud in the middle western arm.

River dominated upper estuary.

The unvegetated intertidal substrate of the Motupipi Estuary is summarised in Table 4 and Figure 2. Overall the estuary was dominated by a mix of sand and firm mud/sand (51%), and soft and very soft mud (43%).

Clear differences were evident in the substrates within the eastern and western arms of the estuary. The eastern arm was dominated by extensive sand flats, with a varied mix of substrates including oyster reef, rock, gravel, cobble and mobile sand present in the lower estuary and around the mouth. No very soft mud areas were recorded, although soft muds were present in the upper southern and eastern reaches. While small in total area, reefs formed by the introduced Pacific oyster were changing the nature of the lower estuary by trapping fine sediments, creating substrate for macroalgae, and adversely impacting on human use of the estuary.

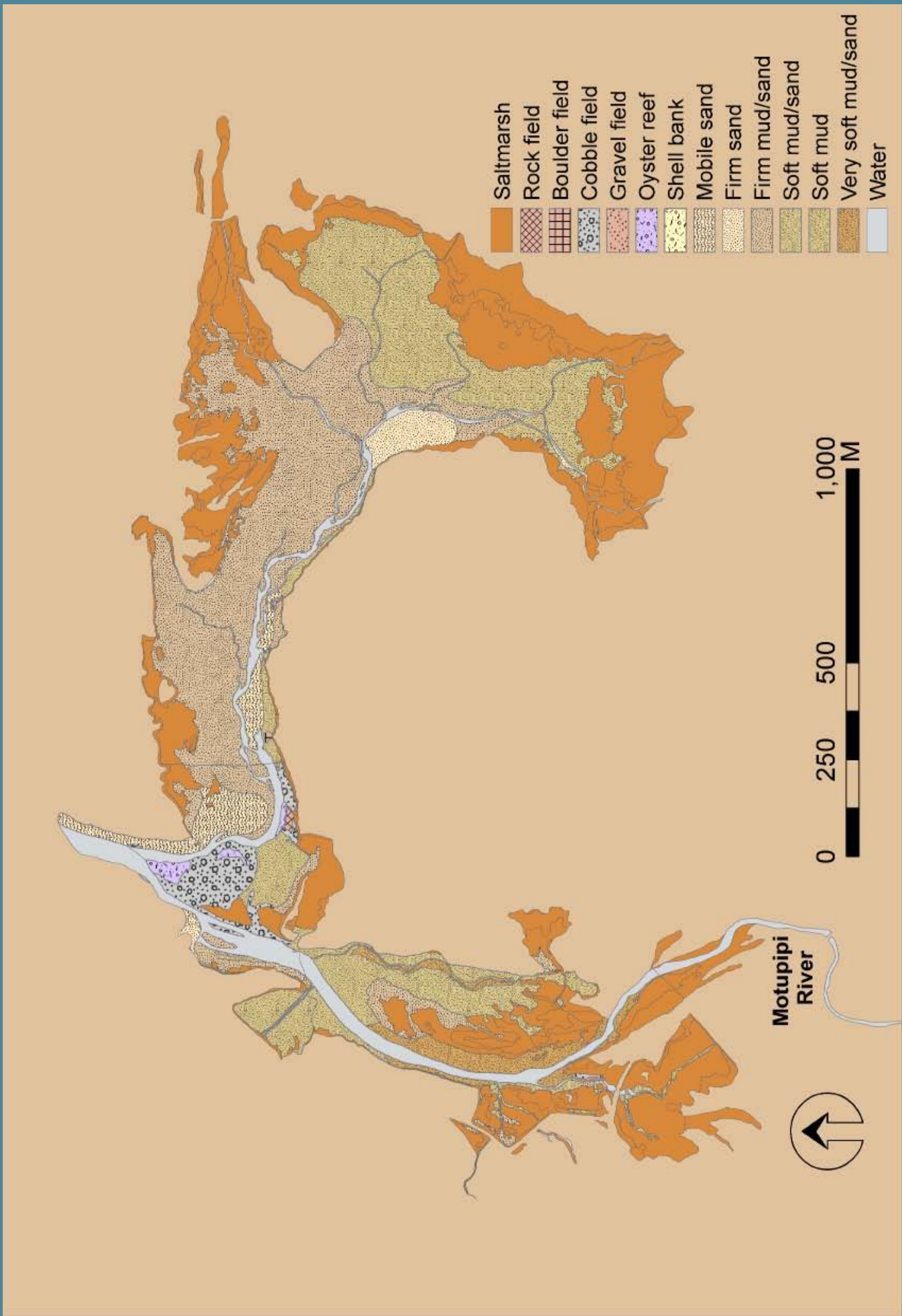
In contrast to the east, the western arm was smaller and much muddier, with widespread soft mud in the middle estuary, and very soft muds along the banks of the Motupipi River. Firm mud/sand areas were relatively small and located at high tidal elevations in the central part of the middle estuary, and near the estuary mouth.

The upper estuary is predominantly subtidal (subtidal substrate is not included in the EMP mapping) with only small intertidal areas of soft mud and cobble habitat.

Table 4. Summary of dominant surface substrate, September 2007.

Estuary Location	Lower		Middle (West)		Middle (East)		Upper		TOTAL	
Area	ha	%	ha	%	ha	%	ha	%	ha	%
Artificial Structure	0.04	0.3	0.05	0.3	0.02	0.0			0.10	0.1
Rockfield	0.13	1.0			0.06	0.1			0.19	0.2
Boulderfield					0.04	0.1			0.04	0.1
Cobblefield	3.75	27.6	0.12	0.7	0.00	0.0			3.87	4.5
Gravelfield			0.02	0.1					0.02	0.0
Oyster reef	0.70	5.1							0.70	0.8
Shellbank					0.01	0.0			0.01	0.0
Mobile Sand	3.26	24.0			1.27	2.3			4.53	5.3
Firm Sand	0.19	1.4			2.51	4.6			2.71	3.2
Firm Mud/Sand	3.25	23.9	1.93	11.4	31.22	56.7			36.56	42.6
Soft Mud/Sand	0.01	0.1			1.13	2.1			1.14	1.3
Soft Mud	2.24	16.5	10.42	61.4	18.83	34.2			31.49	36.7
Very Soft Mud			4.42	26.1			0.01	100	4.43	5.2
TOTAL	13.6	100	17.0	100	55.1	100	0.0	100	85.8	100

Figure 2. Map of Dominant Surface Sediments - Motupipi Estuary, September 2007.



3. RESULTS AND DISCUSSION (CONTINUED)

SEAGRASS

Seagrass (*Zostera muelleri*) is highly valued ecologically for its multiple roles in primary production, nutrient cycling, sediment stabilisation, and as a feeding and nursery area for fish and invertebrates. Seagrass meadows are also a major source of detrital material, and the bacteria and fungi that decompose this material provide a food source for zooplankton, worms, etc. which are the base of the predatory food web. Seagrass is also an important forerunner to the establishment of saltmarsh on tidal flats, and grows subtidally where water clarity allows light to penetrate to it.

Table 5 and Figure 3 summarise the results of seagrass mapping within Motupipi Estuary and provide a baseline for comparing future changes using the Condition Ratings proposed in Section 2.

Table 5. Summary of intertidal seagrass cover results, September 2007.

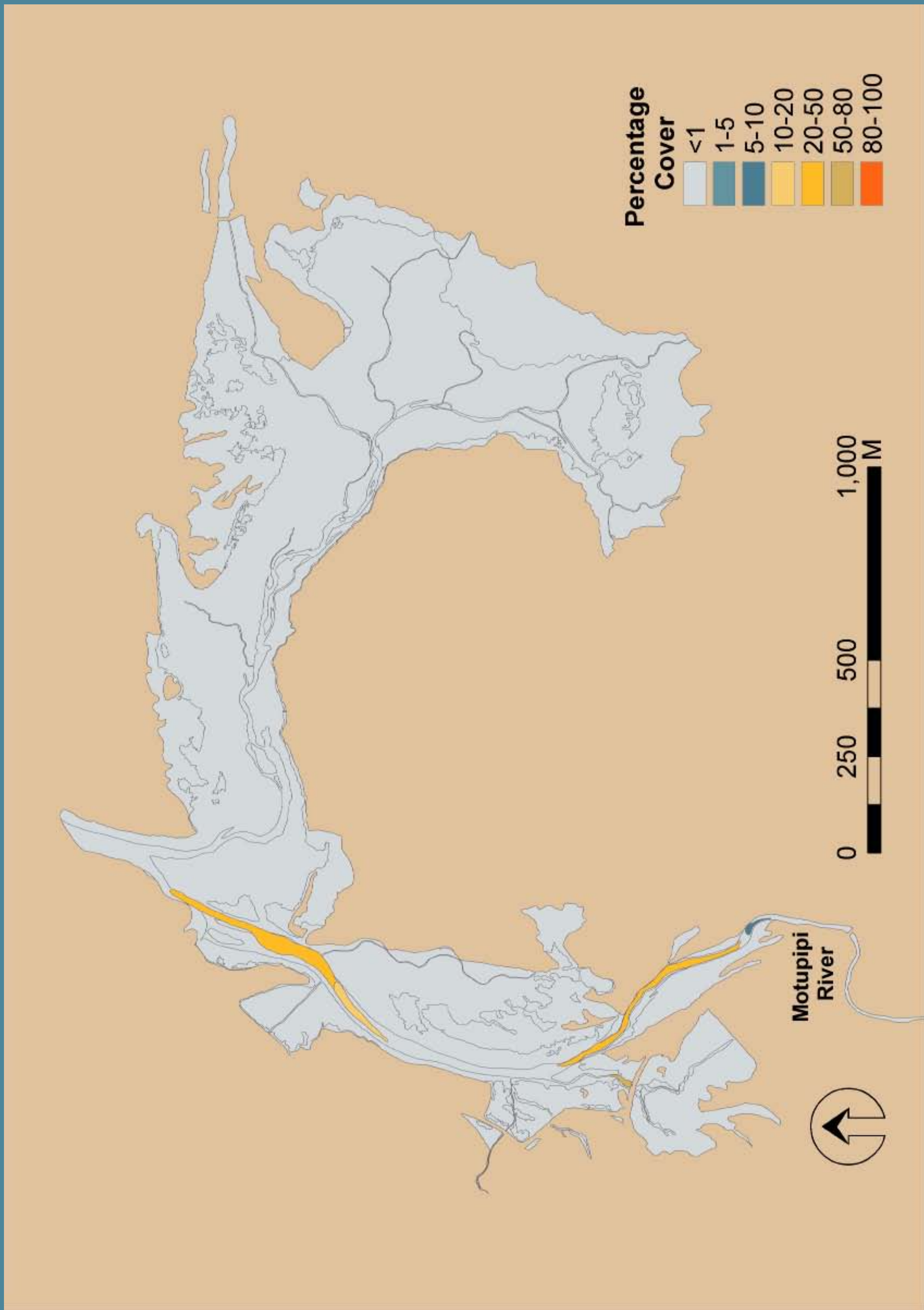
Percent Cover Rating and Category		Area (ha)	Percentage
Very low	<1%	95.71	97.5
Low	1-5%	0	0
Low Low-Moderate	5-10%	0.06	0.1
Low-Moderate	10-20%	0.32	0.3
Moderate	20-50%	2.01	2.0
High	50-80%	0.07	0.1
Very High	>80%	0	0
TOTAL		**98.17**	**100**

Overall, 2.5ha of seagrass was present with a >1% cover in the Motupipi Estuary, and all of this was located in the middle and upper estuary areas of the western arm along the edge of the Motupipi River. Where present, densities were mostly in the moderate category (20-50% cover), with fronds generally lush and long.

Uncommon for the upper reaches of NZ estuaries, extensive subtidal beds were present (see photos below). This is likely to be due to the largely spring fed Motupipi River providing relatively clear and stable flows enabling the seagrass to thrive in the upper estuary.

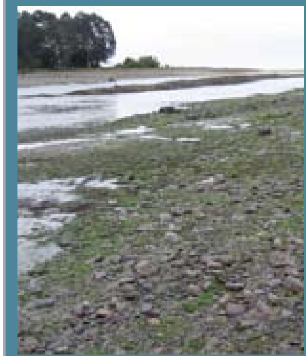
Examples of *Zostera* in the upper Motupipi Estuary

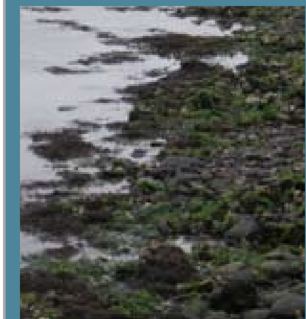
Figure 3. Map of Seagrass Cover - Motupipi Estuary, September 2007.

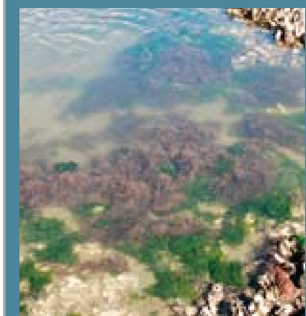


3. RESULTS AND DISCUSSION (CONTINUED)

MACROALGAE







***Gracilaria* and *Enteromorpha* in the lower Motupipi Estuary.**

Estuary eutrophication can result in regular macroalgal blooms. These can deprive seagrass areas of light causing their eventual decline, while decaying macroalgae can accumulate on shorelines causing depletion of sediment dissolved oxygen and nuisance odours.

Table 6 and Figure 4 summarise the results of macroalgal mapping within Motupipi Estuary and provide a baseline for comparing future changes using the Condition Ratings proposed in Section 2.

Table 6. Summary of intertidal macroalgal cover results, September 2007.

Percent Cover Rating and Category		Area (ha)	Percentage	Dominant Species
Very low	<1%	93.1	94.8	-
Low	1-5%	0.7	0.7	*Ulva, Gracilaria*
Low Low-Moderate	5-10%	0.5	0.6	*Enteromorpha*
Low-Moderate	10-20%	0.3	0.3	*Ulva, Gracilaria*
Moderate	20-50%	3.6	3.6	*Gracilaria, Ulva*
High	50-80%	0.07	0.1	*Enteromorpha*
Very High	>80%	0	0	-
TOTAL		**98.2**	**100**	

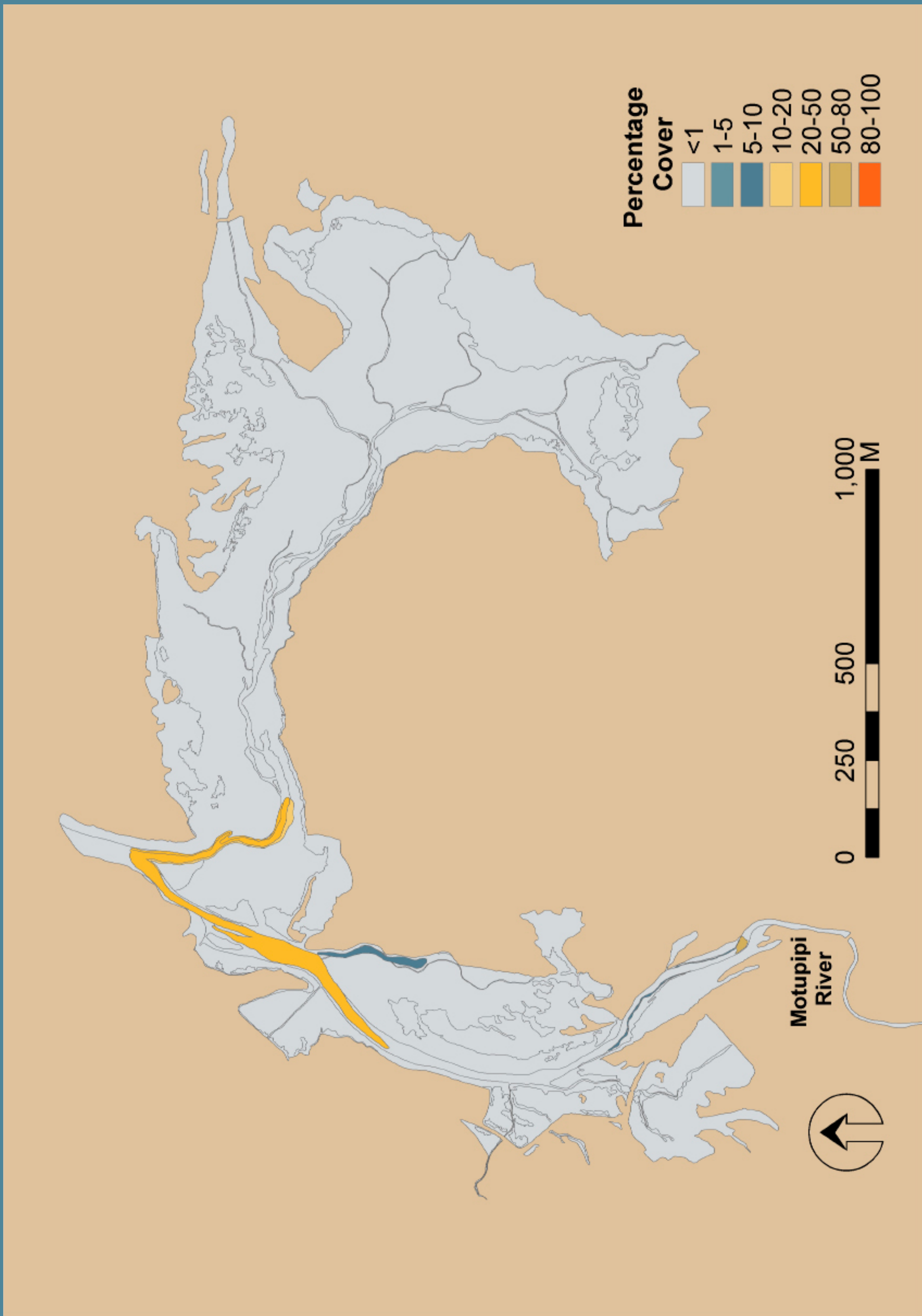
Macroalgal growth was confined to mid to low intertidal areas in the western arm and the lower estuary. In total, macroalgae covered 5.1ha, mostly as a moderate cover. Areas dominated by *Gracilaria* were most extensive (3.6ha) and were concentrated in the low tide channels at the edge of the Motupipi River. *Enteromorpha* was commonly present with *Gracilaria* (see photos in left margin)

In the upper estuary *Enteromorpha* dominated and was present in high densities (50-80% cover), commonly covering rocks and cobbles in riffle zones, and elsewhere in narrow bands along the edge of the river (see photos below).

Sea lettuce (*Ulva*) growth was dominant only in the lower part of the eastern arm and at relatively low densities in a thin band along the edge of the low tide channel.

***Enteromorpha* in the middle and upper reaches of the western arm of the Motupipi Estuary.**

Figure 4. Map of Macroalgal Cover - Motupipi Estuary, September 2007.

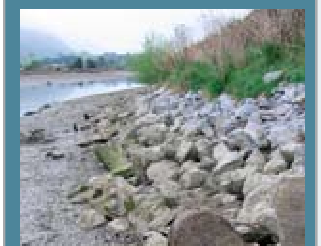


VEGETATION

Rushland in the eastern arm.

Herbfield (glasswort - *Sarcocornia quinqueflora*).

Winter die-off of three square (*Schoenoplectus pungens*).



Rockwall bordering the closed Rototai landfill.

Raised banks of the river dominated upper estuary.

Vegetation is summarised in Table 7 with the broad vegetation class and species composition of the estuary shown in Figures 5 and 6 respectively. Overall saltmarsh (estuarine vegetation able to tolerate saline conditions and where terrestrial plants are unable to survive) covered 39% of the Motupipi Estuary, which is high compared to other estuaries around NZ. Rushland dominated (43ha) - mainly searush *Juncus kraussii* and, to a lesser extent, jointed wire rush *Leptocarpus (Apodasmia) similis* - followed by herbfield (9ha), sedge (5ha), and estuarine shrub (4ha).

The most diverse and extensive saltmarsh was located in the eastern arm of the estuary which included, rush, sedge, herb, shrub, tussock, scrub, grass, and reed communities. Along the estuary site of the barrier spit, extensive *Sarcocornia* (glasswort) dominated herbfields (4.5ha) had established, while rushland in this area was generally in firm sand with a range of herbfield plants present as subdominant species within it. In contrast, the wide rushland beds within the upper reaches of the eastern arm generally had few other species growing within them and grew in soft muds. Large beds of the sedge three square (*Schoenoplectus pungens*) which die back in winter were also present at the seaward edge of rushland in the upper reaches. The southern side of the eastern arm, which rises steeply to surrounding hillside, had only a narrow strip of saltmarsh along the estuary edge.

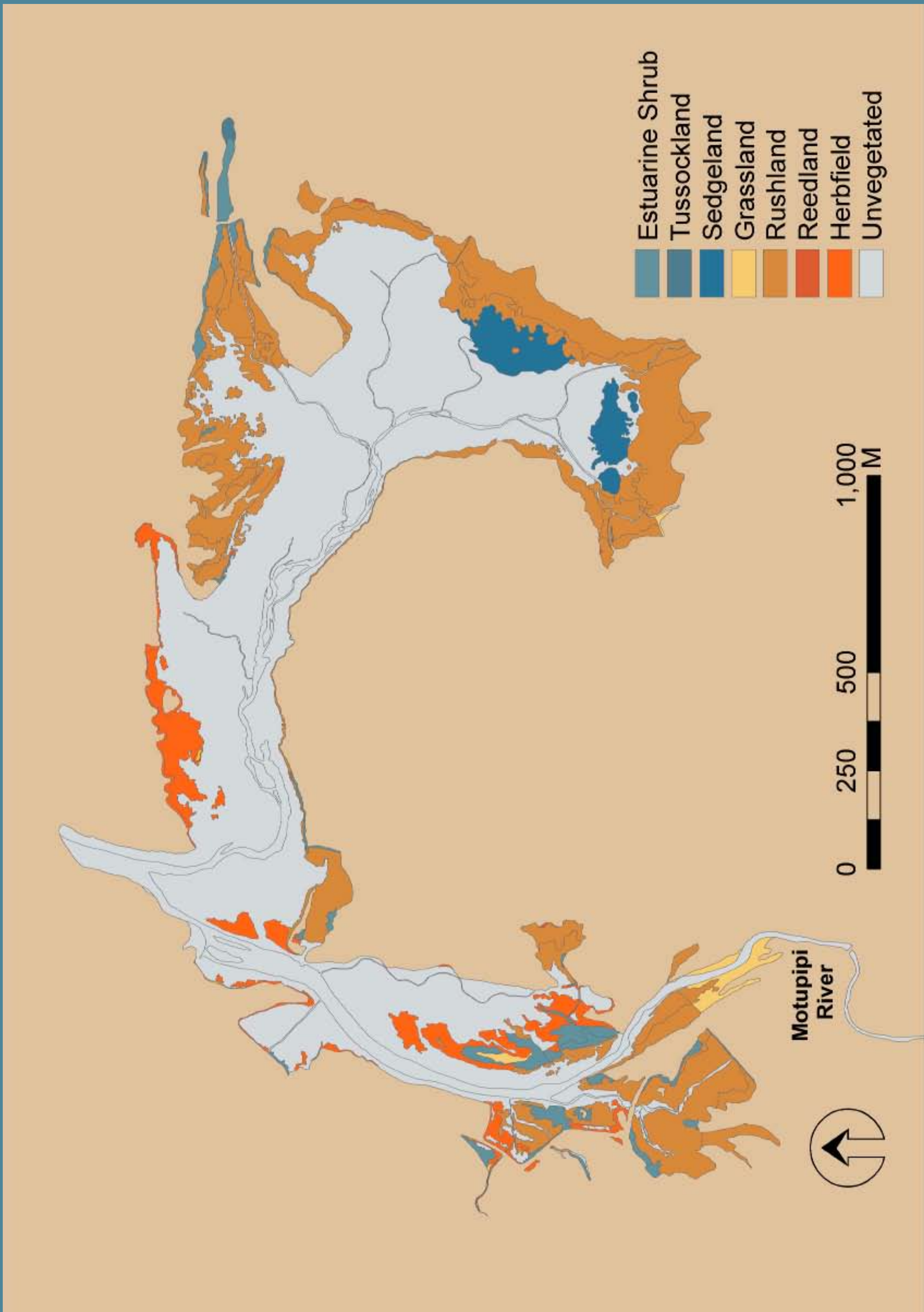
In contrast to the relatively well vegetated eastern arm, the middle and lower sections of the western arm had only small and narrow areas of herbfield dominated saltmarsh. This is mainly attributable to past draining and reclamation of rushland habitat along the western edge of the estuary margin, with hardfill or rockwalls flanking much of the road, and surrounding the closed Rototai landfill. Further up the western arm, saltmarsh was well established in a sequence from herbfield through rushland to estuarine shrubs, then grazed pasture.

The upper estuary is river dominated with little intertidal habitat. The adjacent estuarine saltmarsh and grassland is present on the raised banks of the river/estuary.

Table 7. Summary of broad scale vegetation mapping, September 2007.

Estuary Location	Lower		Middle (West)		Middle (East)		Upper		TOTAL	
Area	ha	%	ha	%	ha	%	ha	%	ha	%
Vegetated	3.81	17.6	18.88	47.8	38.02	39.5	1.49	52.3	62.2	38.8
Scrub			0.17	0.4	0.10	0.1			0.27	0.2
Estuarine Shrub	0.25	1.2	2.9	7.3	1.34	1.4			4.49	2.8
Tussockland					0.21	0.2			0.21	0.1
Sedgeland					4.53	4.7			4.53	2.8
Grassland			0.22	0.6	0.07	0.1	1.25	44.0	1.54	1.0
Rushland	1.87	8.6	11.45	29.0	29.0	30.1	0.24	8.3	42.6	26.5
Reedland			0.02	0.0	0.06	0.1			0.08	0.0
Herbfield	1.69	7.8	4.13	10.4	2.70	2.8			8.52	5.3
Unvegetated	17.9	82.3	20.6	52.2	58.4	60.5	1.4	47.7	98.2	61.2
Unvegetated substrate	13.6	62.6	17.1	43.2	55.1	57.2	0.01	0.2	85.8	53.5
Water	4.3	19.7	3.6	9.0	3.2	3.3	1.4	47.4	12.4	7.7
Total	21.6	100	39.5	100	96.4	100	2.8	100	160.4	100

Figure 5. Map of Saltmarsh Vegetation Class - Motupipi Estuary, September 2007.



At a species level, some key features are evident. Among the herbfield species, the introduced iceplant (*Carpobrotus edulis*) is widespread throughout the lower reaches of the estuary and, particularly along the estuary side of the barrier spit, has established at the upper margins of the estuary and is competing with native herbfield species (the bright green plant in the photo below). Seaward of these, wide salt meadows dominated by *Sarcocornia* (glasswort) have established on raised flats.

Elsewhere, the vegetation reflects that commonly found in other estuaries in Golden Bay and in similar estuaries elsewhere in NZ. The upper reaches are dominated by saltmarsh ribbonwood, with introduced weeds including gorse, broom, blackberry and introduced grasses common at the terrestrial fringe. Progressing down the shore, stands of rushes dominate forming dense vegetated buffers between the terrestrial edge of the estuary and the unvegetated intertidal flats. These beds trap and retain sediment and, as such, substrate levels are likely to rise over time. As the sediment height increases, the corresponding reduction in saline influence will increase susceptibility to the spread of invasive weeds, something already evident along the upper edge of the saltmarsh in many places.

3. RESULTS AND DISCUSSION (CONTINUED)

VEGETATION (CONTINUED)

An important feature of the seaward margin of the estuary is the barrier spit and associated duneland. The barrier spit gives the estuary vital protection from the impacts of coastal storms and erosion by dissipating wave energy, with the duneland trapping and resupplying sand to the beach as part of this process. In addition the duneland provides feeding, breeding, nesting, nursery, and resting habitat for a large variety of birds and other wildlife.

The Motupipi barrier spit and associated duneland has increased notably in size over the past 60 years (Figure 6), predominantly as a seaward migration of the dune (shown in Figures 10, 11, and 12). Coinciding with this change has been the closure of the previous estuary entrance at the western end of the golf course.

Dune vegetation is dominated by the introduced sand binding marram grass (*Ammophila arenaria*), although native sand binders pingao (*Desmoschoenus spiralis*) and kowhangatara (*Spinifex sericeus*) have been reintroduced to the dune.

The dune also supports a range of native and introduced scrub/shrub/forest species evident in discrete bands of vegetation present across the dune (see photo below and Figure 12.), with parts of the inland dune now very much terrestrial in nature.

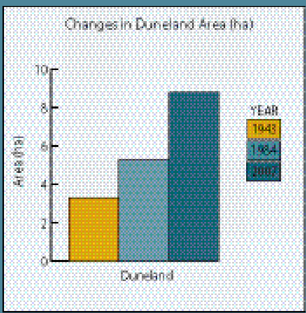


Figure 6. Change in Duneland area (ha): 1943, 1984, 2007.

HISTORICAL VEGETATION MAPPING

Broad scale vegetation present in 1943, 1984, and 2007 is summarised in Table 8 and in Figures 7, 8, and 9, while Figures 10 and 11 show the historical photographs used to map features from 1943 and 1984, along with habitat maps of the dominant vegetation classes.

Overall, the estuary has consistently decreased in size since 1943 (Figure 7). Vegetated areas have declined the most, while unvegetated areas have shown little change since 1984, corresponding to an increase in the percentage of the estuary that is now unvegetated (Figure 8). Figures 10 and 11 show the biggest changes have occurred in the northwest where the estuary has been drained and/or reclaimed for pasture, roading and the Rototai landfill; and in the northeast following development of the golf course. In conjunction with these large changes, many smaller areas of saltmarsh around the estuary margins have also been modified through channelling of water courses, infilling, grazing, and removal of the vegetated terrestrial buffer.

The biggest decrease has been saltmarsh vegetation (23ha, 27%), predominantly through losses of rushland (18.6ha, 31% reduction) and estuarine shrub (3.1ha, 41% reduction), and small losses of sedgeland and herbfield. Most of the change (21ha) occurred between 1943 and 1984, with only small overall loss of saltmarsh (2.5ha) since 1984 (Figure 9). While rushland beds generally appear very stable (1943 beds are still clearly distinguishable in 2007), some seaward expansion of rushland is evident. Consequently, the loss of rushland along the terrestrial margin will be larger than the overall figures indicate.

There is also a trend of slight increases in terrestrial/freshwater classes (grassland, tussockland, reedland) which reflect both the past modifications to the estuary and margins, but is also an artefact of the greater detail included in the ground-truthing of the 2007 photos.

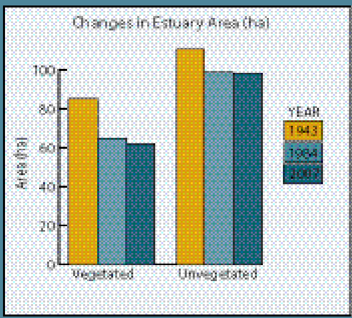


Figure 7. Change in estuary area (ha): 1943, 1984, 2007.

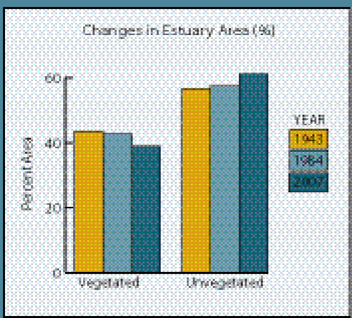


Figure 8. Percent change in estuary area: 1943, 1984, 2007.

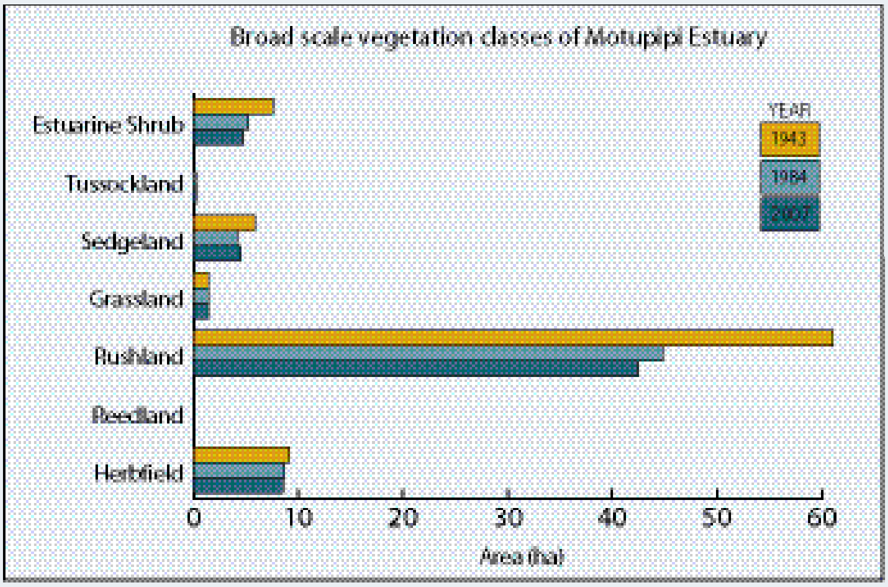
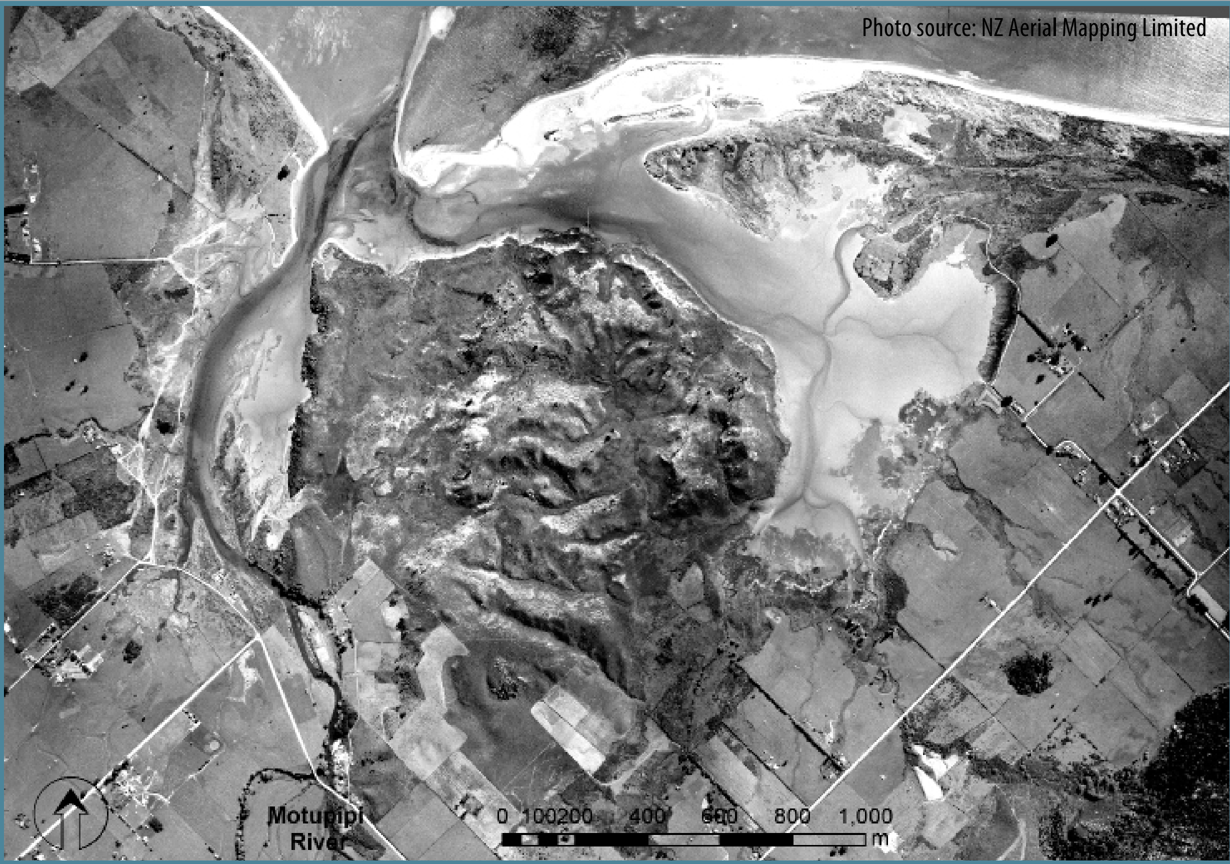


Figure 9. Change in broad scale vegetation class (ha): 1943, 1984, 2007.

Table 8. Summary of Broad Scale Vegetation of the Motupipi Estuary for 1943, 1984 and 2007.

Class	Dominant Species	Primary subdominant sp.	1943		1984		2007	
			Area (Ha)	% area	Area (Ha)	% area	Area (Ha)	% area
Scrub			-	-	0.3	0.2	0.3	0.2
	Ulex europaeus				*0.1*	*0.1*	*0.1*	*0.08*
	Ulex europaeus	*Isolepis nodosa*			*0.1*	*0.05*	*0.1*	*0.04*
	Ulex europaeus	*Plagianthus divaricatus*			*0.1*	*0.05*	*0.1*	*0.05*
Estuarine Shrub			7.6	3.9	4.9	3.0	4.5	2.8
	Plagianthus divaricatus		*1.3*	*0.7*	*0.7*	*0.4*	*0.7*	*0.4*
	Plagianthus divaricatus	*Festuca arundinacea*					*0.1*	*0.1*
	Plagianthus divaricatus	*Juncus kraussii*	*1.2*	*0.6*	*0.4*	*0.3*	*0.4*	*0.2*
	Plagianthus divaricatus	*Leptocarpus similis*	*4.5*	*2.3*	*2.6*	*1.6*	*2.2*	*1.4*
	Plagianthus divaricatus	*Muehlenbeckia complexa*					*0.1*	*0.1*
	Plagianthus divaricatus	*Phormium tenax*			*0.1*	*0.1*	*0.1*	*0.1*
	Plagianthus divaricatus	*Sarcocornia quinqueflora*	*0.6*	*0.3*	*0.6*	*0.4*	*0.6*	*0.4*
	Plagianthus divaricatus	*Ulex europaeus*			*0.4*	*0.3*	*0.4*	*0.2*
Tussockland			-	-	0.2	0.1	0.2	0.1
	Phormium tenax				*0.2*	*0.1*	*0.2*	*0.1*
Sedgeland			5.9	3.0	4.1	2.5	4.5	2.8
	Schoenoplectus pungens		*5.9*	*3.0*	*4.1*	*2.5*	*4.5*	*2.8*
Grassland			1.4	0.7	1.5	0.9	1.5	0.9
	Festuca arundinacea				*0.0*	*0.0*	*0.01*	*0.0*
	Festuca arundinacea	*Juncus kraussii*	*0.2*	*0.1*	*1.3*	*0.8*	*0.3*	*0.2*
	Festuca arundinacea	*Leptocarpus similis*	*1.2*	*0.6*			*1.0*	*0.6*
	Festuca arundinacea	*Plagianthus divaricatus*			*0.2*	*0.1*	*0.2*	*0.1*
Rushland			61.1	31.2	44.8	27.4	42.5	26.5
	Juncus kraussii		*15.9*	*8.1*	*24.1*	*14.8*	*23.3*	*14.5*
	Juncus kraussii	*Carpobrotus edulis*			*0.1*	*0.0*	*0.2*	*0.1*
	Juncus kraussii	*Leptocarpus similis*	*22.8*	*11.6*	*6.3*	*3.8*	*6.0*	*3.7*
	Juncus kraussii	*Plagianthus divaricatus*	*4.5*	*2.3*	*3.1*	*1.9*	*3.1*	*1.9*
	Juncus kraussii	*Samolus repens*			*0.1*	*0.1*		
	Juncus kraussii	*Sarcocornia quinqueflora*	*2.6*	*1.3*	*0.3*	*0.2*	*0.3*	*0.2*
	Juncus kraussii	*Typha orientalis*			*0.4*	*0.2*	*0.4*	*0.2*
	Leptocarpus similis		*2.8*	*1.4*	*2.1*	*1.3*	*2.1*	*1.3*
	Leptocarpus similis	*Juncus kraussii*	*11.0*	*5.6*	*8.1*	*5.0*	*7.0*	*4.4*
	Leptocarpus similis	*Plagianthus divaricatus*	*1.4*	*0.7*	*0.0*	*0.0*	*0.05*	*0.0*
	Leptocarpus similis	*Samolus repens*			*0.2*	*0.1*	*0.2*	*0.1*
Reedland			0.0	0.0	0.1	0.0	0.1	0.1
	Typha orientalis		*0.0*	*0.0*	*0.0*	*0.0*	*0.02*	*0.0*
	Typha orientalis	*Phormium tenax*			*0.1*	*0.0*	*0.1*	*0.1*
Herbfield			9.2	4.7	8.7	5.3	8.5	5.3
	Carpobrotus edulis				*0.1*	*0.1*	*0.1*	*0.1*
	Carpobrotus edulis	*Muehlenbeckia complexa*					*0.3*	*0.0*
	Carpobrotus edulis	*Sarcocornia quinqueflora*					*0.003*	*0.0*
	Samolus repens	*Selliera radicans*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
	Sarcocornia quinqueflora		*6.8*	*3.5*	*3.5*	*2.1*	*3.4*	*2.1*
	Sarcocornia quinqueflora	*Juncus kraussii*	*1.9*	*0.9*	*0.6*	*0.3*	*0.5*	*0.3*
	Sarcocornia quinqueflora	*Leptocarpus similis*	*0.4*	*0.2*	*0.2*	*0.1*	*0.2*	*0.1*
	Sarcocornia quinqueflora	*Plagianthus divaricatus*			*0.1*	*0.1*	*0.1*	*0.1*
	Sarcocornia quinqueflora	*Selliera radicans*			*0.5*	*0.3*	*0.5*	*0.3*
	Sarcocornia quinqueflora	*Suaeda novae-zelandiae*			*3.2*	*2.0*	*3.2*	*2.0*
	Suaeda novae-zelandiae	*Carpobrotus edulis*			*0.4*	*0.3*	*0.4*	*0.2*
Unvegetated substrate			110.4	56.5	98.6	57.4	98.2	61.2
Grand Total			**195.6**	**100**	**163.2**	**100**	**160.4**	**100**

Figure 10. 1943 aerial photograph of Motupipi Estuary (top) and broad scale estuary vegetation (bottom).



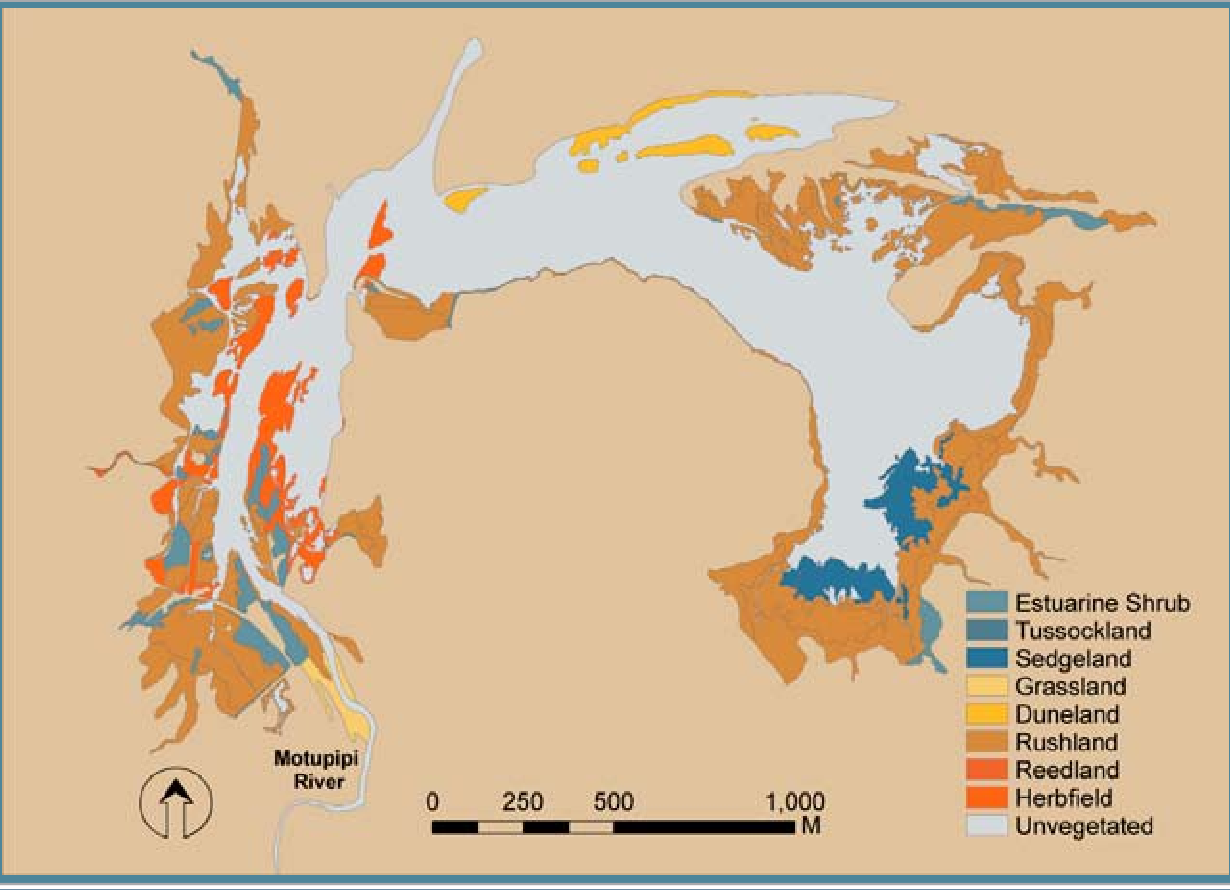
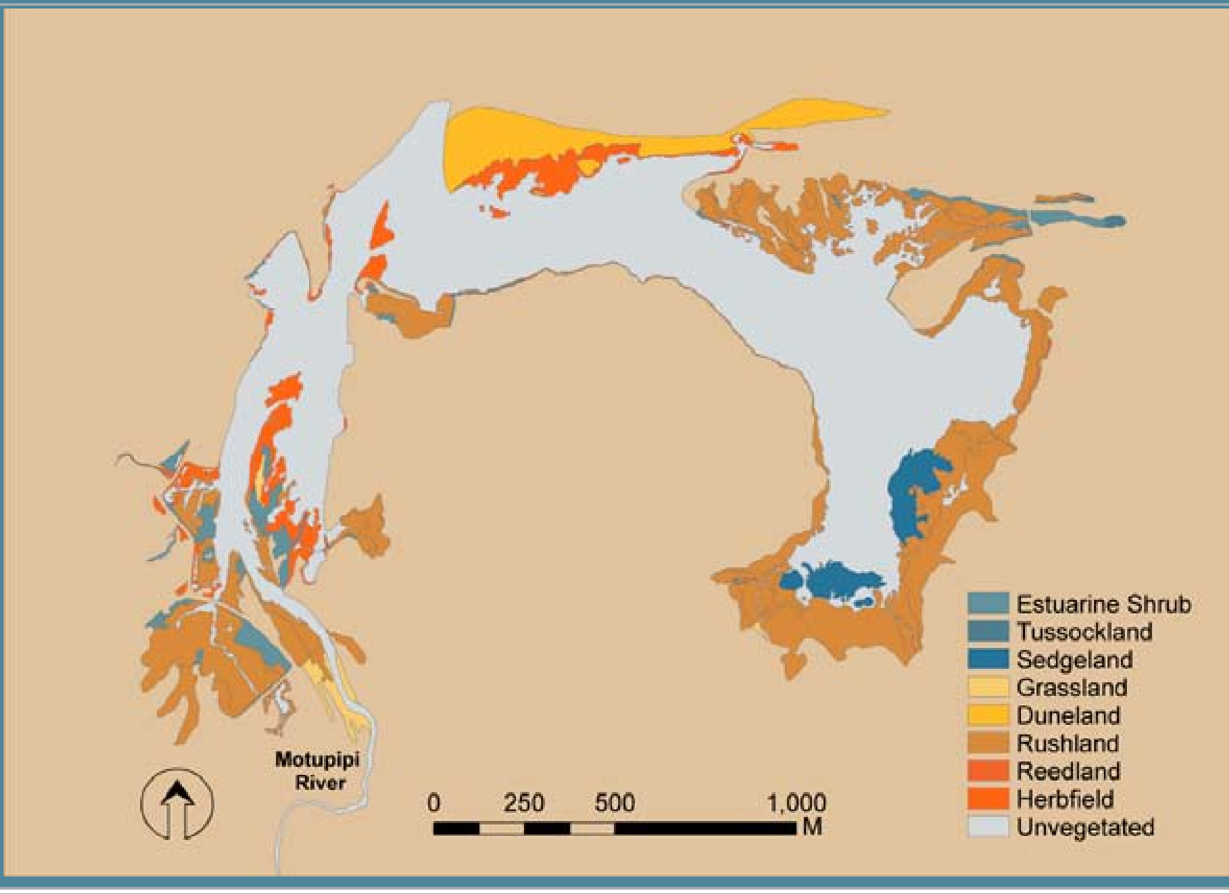
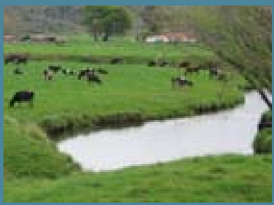
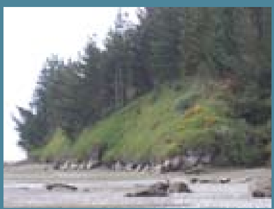


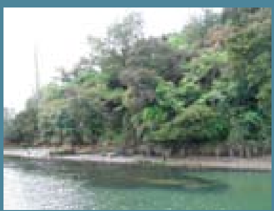
Figure 11. 1984 aerial photograph of Motupipi Estuary (top) and broad scale estuary vegetation (bottom).

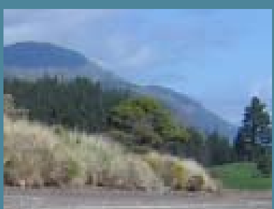


TERRESTRIAL MARGIN MAPPING









The results of the 200m terrestrial margin mapping are summarised in Table 9 and Figure 12. Grassland dominated the margin (66%) and, with the exception of the golf course in the northeast, was mostly channelled and drained pasture with no vegetated buffer. Grazing occurred to the edge of the remaining saltmarsh in most places.

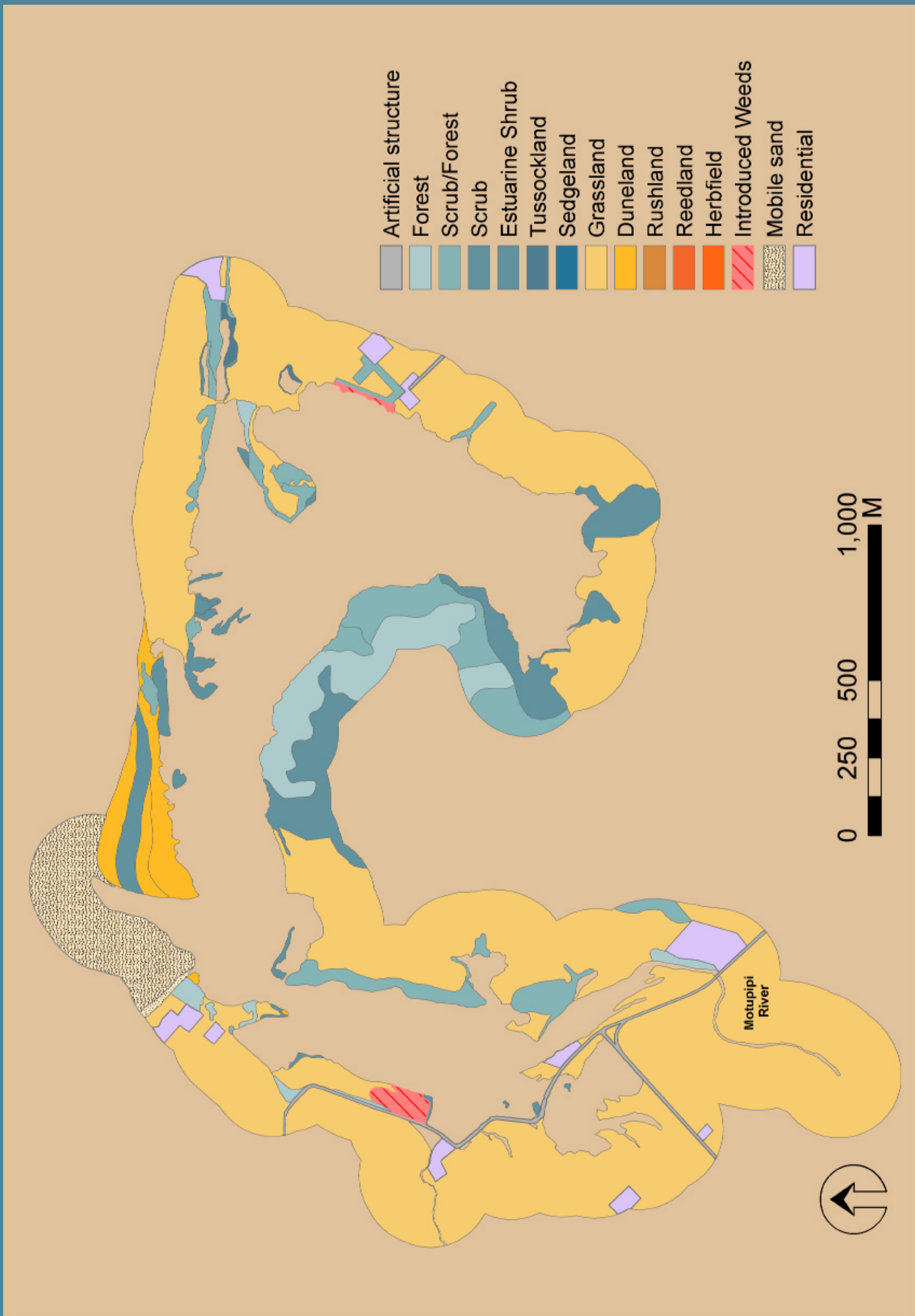
Mixed scrub and forest (21%) was the other major feature, mostly gorse and pine trees on the steep hillsides in the central southern area between the east and west arms, along with a few patches of native scrub dotted throughout the estuary margin. Duneland was also a feature on the barrier spit with vegetation now covering areas that were historically intertidal flats. Introduced weeds were present in most areas around the estuary and appeared as dominant features at the closed Rototai landfill, and along a narrow strip next to the road edge in the east.

Overall, almost all easily accessible land around the estuary margin had been cleared and converted to farmland, with much of the changes already apparent in 1943. A vegetated buffer between the pasture and saltmarsh was generally absent in these areas, although replanting has recently started on the banks of the upper estuary.

Table 9. Summary of 200m terrestrial margin vegetation, September 2007.

Class	Dominant Vegetation	Area (ha)	Percentage
Forest		14.7	5.3
	Eucalyptus spp. (gum tree) Exotic forest Mixed native and exotic forest *Pinus radiata* (pine tree)	1.1 0.8 0.6 12.2	0.4 0.3 0.2 4.4
Scrub/Forest		22.1	7.9
	Leptospermum scoparium (manuka) *Pinus radiata* (pine tree) Native scrub/forest *Cupressus macrocarpa* (macrocarpa) *Melicytus ramiflorus* (mahoe) Exotic scrub/forest Mixed native and exotic scrub/forest	9.4 4.8 3.0 2.2 1.3 0.9 0.5	3.4 1.7 1.1 0.8 0.5 0.3 0.2
Scrub		22.8	8.2
	Ulex europaeus (gorse) Mixed native and exotic scrub *Leptospermum scoparium* (manuka) *Chamaecytisus palmensis* (Tree lucerne, Tagasaste) Native scrub	9.5 4.4 4.3 3.0 1.6	3.4 1.6 1.5 1.1 0.6
Tussockland		0.6	0.2
	Phormium tenax (NZ flax)	0.6	0.2
Duneland		8.8	3.2
	Ammophila arenaria (marram grass) *Spinifex sericeus* (Silvery grass)	8.7 0.1	3.1 0.0
Grassland		183.1	65.6
	Grassland (unidentified mixed grasses) *Festuca arundinacea* (tall fescue)	181.2 2.5	64.7 0.9
Introduced weeds	Unidentified introduced weeds	1.7	0.6
Mobile sand		14.8	5.3
Firm sand		0.4	0.1
Water		0.1	0.0
Artificial structure	Road	2.8	1.0
Residential		7.3	2.6
TOTAL		**280**	**100**

Figure 12. Map of 200m Terrestrial Margin Vegetation - Motupipi Estuary, September 2007.



CONDITION RATINGS

The 2007 broad scale and historical mapping has enabled condition ratings to be applied for the key issues of sedimentation (extent of soft mud), eutrophication (macroalgal cover), and habitat loss (extent of saltmarsh and terrestrial vegetated buffer). In addition a baseline has been established against which future changes in the estuary can be assessed. A summary of condition ratings is presented in Table 10, and results discussed for each issue in the following sections.

Table 10. Summary of Condition Ratings for indicators of estuary issues.

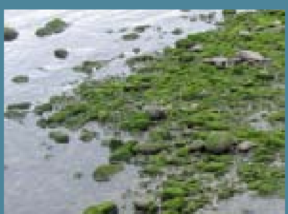
Estuary Issue	Indicator	Condition Rating
Sedimentation	Soft mud % cover	High
	Area of soft mud	Baseline established
Eutrophication	Macroalgal cover	Fair
Habitat loss	Seagrass area	Baseline established
	Saltmarsh % cover	Very High
	Saltmarsh area	Baseline established
	Terrestrial buffer % cover	Poor
	Terrestrial buffer area	Baseline established

SEDIMENTATION:

The broad scale mapping showed that 43% of the estuary was soft or very soft mud, rating sedimentation as a "high" issue overall. Sediment impacts are of particular concern in tidal lagoon estuaries like the Motupipi because they have a central basin which forms a sink for fine sediments, usually derived from catchment soil erosion. In terms of sediment associated problems, the western arm is the most affected, where muds are widespread, deep, poorly oxygenated, and close to nutrient and contaminant sources. Consequently fish and invertebrate communities are likely to reflect those able to tolerate muddier and more enriched conditions. In comparison, in the eastern arm the degree of muddiness is much less, and the muds are well oxygenated, appear less enriched, and are likely to be supporting a healthy biological community.

Such results confirm the findings of the Estuary Vulnerability Assessment (Robertson and Stevens 2008) that increasing muddiness is an issue in the estuary that requires ongoing monitoring and source management. Sediment plates were deployed during the study to provide a means of monitoring sedimentation rates. Ongoing broad scale mapping of substrate will provide the other key long term indicator of muddiness.

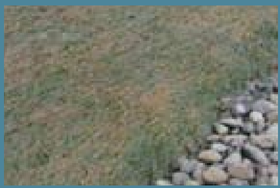
EUTROPHICATION:



The extent of macroalgal growth in the Motupipi Estuary was low to moderate ("good" category), however because there were significant areas of localised nuisance conditions in the western arm (e.g. muddy smelly sediments with low oxygen levels and the potential for nutrient release), it was given an overall "fair" category. Such conditions, which are caused by excessive catchment nutrient inputs, are symptomatic of a partially eutrophic estuary and, like sedimentation require ongoing monitoring and source management. This management should focus on the western arm as it is the most affected i.e. largest areas of macroalgal growth and associated nuisance conditions.

HABITAT LOSS:

Extensive areas of vegetation (particularly seagrass, saltmarsh and terrestrial margin) in good condition are important for the healthy functioning of an estuary.



Seagrass

The extent of seagrass was low-moderate with most located in the subtidal reaches of the Motupipi River in the western arm of the estuary, and as beds extending into lower intertidal areas. The beds appeared relatively free of sediment, healthy and lush, and stable despite the light limitation caused by phytoplankton blooms in the upper estuary. Such extensive subtidal beds are not commonly found in the upper reaches of NZ estuaries, and are likely to be in the Motupipi because of spring fed flows that maintain a relatively clear and constant base flow in the upper reaches. A baseline record of seagrass has been established to measure future change.

Saltmarsh

The percentage cover of saltmarsh rated in the "very high" category, and was most extensive in the upper tidal reaches of the middle estuary. While large areas of healthy saltmarsh remain, past reclamations, causeways, rubbish dumping, stock grazing, drainage, and erosion protection have all reduced the extent of saltmarsh. Most recently the changes have been relatively small - a 3% loss between 1984 and 2007, while between 1943 and 1984 saltmarsh reduced by 27%. These losses have reduced the significant wildlife habitat and recreational and aesthetic value such areas provide, while also adversely impacting on their role in flood and erosion protection, contaminant mitigation, sediment stabilisation, and nutrient cycling.

Vegetated Terrestrial Buffer

Terrestrial buffer vegetation was in the "poor" category, with most of the estuary surrounded by grazed pasture, and the remaining vegetated areas often in relatively poor condition. Like saltmarsh, the terrestrial buffer provides significant wildlife habitat and recreational and aesthetic value, and plays a vital role in flood and erosion control, contaminant mitigation, sediment stabilisation, nutrient cycling, and protection against the invasion of nuisance weeds into the estuary. Its removal, predominantly the conversion of native bush to farmland prior to 1943, has been compounded by other modifications around the estuary including reclamations, causeways, rubbish dumping, stock grazing, drainage, and erosion protection.

Collectively these activities have contributed to a "coastal squeeze", where the capacity for estuarine vegetation to respond to changes in sediment and water levels has been greatly reduced. This has significant implications for the ability of the estuary to respond to predicted sea level rise, a key issue identified in the Motupipi Estuary Ecological Vulnerability Assessment (Robertson and Stevens 2008). It confirms that the loss of margin habitat is an issue requiring ongoing monitoring and management.

4. MONITORING

Motupipi Estuary has been identified by TDC as a priority for monitoring, and is a key part of TDC's existing estuary monitoring programme being undertaken in a staged manner throughout the Nelson/Golden Bay region. Under this long term programme, TDC will undertake broad scale monitoring on a 5 yearly cycle (next scheduled for September 2012) to monitor and assess ongoing changes in broad scale substrate and vegetation in the Motupipi.

5. RECOMMENDED MANAGEMENT

Both the broad and fine scale monitoring results have reinforced the need for management of fine sediment and nutrient sources entering the estuary. In addition, the absence of a densely vegetated terrestrial buffer means the buffering function provided previously by the bush-covered margin has largely been lost, and, in conjunction with modification of the estuary margins, the capacity for the estuary to respond to key pressures such as sea level rise is greatly diminished. It is recommended that options be considered for the following (as identified in the estuary vulnerability assessment - Robertson and Stevens 2008):

Identify and Implement Catchment BMPs

- Catchment runoff was identified as one of the major stressors in the Motupipi with the likely ecological response one of lowered biodiversity and lowered aesthetic and human use values. To prevent avoidable inputs, best management practices (BMPs) should be identified and implemented to reduce sediment, nutrient and pathogen runoff from catchment "hotspots".

TDC and Landcare Research are currently working with farmers in the catchment to identify catchment nutrient sources and "hotspots", and to implement BMPs for reducing nutrient mobilisation and runoff to surface and groundwater.

Set Limits on Nutrient Inputs

- An increase in nuisance growths of macroalgae will result in reduced public amenity values, reduced biodiversity and increased sediment enrichment in the estuary. Because nutrient input was both high and strongly related to the eutrophication symptoms, it is recommended that catchment nutrient inputs be reduced and Total Daily Maximum Loads (TDMLs) set.

Reinstate Margin Buffer

- Historical clearance of bush around the terrestrial margin of the estuary means it is now dominated by grazed pasture. Additionally, there have been significant areas of saltmarsh drained and reclaimed for pastoral use, roading and the now closed Rototai landfill. This has almost certainly contributed to reduced biodiversity and increased sedimentation in the estuary. Many areas are also adversely affected by nuisance weeds. Because of the importance of a natural vegetated margin around the estuary, it is recommended that a management plan be developed to encourage its re-establishment.

Coastal Squeeze

- Sea level rise is a key estuary stressor. The ability of estuary vegetation to respond to sea level rise relies to a large extent on saltmarsh and terrestrial margin vegetation being able to migrate landward to maintain suitable growing conditions. In the Motupipi, migration is limited by reclamations, seawalls, causeways, flood controls, and by drainage of low-lying land (now mostly converted to pasture) resulting in coastal squeeze. Areas where coastal squeeze is likely to occur should be identified and used to guide existing revegetation efforts, and to identify where future estuary expansion may need to be allowed for as a consequence of sea level rise.

6. ACKNOWLEDGEMENTS

This survey and report have been undertaken with help from various people. Particular thanks are due to the locals who provided us with access to the estuary and freely discussed changes and issues associated with the area, and to Trevor James (Tasman District Council) for field assistance and feedback on the report and Rob Smith (Tasman District Council) for making it all happen.

7. REFERENCES

Atkinson, I.A.E. 1985. Derivation of vegetation mapping units for an ecological survey of Tongariro National Park Nth Island, NZ. NZ Journal of Botany, 23; 361-378.

Robertson, B.M., Gillespie, P.A., Asher, R.A., Frisk, S., Keeley, N.B., Hopkins, G.A., Thompson, S.J., Tuckey, B.J. 2002. Estuarine Environmental Assessment and Monitoring: A National Protocol. Part A. Development, Part B. Appendices, and Part C. Application. Prepared for supporting Councils and the Ministry for the Environment, Sustainable Management Fund Contract No. 5096. Part A. 93p. Part B. 159p. Part C. 40p plus field sheets.

Robertson, B., and Stevens, L. 2006. Southland Estuaries State of Environment Report 2001-2006. Prepared for Environment Southland.

Robertson, B.M. and Stevens, L. 2007. Waikawa Estuary 2007 Fine Scale Monitoring & Historical Sediment Coring. Prepared for Environment Southland. 29p.

Robertson, B.M. and Stevens, L. 2007a. Wairarapa Coastal Habitats: Mapping, Risk Assessment and Monitoring. Prepared for Greater Wellington Regional Council. 120p.

Robertson, B.M. and Stevens, L. 2007b. Wellington Harbour, Kapiti, Southwest and South Coasts - Risks and Monitoring. Prepared for Greater Wellington Regional Council. 57p.

Robertson, B.M. and Stevens, L. 2008. Motupipi Estuary Vulnerability Assessment & Monitoring Recommendations. Prepared for Tasman District Council. 47p.

Robertson, B.M. and Stevens, L. 2008a. Motupipi Estuary 2008 Fine Scale Monitoring. Prepared for Tasman District Council.

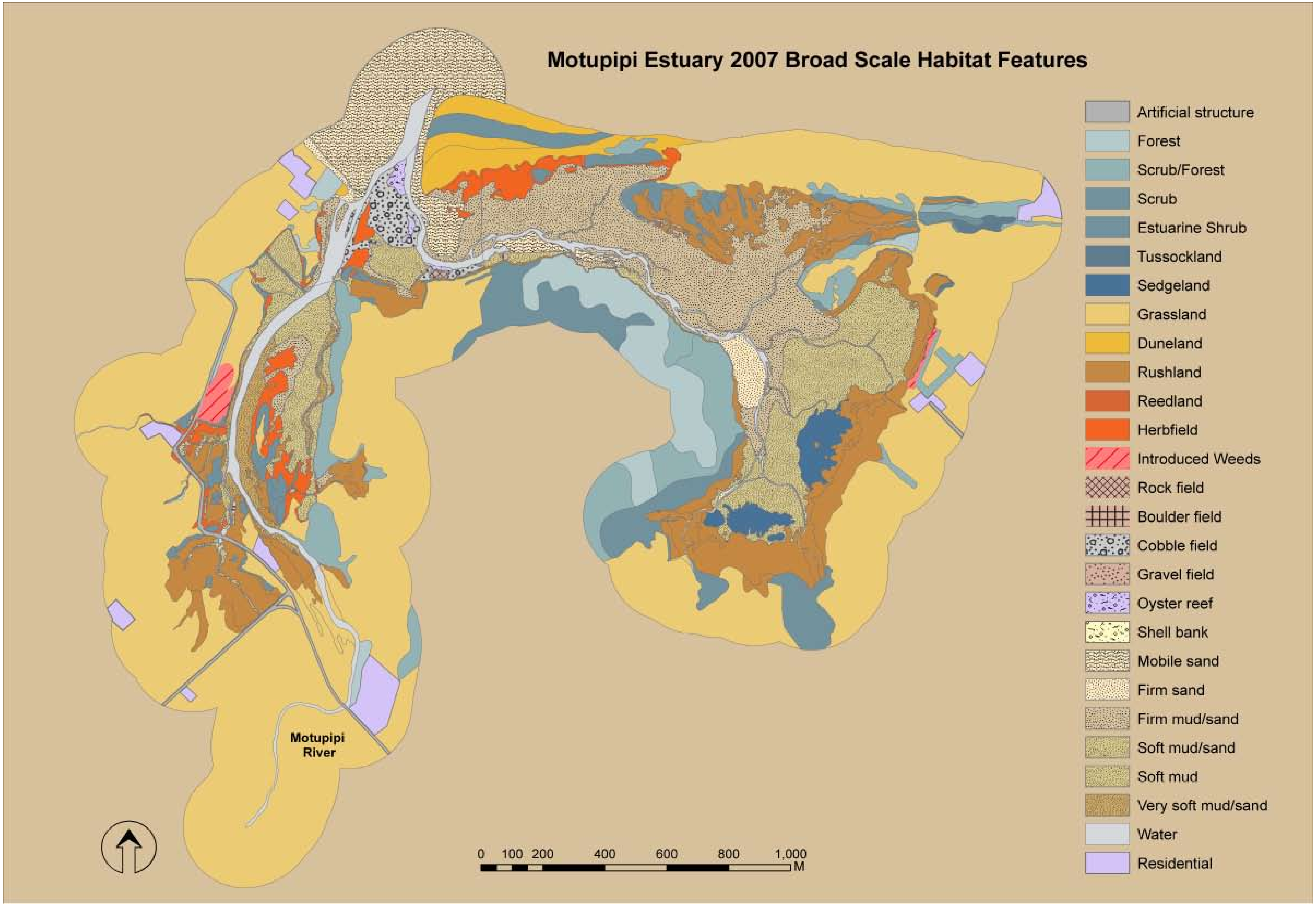
Stevens, L. and Robertson, B., 2007. Waituna Lagoon 2007. Broad Scale Habitat Mapping and Historical Sediment Coring. Report prepared by Wriggle Coastal Management for Environment Southland. 36p.

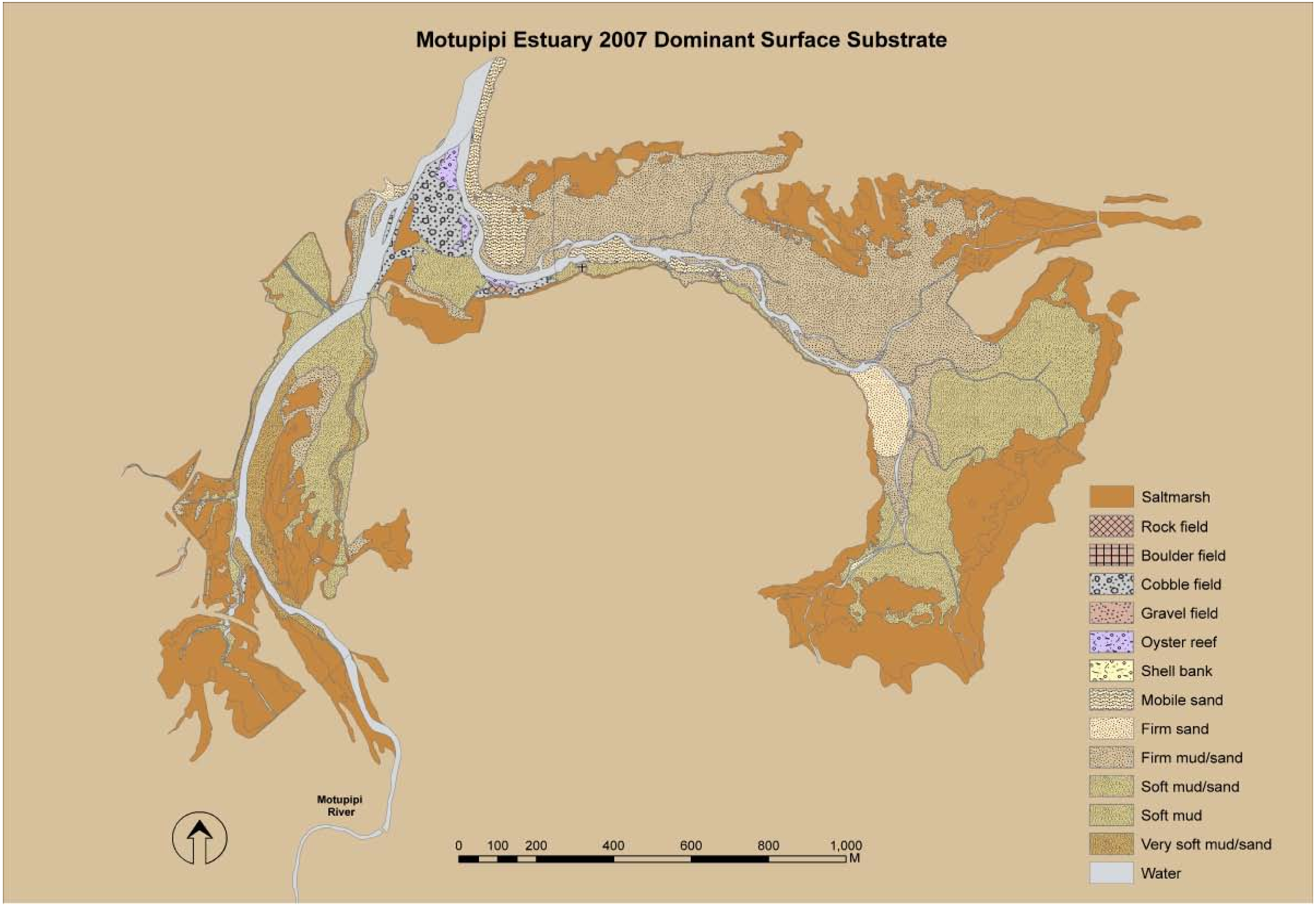
Stevens, L. and Robertson, B., 2007a. Waituna Lagoon 2007. Ecological Vulnerability Assessment and Monitoring Recommendations. Report prepared by Wriggle Coastal Management for Environment Southland. 40p.

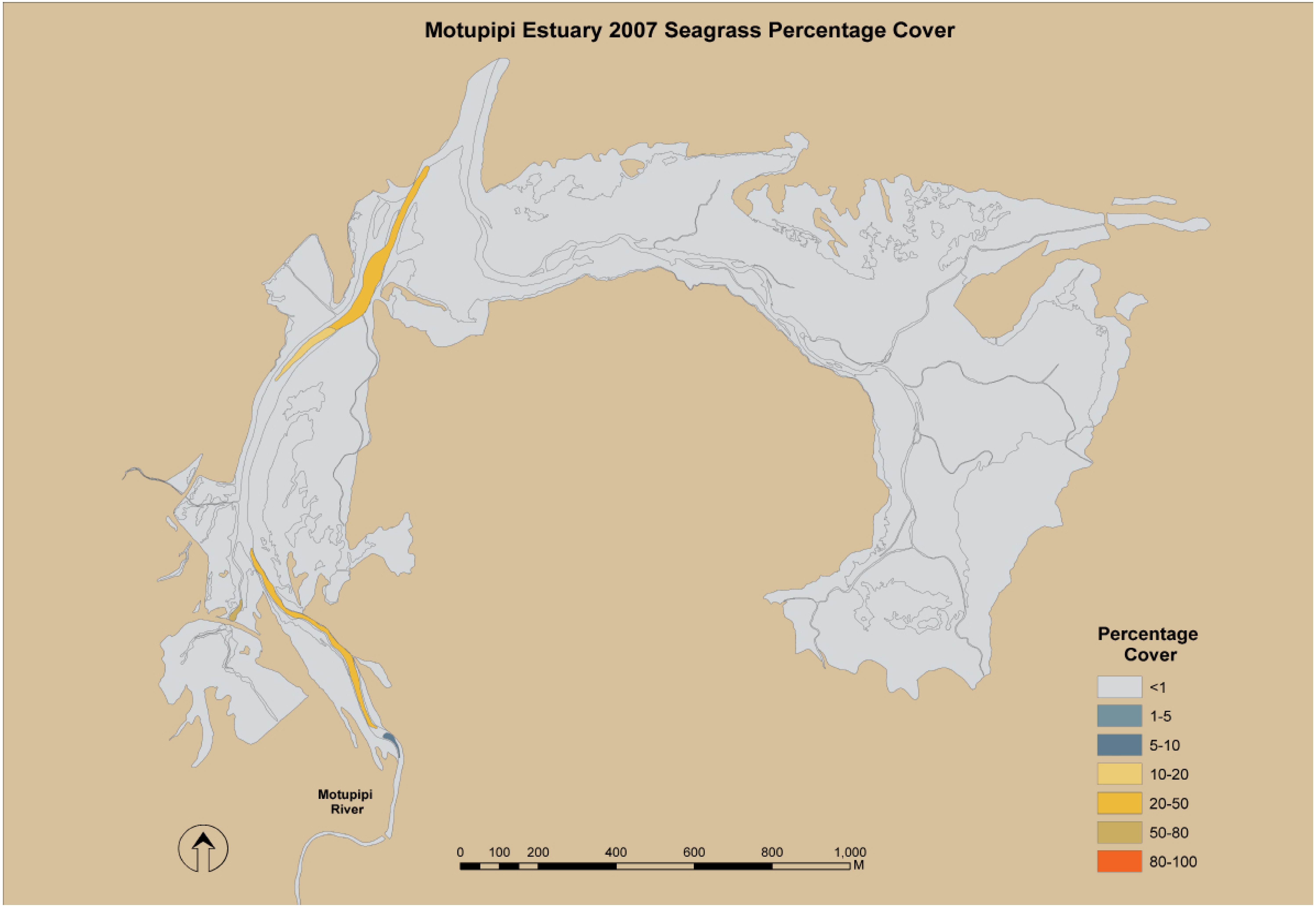
APPENDIX 1. BROAD SCALE HABITAT CLASSIFICATION DEFINITIONS

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: Area that is dominated by both live and dead cockle shells.
Mussel reef: Area that is dominated by one or more mussel species.
Oyster reef: Area that is dominated by one or more oysters species.
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.

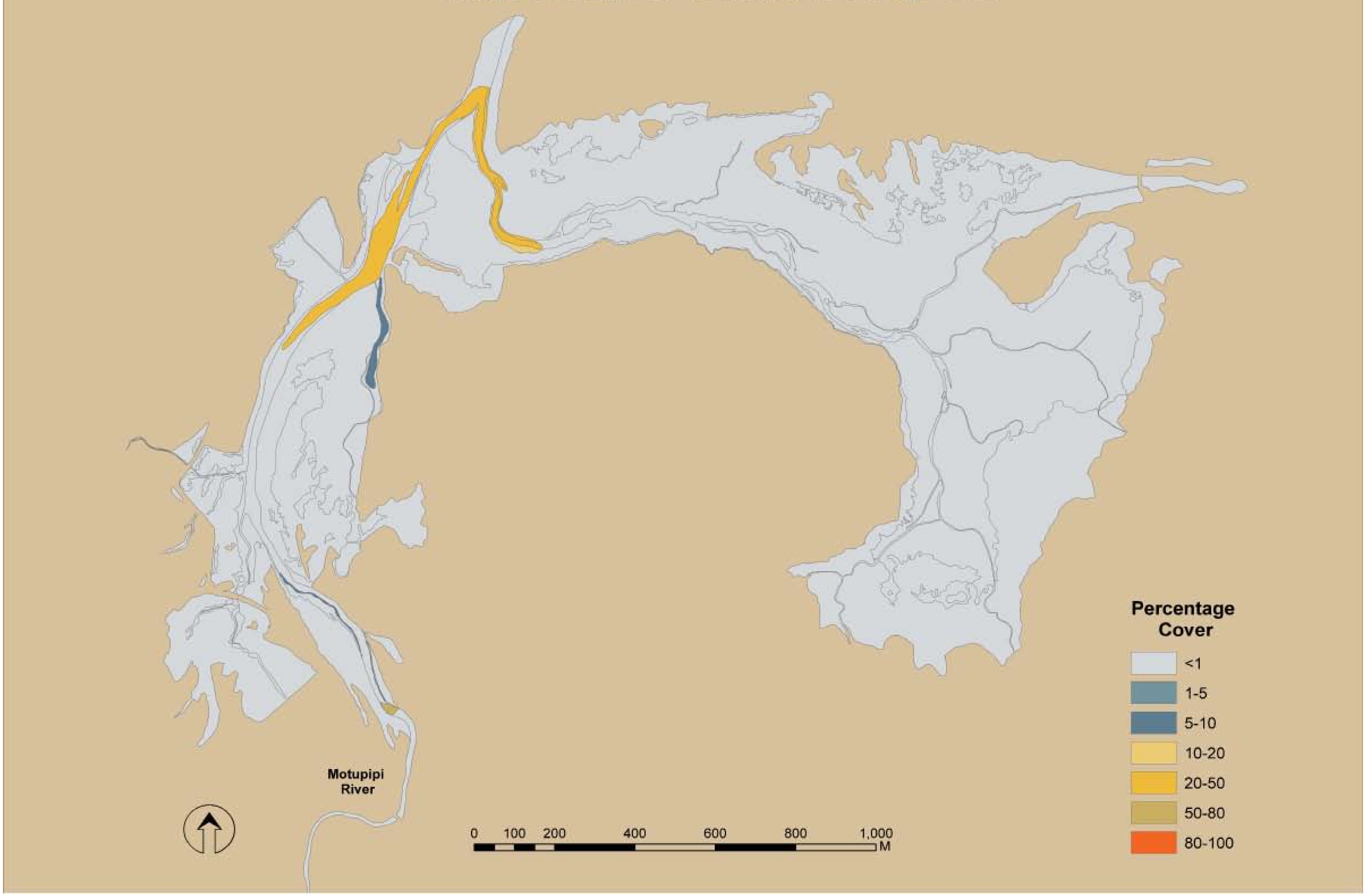
APPENDIX 2. MOTUPIPI ESTUARY BROAD SCALE HABITAT MAPS

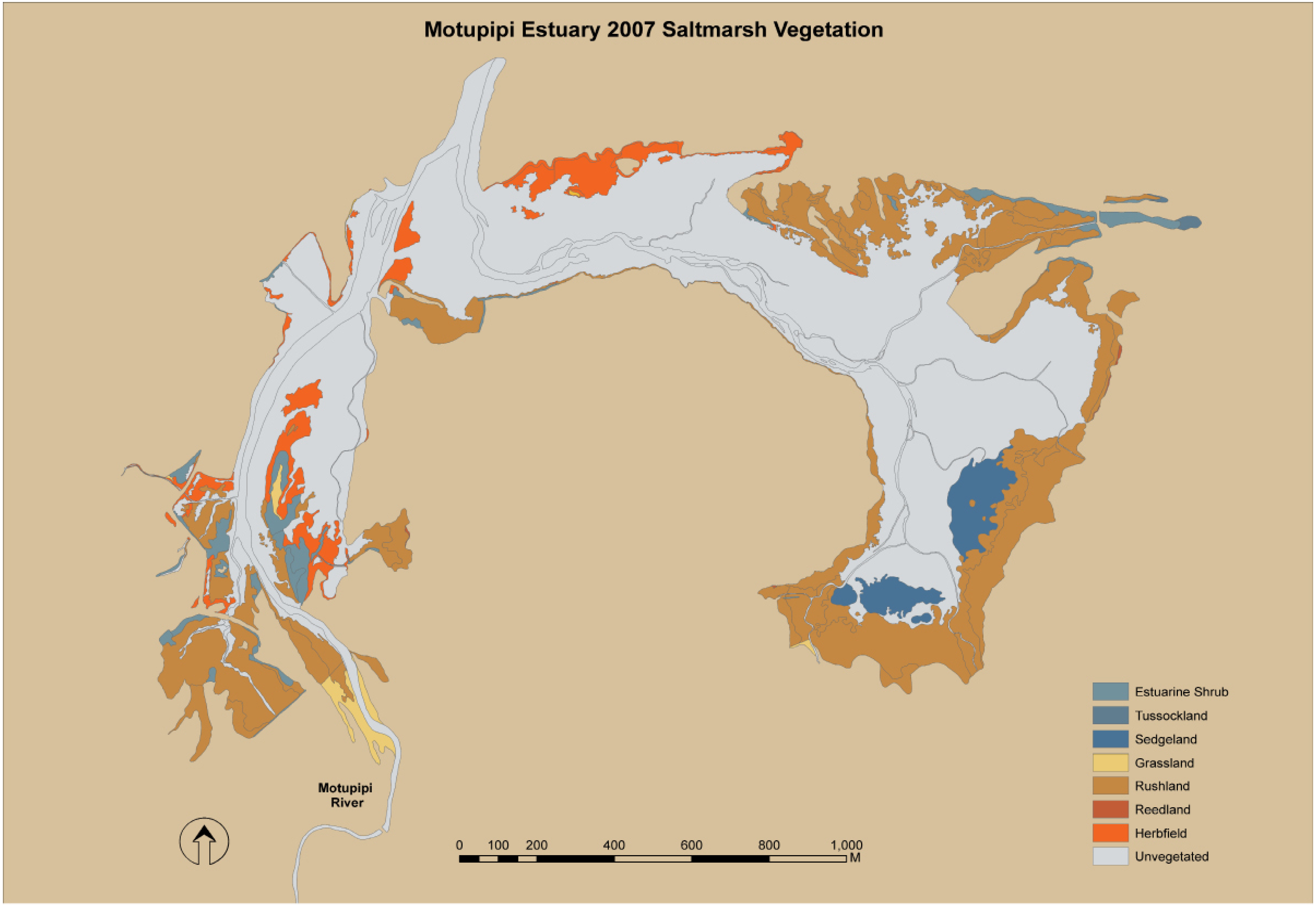

Motupipi Estuary 2007 Broad Scale Habitat Features
Artificial structure
Forest
Scrub/Forest
Scrub
Estuarine Shrub
Tussockland
Sedgeland
Grassland
Duneland
Rushland
Reedland
Herbfield
Introduced Weeds
Rock field
Boulder field
Cobble field
Gravel field
Oyster reef
Shell bank
Mobile sand
Firm sand
Firm mud/sand
Soft mud/sand
Soft mud
Very soft mud/sand
Water
Residential
Motupipi River
0 100 200 400 600 800 1,000 M


Motupipi Estuary 2007 Dominant Surface Substrate
Motupipi River
0
100
200
400
600
800
1,000
M
Saltmarsh
Rock field
Boulder field
Cobble field
Gravel field
Oyster reef
Shell bank
Mobile sand
Firm sand
Firm mud/sand
Soft mud/sand
Soft mud
Very soft mud/sand
Water

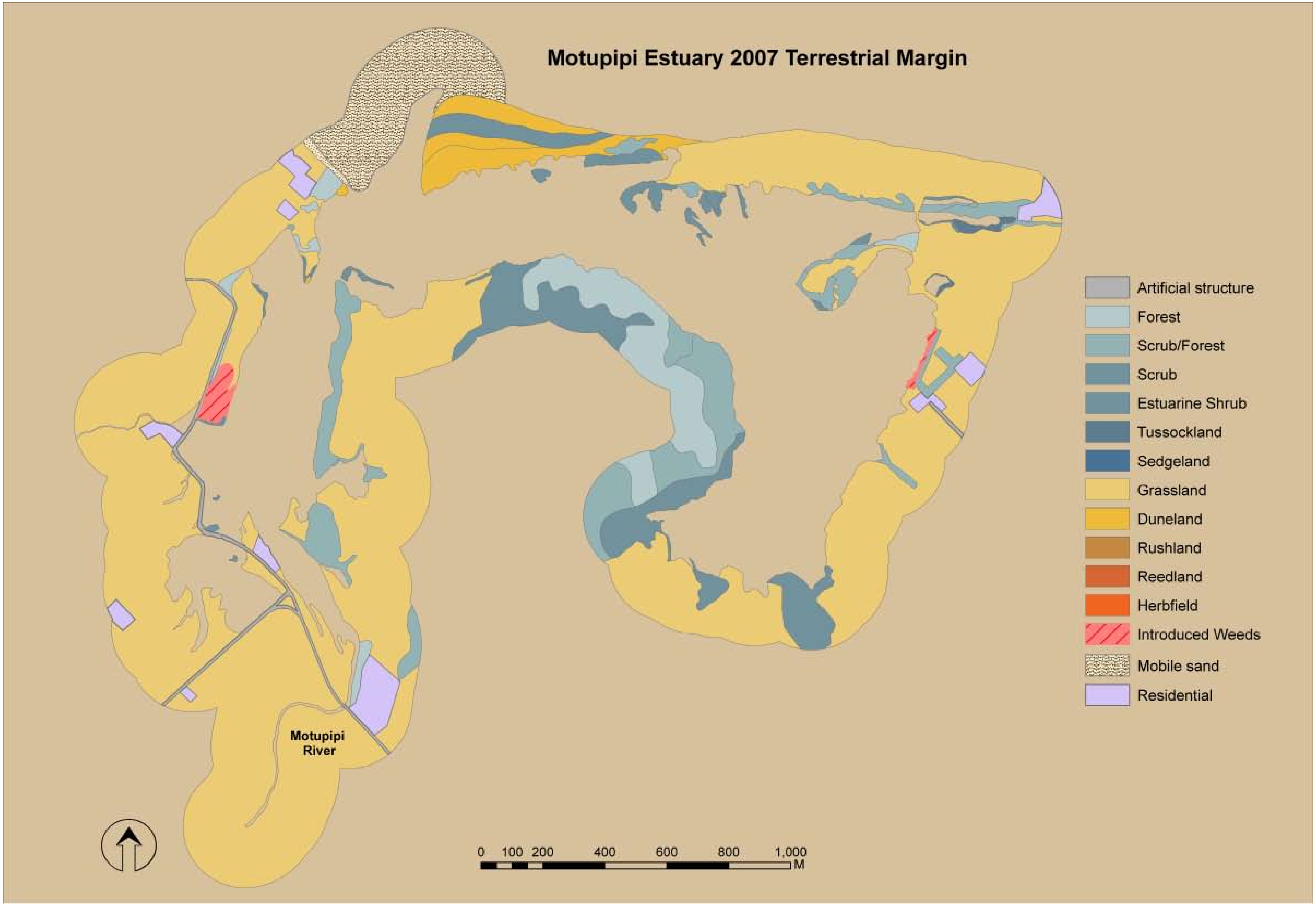

Motupipi Estuary 2007 Seagrass Percentage Cover
Motupipi River
0 100 200 400 600 800 1,000 M
Percentage Cover
<1
1-5
5-10
10-20
20-50
50-80
80-100

Motupipi Estuary 2007 Macroalgal Percentage Cover



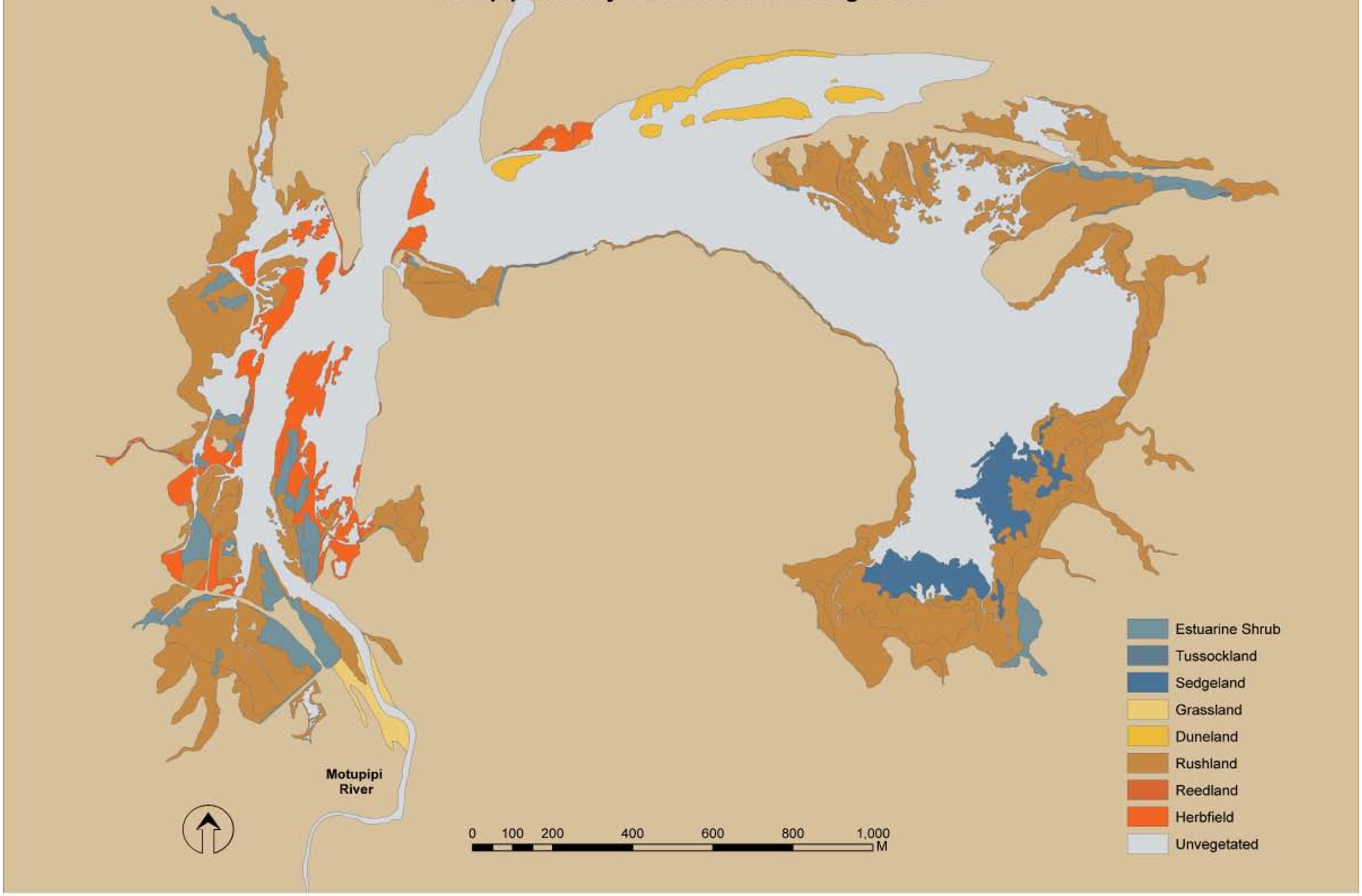


Wriggle coastalmanagement



Wriggle coastalmanagement

Motupipi Estuary 1943 Broad Scale Vegetation



Motupipi Estuary 1984 Broad Scale Vegetation