CAWTHRON

Historical Broad Scale Habitat Mapping of Moutere Inlet (1947, 1988 and 2004)

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Historical Broad Scale Habitat Mapping of Moutere Inlet (1947, 1988 and 2004)

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EXECUTIVE SUMMARY

Broad scale habitat maps of the Moutere Inlet were created based on historical photographs from 1947 and 1988. These maps were compared to a recent habitat map of the Moutere Inlet based on 2004 photographs and ground-truthing of habitat features in the field (see Clark et al. 2006).

Several differences in estuary habitats can be seen:

- The total area of Moutere Inlet decreased by over 40 ha, or 5.5%, between 1947 and 2004.
- The area of unvegetated substrate (including water) in the Inlet has increased over time from 81% of the area (651 ha) in 1947 to 89% (677 ha) in 2004.
- This increase has resulted from reductions in the areas of rushland (82.3 ha in 1947 to 42.6 ha in 2004), herbfield (52.4 ha in 1947 to 29.1 ha in 2004) and estuarine shrubs (14.6 ha in 1947 to 3.0 ha in 2004).
- New roading (SH 60) along the western side of the estuary has created several embayments, restricting flow to these areas of the estuary.

Substantial loss of peripheral vegetated habitat and localised restriction in flushing efficiency has occurred in Moutere Inlet during the period 1947-2004. However we can probably assume that considerably greater changes occurred prior to 1947. This alteration in physical and biological structure, relating to human activities (primarily roading and other shoreline development), is cumulative and is likely to have resulted in significant modification of ecosystem function. Partial recovery of estuarine function could be achieved by road bridging and/or culvert installation in conjunction with saltmarsh revegetation.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1. INTRODUCTION

1.1. Background

Estuarine intertidal areas linking terrestrial and marine environments play an important role in the nourishment of coastal ecosystems. They often encompass habitats of high ecological value and support resources of cultural, recreational and/or commercial importance. Broad scale habitat mapping can be used as a monitoring tool (MfE Confirmed Indicators for the Marine Environment, 2001) to assist in regional strategic planning, and in the management of specific issues associated with estuarine habitat (e.g. resource consents, pollution monitoring, and State of the Environment monitoring).

A detailed point-in-time spatial description of the major intertidal habitats of Moutere Inlet was carried out by Cawthron using aerial photographs taken in 2004 (Clark et al. 2006). The rationale, methods and potential applications of broadscale habitat mapping are summarised in that report and described in detail in Robertson et al. (2002).

Cawthron was commissioned by the Tasman District Council (TDC) to prepare additional broadscale habitat maps of the same estuary based on two sets of historical aerial photographs. The purpose of the project was to identify any major changes in habitat structure that may have occurred over the time intervals selected and interpret these with respect to the functional health of the estuary.

1.2. Study Area

The Moutere Inlet is located approximately 24 km northwest of Nelson near the town of Motueka (Figure 1). It is a bar-built, tidal estuary open to the sea at two locations (Port Motueka and the northwestern end of Kina Peninsula). Having near-complete drainage at low tide, it encompasses a, previously estimated, total intertidal area of 713 ha (Spencer & Westcott 1980). The intertidal habitats are characterised by open mud flats fringed with salt marsh in peripheral regions, and productive sand flats in central regions that are colonised by microalgae and in some areas macroalgae or eelgrass.

Considerable modification/infilling of peripheral intertidal and supratidal habitats has occurred in past years, largely in conjunction with roading development. State Highway 60, along the inland estuary margin, cuts across a series of small embayments resulting in partial or complete restriction of tidal flushing with consequent reduction of estuary ecosystem function. Wharf Road cuts across the top (Moutere) end of the Inlet with significant flow restriction resulting in partial ponding of tidal waters and subsequent nutrient retention (Gillespie et al. 2005).

The Inlet receives a relatively small freshwater input from the Moutere River (mean flow ~1280 litres/s) and a number of smaller inflow streams with a total mean flow of ~450 litres/s

(Gillespie et al. 1995). Sources of freshwater nutrients and the enrichment status of benthic habitats in the estuary were described by Gillespie et al. (1995) in a detailed assessment of the Moutere Inlet ecosystem. Further background and historical ecological information may be obtained from references cited in that report.

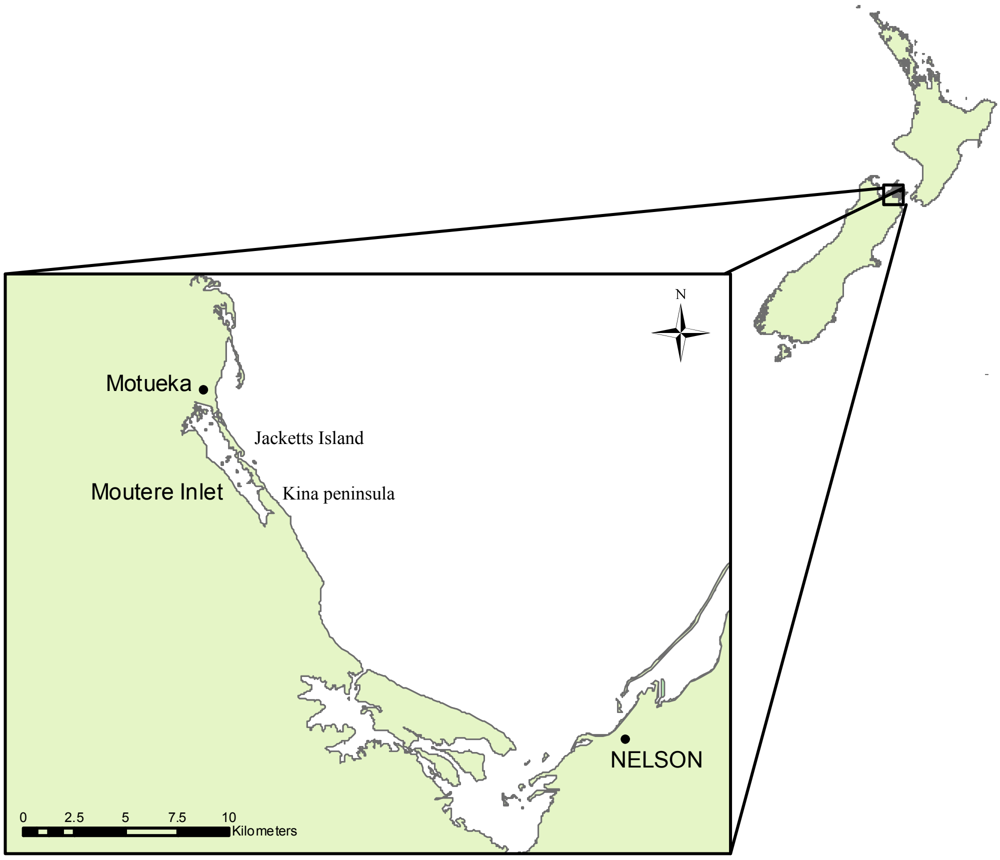

Figure 1. General location of Moutere Inlet.

2. METHODS

2.1. Construction of historical broad scale maps

The methodologies used to construct the 2004 baseline maps for the estuary are detailed in Clark et al. (2006) and summarised below. Historical maps were developed using a subset of these methods.

2.1.1. Aerial photography

The baseline colour photograph was taken on 17 January 2004 (in conjunction with a 1.04 m MSL low tide) by Peter Inwood (TDC) and provided to Cawthron as a rectified tiff file at a scale of 1:10,000.

The 1947 historical photograph was taken on March 27 1947 (low tide of 1.69 m MSL) and was supplied by New Zealand Aerial Mapping Ltd as a black and white tiff file at a scale of 1:18,000. The tiff file had been rectified.

The 1988 historical photographs were supplied by GeoSmart as black and white tiff files, taken on January 29 1988 (low tide of 0.74 m MSL) at a scale of 1:15,000. The tiff files from GeoSmart had not been rectified.

2.1.2. Rectification of tiff files

The 1988 photographs (tiff files) were rectified within ArcMap™ using a geo-referencing tool. Several features common to both the historical photographs (tiff files) and the rectified images used to generate the recent broad scale maps (i.e. the corner of a house or intersection of roads) were located. These locations became control points. Using the geo-referencing tool, the locations within the historical photographs (tiff files) were matched corresponding to the control points created from the rectified images. Once the images were matched, the tiff files were saved as rectified tiffs.

2.1.3. Classification of habitat features

The system for classification of habitat features was adapted from the proposed national classification system, which was developed under a Ministry for the Environment SMF (Sustainable Management Fund) project (Monitoring Changes in Wetland Extent: An Environmental Performance Indicator for Wetlands) by Lincoln Environmental, Lincoln. The classification system for wetland types is based on the Atkinson System (Atkinson 1985) and covers four levels, ranging from broad to fine scale. These are:

- Level I: Hydrosystem (e.g. estuary)
- Level II: Wetland Class (e.g. saltmarsh, mud/sand flat, macroalgal bed)

- Level III: Structural Class (e.g. marshland, mobile sand, cobble)
- Level IV: Dominant Cover (e.g. *Leptocarpus similis*)

Dominant biota with a spatial coverage of >2 m in diameter was classified using an interpretation of the Atkinson (1985) system. In this report, biota and substratum are listed in order of dominance as described below:

- Individual plant species are coded using the two first letters of their Latin genus and species names; e.g. Pldi = *Plagianthus divaricatus* (ribbonwood), Lesi = *Leptocarpus similis* (jointed wire rush).
- Subdominant species are indicated by appending them following an underscore symbol (_); e.g. Lesi_Pldi = Pldi is subdominant to Lesi. The classification is based on a subjective observation of which vegetation is the dominant or subdominant species within the patch, and not on percentage cover.
- Individual features in the GIS have been labelled in the same manner as that described above.

A list of all the classification types and their codes are given in Appendix 1 and definitions for classification of the Level III structural class are provided in Appendix 2. A subset of classification types (those covering features present in Moutere Inlet) was used for the 2004 baseline mapping exercise. Because historical photographs were black and white, and ground-truthing in the field was not possible, the definition of some habitat boundaries was not achievable. In particular, it was difficult to distinguish categories within the unvegetated habitat. Consequently, the extent of soft muds, cobbles, sands etc. in the estuary was not mapped for the earlier years but the overall boundaries for these combined habitats was easily apparent.

2.1.4. Digitisation of habitat boundaries

Vegetation and substrate features were digitally mapped on screen from the rectified photographs using ArcMap 9.0 GIS software. This procedure involved copying the habitat features as precisely as possible onto rectified aerial photographs within the GIS. The upper boundary was set at the estimated MHWS (Mean High Water Spring), unless supra-littoral habitat was considered integral with the upper intertidal, in which case it was included. The lower boundary was set at the estimated MLWS (Mean Low Water Spring). The software was then used to produce maps and calculate the area cover for each habitat type.

More detail, especially in terms of substrate type, was able to be mapped for 2004 than for the earlier years because the photographs were able to be ground-truthed in order to verify habitat types and boundaries. However, to enable easy comparison between surveys the different substrate types have been combined into the 'unvegetated' habitat in this report and on the accompanying CD-ROM. See Clark et al. (2006) for the more detailed 2004 habitat map.

3. RESULTS

The three habitat maps constructed for historical comparison are described in the following sections (3.1-3.3). Full details on the vegetation and substrates present, from which the broadscale figures and tables were derived, are included on the accompanying CD-ROM, "Historical Broad Scale Intertidal Habitat Mapping of Moutere Inlet, 1947, 1988 and 2004". This source can be used to view individual GIS habitat layers separately if required by querying a subset of data, based on class, using a definition query. The area coverage of dominant habitats in Moutere Inlet (1947 versus 1988 versus 2004) are provided in Table 1 and discussed individually in the following sections.

3.1. 1947 habitat map

A total estuary area of 805 ha was mapped using the 1947 aerial photograph (Figure 2). Most of this area was unvegetated (80.8%, covering 656 ha). The vegetation was dominated by Rushland (10.2%, 82 ha) and Herbfield (6.5%, 52 ha). The most common species in the Rushland areas was likely *Juncus kraussii* (9.7% of total area), with *Isolepsis nodosa* and *Leptocarpus similis* likely also present, however individual species were not able to be identified on the photograph. The herbfield areas were likely dominated by *Sarcocornia quinqueflora*. Small areas of estuarine shrubs, tussockland, terrestrial shrub/scrub/forest and macroalgal beds were also present (Table 1).

The land adjacent to the estuary was already substantially developed in 1947. Most of the estuary margin was dominated by roading and farm land, while the eastern margin was mostly vegetated with grasses and introduced trees (likely *Pinus radiata*).

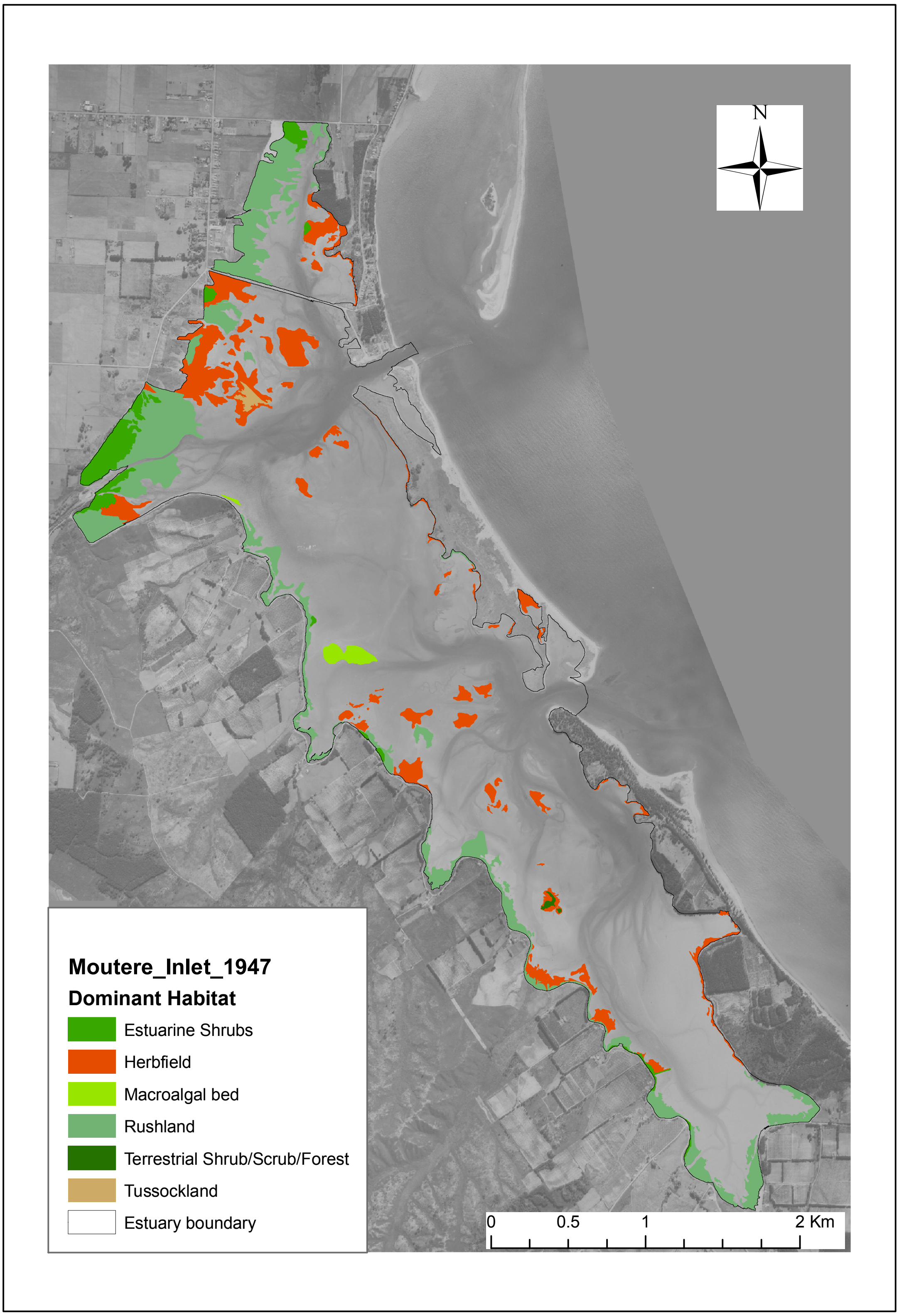

Figure 2. Estimated areas of structural habitat classes in the Moutere Inlet, 1947.

3.2. 1988 habitat map

The 1988 habitat map (Figure 3) featured a total area of 766 ha. The percentage of unvegetated substrate was 87% or 667 ha of the total estuary area.

The dominant vegetation types were Rushland (5.3%, 41 ha) and Herbfield (4.1%, 31 ha). Small areas of estuarine shrubs, tussockland, terrestrial shrub/scrub/forest, sedgeland and seagrass meadow were also present (Table 1). Macroalgal beds in the estuary covered an area of 3.4 ha.

Sealed roads dominated most of the estuary margin by 1988. State Highway 60 cut across several embayments on the western side of the estuary. There were also noticeably more houses and other buildings present around the estuary margins than in 1947.

3.3. 2004 habitat map

The 2004 habitat map is discussed in more detail in Clark et al. (2006). An area of 761 ha was mapped, 89% or 677 ha of which was unvegetated (Figure 4, Table 1). The dominant vegetation types were Rushland (5.6%, 43 ha) and Herbfield (3.8%, 29 ha). Small areas of estuarine shrubs, tussockland, terrestrial shrub/scrub/forest, sedgeland and seagrass meadow were also present (Table 1).

Similarly to 1988, the road was found to cover nearly half (46%) of the estuary margin, forming a barrier between the estuary and the low-lying surrounding land. Since 1988, extensive development of the port and residential housing is evident, especially around the town of Motueka.

Figure 3. Estimated areas of structural habitat classes in the Moutere Inlet, 1988.

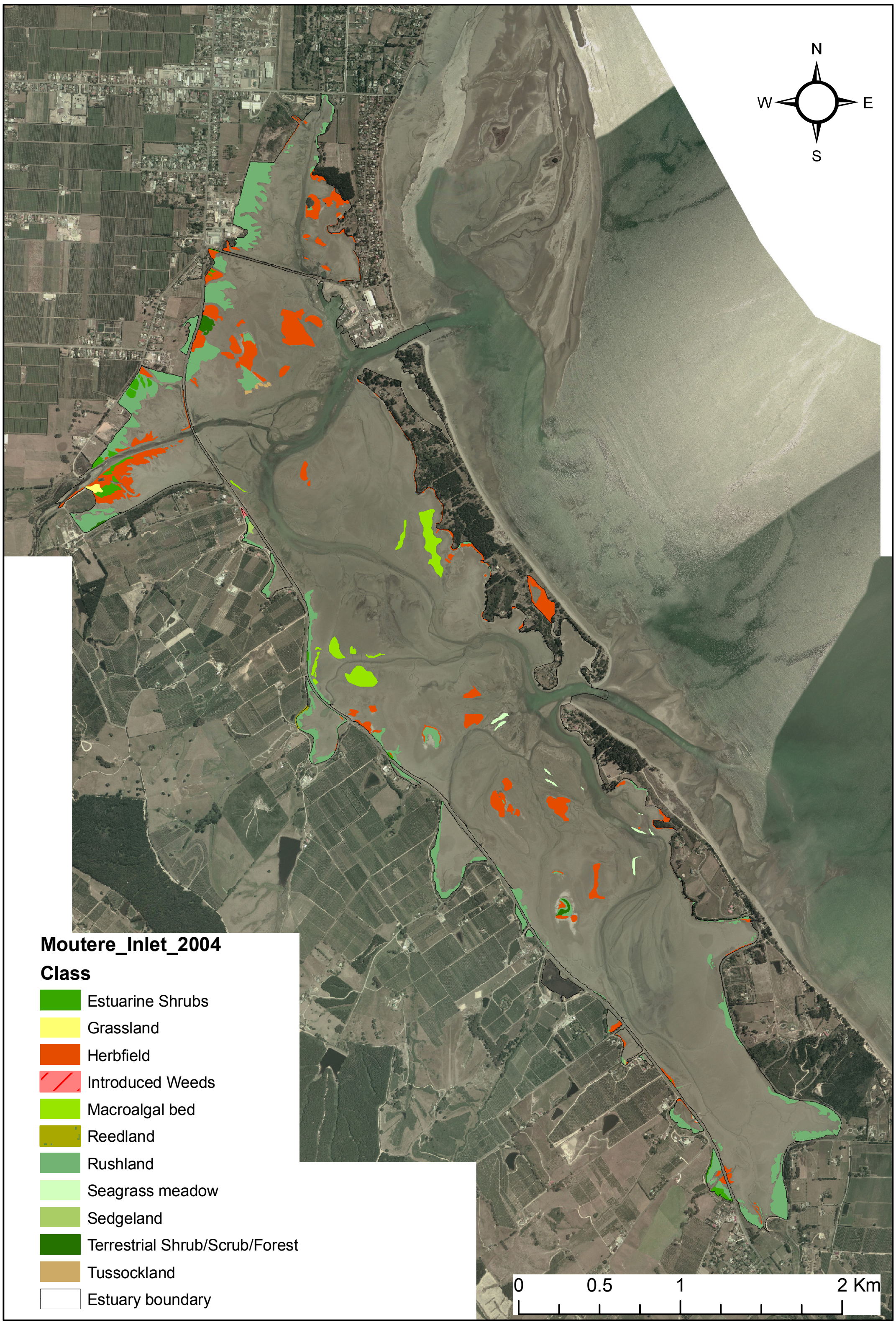

Figure 4. Estimated areas of structural habitat classes in the Moutere Inlet, 2004.

4. DISCUSSION

4.1. Changes in habitat structure

The total area of Moutere Inlet decreased by over 40 ha, or 5.5%, between 1947 and 2004 (Table 1). Much of this loss of estuary area was due to development around the estuary margins. Port Motueka, on the north-eastern boundary of the estuary, has been extensively developed since 1947. The most recent Resource Consent for reclamation of land surrounding the port was granted in April 1997 and work began in 1997-8 (Eric Verstappen, TDC, pers. comm.). Dredging within the marina environs has occurred as recently as October 2005 and it is likely that more construction in this area, in the form of jetties and wharves will be undertaken in the near future (Eric Verstappen, TDC, pers. comm.). The port development has resulted in the loss of some estuary area, although little of the reclaimed area was vegetated prior to port construction.

The area of unvegetated substrate (including water) in the Inlet has increased over time from 81% of the area (651 ha) in 1947 to 89% (677 ha) in 2004 (Figures 5 and 6). This increase corresponds to a reduction in the areas of rushland (82.3 ha in 1947 to 42.6 ha in 2004), herbfield (52.4 ha in 1947 to 29.1 ha in 2004) and estuarine shrubs (14.6 ha in 1947 to 3.0 ha in 2004) (Table 1). Other habitats identified in the surveys have also increased or decreased slightly over time but not as significantly. Small changes in habitat areas should be interpreted with caution due to the difficulty in identifying some types of vegetation (e.g. seagrass meadows) from the black and white photographs used for the 1988 and 1947 surveys.

A marked change can be seen on the western boundary of the estuary where construction of State Highway 60 began during 1968. The road provides a barrier to the land/freshwater wetland/intertidal continuance that is an important feature of estuarine function. The highway cuts across several small embayments which contain open sand flats with fringing salt marsh habitat. One of these embayments has been permanently shut off from the estuary and is used to hold fresh water for irrigation purposes. Although this has not been subtracted from the total area of the estuary, it is nonetheless isolated and therefore non-functional in terms of the land/sea interface. However, the other embayments are all subject to a partially restricted tidal flushing by way of open culverts under the road (Eric Verstappen, TDC, pers. comm.). In spite of the provision of some water exchange via culverts, the areas of rushland and herbfield within the embayments have diminished significantly subsequent to the roading development.

In 1988 large macroalgal beds, most likely *Gracilaria chilensis* mixed with some *Ulva* spp., were present in the mid-region of the estuary (Figures 5 and 6). Macroalgal beds are subject to considerable seasonal and year-to-year variation depending on climatic conditions. On some occasions the extent and density of the beds can also change rapidly over the shorter term in response to storm/wave disturbance. Therefore, although all three photographs used in this study were taken during the summer months (January and March), it is possible that the increase in the area of macroalgal beds in 1988 was due to natural variability rather than a specific cause such as increasing nutrient inputs.

Significant changes have occurred around the estuary margins, however these have not been mapped due to difficulties related to lack of ground-truthing. Nevertheless, some differences are easily recognised. The township of Motueka, in the top left corner of the photographs, was significantly larger in 2004 than in 1947. This will likely have had impacts on the estuary in terms of runoff as well as effects on wildlife such as birds and fish from an increased human and traffic presence around and on the estuary. Another striking difference between photographs is the change to vegetation on Jacketts Island. In 1947 the Island had little large vegetation (shrubs/trees) and was largely covered in grasses. By 1988 the Island had some houses on it and a large proportion was vegetated with large shrubs and trees. In 2004 the Island was largely vegetated, with exotic pine trees (*Pinus radiata*) and large shrubs common. Several houses and a wharf were present on the Island in 2004.

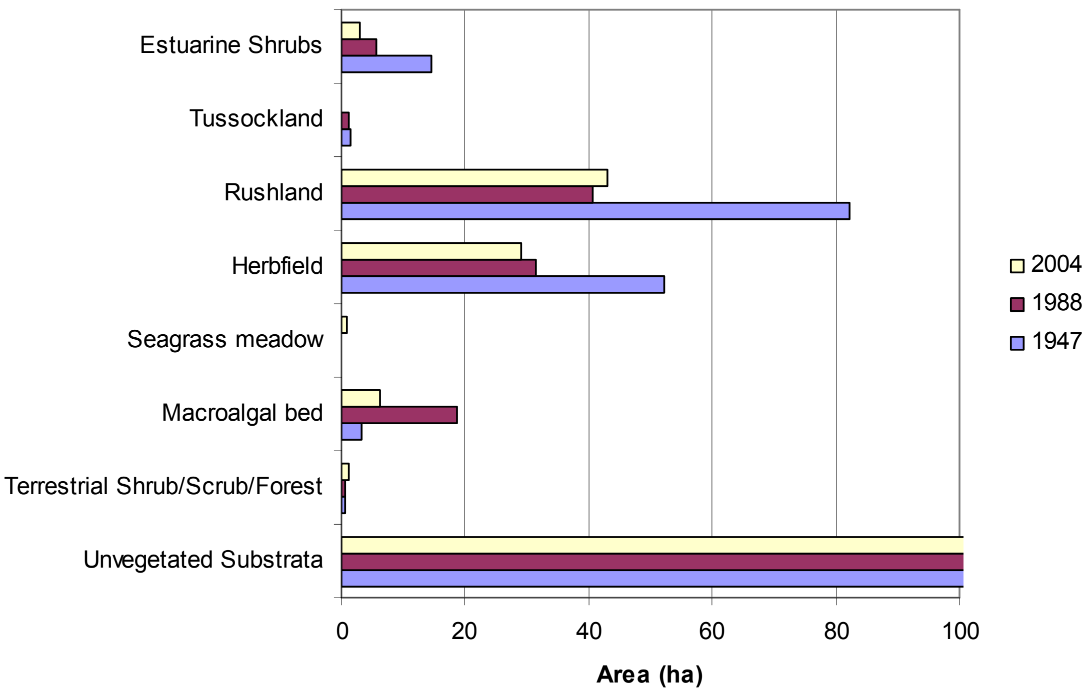

Figure 5. Comparative bar chart of areas of selected structural class habitats of the Moutere Inlet across the three surveys.

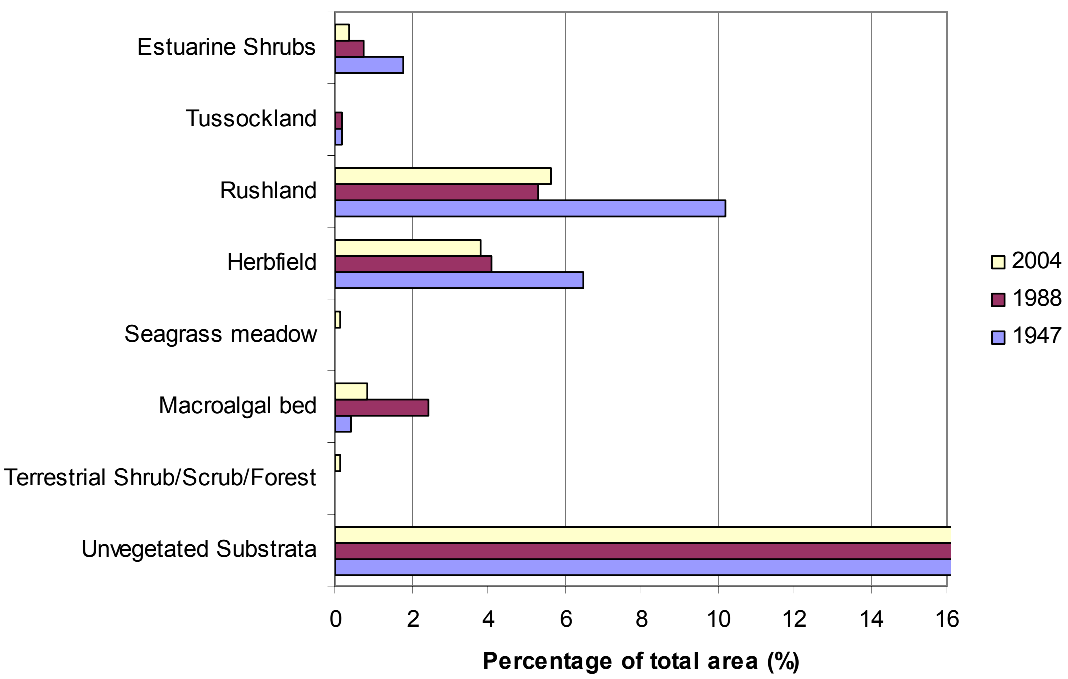

Figure 6. Comparative bar chart of percentage area of selected structural class habitats of the Moutere Inlet across the three surveys.

Table 1. Dominant habitats of the Moutere Inlet.

	1947		1988		2004	
	Area (ha)	% Total Area	Area (ha)	% Total Area	Area (ha)	% Total Area
Terrestrial Shrub/Scrub/Forest	**0.50**	**0.06**	**0.48**	**0.06**	**1.25**	**0.16**
Knightia excelsa (Rewarewa)	0	0	0	0	0.65	0.08
Leptospermum scoparium (Manuka)	0.50	0.06	0.48	0.06	0.51	0.07
Ulex europaeus (Gorse)	0	0	0	0	0.10	0.01
Estuarine Shrubs	**14.58**	**1.81**	**5.67**	**0.74**	**2.98**	**0.39**
Plagianthus divaricatus (Saltmarsh ribbonwood)	14.58	1.81	5.67	0.74	2.98	0.39
Grassland	**0**	**0**	**0**	**0**	**0.35**	**0.05**
Festuca arundinacea (Tall fescue)	0	0	0	0	0.35	0.05
Herbfield	**52.35**	**6.50**	**31.43**	**4.10**	**29.08**	**3.82**
Disphyma australe (NZ Ice Plant, Horokaka)	0	0	0	0	0.02	0.00
Sarcocornia quinqueflora (Glasswort)	52.35	6.50	31.43	4.10	29.06	3.82
Suaeda novaeûzelandiae (Sea blite)	0	0	0	0	0.01	0.00
Tussockland	**1.56**	**0.19**	**1.30**	**0.17**	**0.27**	**0.04**
Carex spp. (Sedge)	1.56	0.19	1.30	0.17	0.27	0.04
Rushland	**82.27**	**10.22**	**40.80**	**5.33**	**42.56**	**5.59**
Isolepis nodosa (Knobby clubrush)	3.51	0.44	3.06	0.40	6.13	0.80
Juncus kraussii (Searush)	77.88	9.67	37.38	4.88	35.79	4.70
Leptocarpus similis (Jointed wirerush)	0.89	0.11	0.35	0.05	0.65	0.08
Reedland	**0**	**0**	**0**	**0**	**0.09**	**0.01**
Typha orientalis (Raupo)	0	0	0	0	0.09	0.01
Sedgeland	**0**	**0**	**0.06**	**0.01**	**0.22**	**0.03**
Schoenoplectus pungens (Three-square)	0	0	0.06	0.01	0.22	0.03
Introduced Weeds	**0**	**0**	**0**	**0**	**0.06**	**0.01**
Unidentified introduced weeds	0	0	0	0	0.06	0.01
Seagrass meadow	**0**	**0**	**0.17**	**0.02**	**0.91**	**0.12**
Zostera sp (Eelgrass)	0	0	0.17	0.02	0.91	0.12
Macroalgal bed	**3.41**	**0.42**	**18.61**	**2.43**	**6.34**	**0.83**
Gracilaria chilensis	3.41	0.42	18.61	2.43	6.34	0.83
Unvegetated + Water	**650.53**	**80.79**	**667.17**	**87.13**	**677.30**	**88.95**
Total Area of Estuary	**805.20**		**765.68**		**761.41**	

4.2. Ecological implications of change

An ecosystem services valuation study (Constanza et al. 1997) found that estuaries had amongst the highest values of all ecosystem types. Ecosystem services provided by estuaries include nutrient retention and recycling, disturbance regulation, feeding, breeding and nursery grounds for biota, sediment retention, habitat for resident and transient populations, mitigation for point and non-point source waste discharges, water regulation, food production, recreational and cultural pursuits. Any decrease in estuary area represents a decrease in these values.

The most significant habitat losses within Moutere Inlet over the past 50+ years have been in the area coverage of rushland, herbfield and estuarine shrubs (Figures 5 and 6). These are potentially productive habitats that can contribute significantly to the coastal food web (Gillespie 1983). Their function as a buffer between land and sea is well known (Knox 1986; Kennish 1990). For example, such plant communities intercept and temporarily retain pulses of elevated terrestrial inorganic nutrient inflow that could otherwise contribute to the cyclic "boom or bust" productivity of coastal phytoplankton and benthic microalgae (Gillespie 1983). These short-term pulses of nutrients are then released more gradually over the longer term, largely in a combined (organic) form (e.g. detrital particles and/or dissolved organic materials) thereby nourishing the coastal food web in a more ecologically stable manner. Although these functional attributes are well known, and the effects of habitat loss are likely to be cumulative, it is not possible to estimate the impacts of the observed habitat changes in Moutere Inlet beyond a broad theoretical consideration.

Roading on the western side of the Inlet has created a series of embayments. One of the embayments is permanently cut off from the estuary and is permanently filled with freshwater. The other embayments are open to the estuary by culverts, which allow tidal flushing but likely restrict flow to some extent. This may affect biota such as fish that move into the estuary fringe at high tide. Terrestrial vegetation (e.g. various species of grasses) that grow along the extreme upper intertidal fringe provide important spawning sites for native galaxids (whitebait). Where spring high tides impinge on unvegetated shoreline (e.g. hard substrates imposed by rocky or gravel road margins) such spawning habitat will be limited.

By 1947, the vegetation around the estuary margins was likely already composed primarily of exotic species. The majority of the land surrounding the estuary was farmed or forested, and this was still the case in 2004. In 1947, a large proportion of the vegetation on the estuary margin was likely made up of exotic grasses and trees (especially *Pinus radiata*).

We conclude that substantial loss of peripheral vegetated habitat and localised restriction in flushing efficiency has occurred in Moutere Inlet during the period 1947-2004. However we can assume that considerably greater changes occurred prior to 1947. This alteration in physical and biological structure relating to human activities (primarily roading and other shoreline development) is cumulative and is likely to have resulted in significant modification of ecosystem function. Partial recovery of estuarine function could be achieved by road bridging and/or culvert installation in conjunction with saltmarsh revegetation.

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Appendix 1. Adapted estuarine components of UNEP-GRID classification

Level I **Hydrosystem**	**Level IA** **Sub-System**	**Level II** **Wetland Class**	**Level III** **Structural Class**	**Level IV** **Dominant Cover**	**Habitat** **Code**
Estuary **(alternating saline and freshwater)**	Intertidal/ supratidal	Saltmarsh	Grassland	*Ammophila arenaria*, “Marram grass’ *Elytrigia pycnanph*,, “Sea couch” *Festuca arundinacea*, “Tall fescue” *Paspalum distichum*, “Mercer grass”	Amar Elpy Fear Padi
			Herbfield	*Apium prostratum*, “Native celery” *Cotula coronopifolia* , “Bachelor’s button” *Leptinella dioica* *Plantago coronopus*, “Buck’s-horn plantain” *Samolus repens*, “Primrose” *Sarcocornia quinqueflora*, “Glasswort” *Selliera radicans*, “Remuremu” *Suaeda novae – zelandiae*, “Sea blite” *Triglochin striata*, “Arrow-grass”	Appr Coco Ledi Plco Sare Saqu Sera Suno Trst
			Reedland	*Glyceria maxima*, “Reed sweetgrass” *Spartina anglica*, “Cord grass” *Spartina alterniflora*, “Smooth cord grass” *Typha orientalis*, “Raupo”	Glma Span Spal Tyor
			Rushland	*Baumea juncea*, “ Bare twig rush” *Isolepis nodosa*, “Knobby clubrush” *Juncus artoiculatus*, “Jointed rush” *Juncus effuses*, “Softrush” *Juncus kraussii*, “Searush” *Juncus pallidus*, “ Pale rush” *Leptocarpus similis*, “Jointed wirerush” *Wilsonia backhousei*	Baju Isno Juar Juef Jukr Jupa Lesi Wiba
			Sedgeland	*Cyperus eragrostis*, “Umbrella sedge” *Cyperus ustulatus*, “Giant umbrella sedge *Eleocharis sphacelata*, “Bamboo spike-sedge” *Isolepis cernua*, “Slender clubrush” *Schoenoplectus pungens*, “Three-square”	Cyer Cyus Elsp Isce Scpu
			Scrub	*Avicennia marina var. resinfera*, “Mangrove” *Cordyline australis*, “Cabbage tree” *Cytisus scoparius*, “Broom” *Leptospermum scoparium*, “Manuka” *Plagianthus divaricatus*, “Saltmarsh ribbonwood” *Ulex europaeus*, “Gorse”	Avre Coau Cysc Lesc Pldi Uleu
			Tussockland	*Cortaderia* sp., “Toetoe” *Phormium tenax*, “New Zealand flax” *Poa*, “Silver tussock” *Puccinella stricta*, ”Salt grass” *Stipa stipoides*, “Needle tussock”	Co sp Phte Poa Pust Stst
		Seagrass meadows	Seagrass meadow	*Zostera sp*, “Eelgrass”	Zo sp
		Macroalgal bed	Macroalgal bed	*Enteromorpha* sp. *Gracilaria chilensis* *Ulva sp*, “Sea lettuce”	En sp Grch Ulri

Appendix 1. continued.

Level I **Hydrosystem**	**Level IA** **Sub-System**	**Level II** **Wetland Class**	**Level III** **Structural Class**	**Level IV** **Dominant Cover**	**Habitat** **Code**
		Mud/sandflat	Firm shell/sand (<1cm) Firm sand (<1cm) Soft sand Mobile sand (<1cm) Firm mud/sand (0-2cm) Soft mud/sand (2-5cm) Very soft mud/sand (>5cm)		FSS FS SS MS FMS SM VSM
		Stonefield Boulderfield Rockland Shell bank Shellfish field Worm field	Gravel field Cobble field Boulder field Rockland Shell bank Cocklebed Musselreef Oysterreef Sabellid field		GF CF BF RF Shell Cockle Mussel Oyster Sabellid
	Subtidal	Water	Water		Water

Appendix 2. Definitions of Classification Level III Structural Class

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 in which the 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 in which the lichen cover exceeds that of any other growth form or bare ground.

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. If the reed is broken the stem is both round and hollow – somewhat like a soda straw. The flowers will each bear six tiny petal-like structures – neither grasses nor sedges will bear flowers, which look like that. Reeds are herbaceous plants growing in standing or slowly-running water that have tall, slender, erect, unbranched leaves or culms that are either hollow or have a very spongy pith. Examples include *Typha, Bolboschoenus, Eleocharis sphacelata,* and *Baumea articulata.*

Rushland: Vegetation in which the cover of rushes in the canopy is 20-100% and in which the rush cover exceeds that of any other growth form or bare ground. A tall grass-like, often hollow-stemmed plant, included in the rush growth form are some species of *Juncus* and all species of*, Leptocarpus.* Tussock-rushes are excluded.

Sedgeland: Vegetation in which the cover of 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. Included in the sedge growth form are many species of *Care* and *Uncinia,*. Tussock-sedges and reed-forming sedges (c.f. REEDLAND) are excluded.

Scrub: Woody vegetation in which the 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 diameter at breast height (dbh).

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 >10 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.*

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 dbh. Tree ferns ≥10cm dbh are treated as trees.

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 that can be seen without the use of a microscope.

Firm mud/sand: A mixture of mud and sand, the surface appears brown, and many have a black anaerobic layer below. When walking on the substrate 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 walking on the substrate 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 on the substrate you'll sink greater than 5 cm.

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 less than 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 impossible.

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

Stonefield/gravelfield: Land in which the area of unconsolidated gravel (2-20 mm diameter) and/or bare stones (20-200 mm diameter) exceeds the area covered by any one class of plant growth-form. The appropriate name is given depending on whether stones or gravel form the greater area of ground surface. Stonefields and gravelfields are named from the leading plant species when plant cover of ≥1%.

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

Rockland: Land in which the area of residual bare rock exceeds the area covered by any one class of plant growth-form. Cliff vegetation often includes rocklands. They are named from the leading plant species when plant cover is ≥1%.

Cocklebed: Area that is dominated by primarily dead cockle shells.

Musselreef: Area that is dominated by one or more mussel species.

Oysterreef: Area that is dominated by one or more oyster species.

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