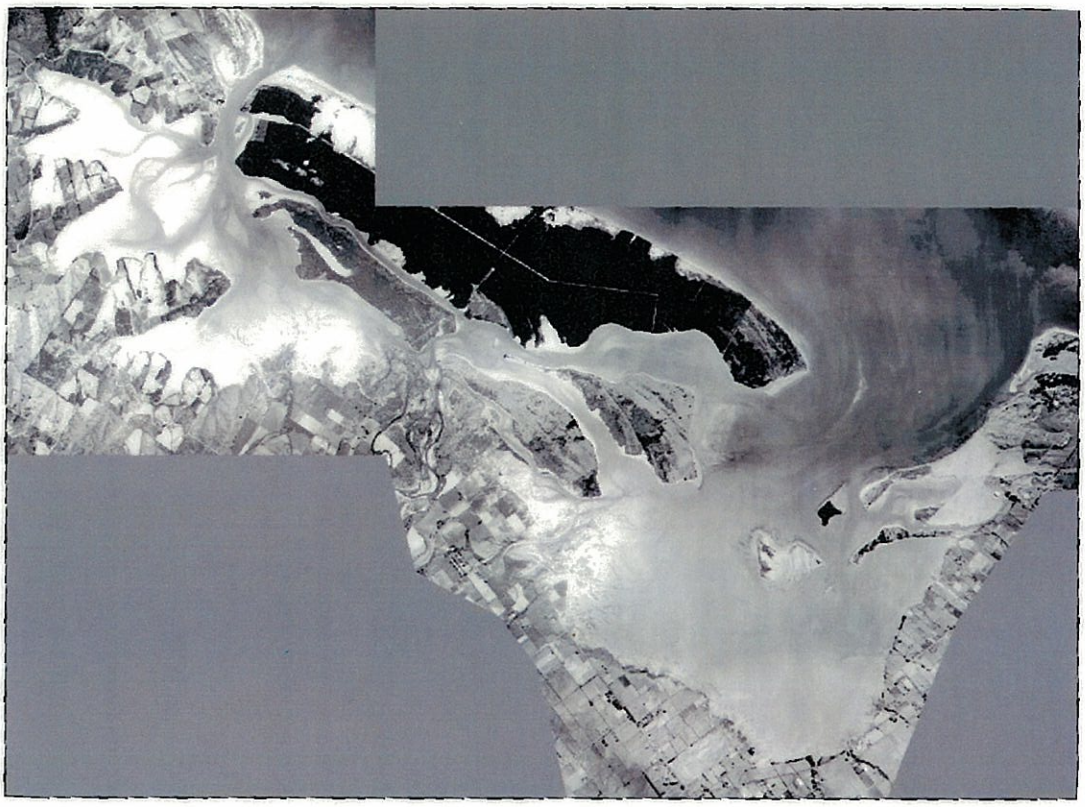
Cawthron Report No. 828

CAWTHRON

Broad Scale Mapping of Waimea and Ruataniwha Estuaries using Historical Aerial Photographs



Prepared for

Tasman District Council

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Broad Scale Mapping of Waimea and Ruataniwha Estuaries using Historical Aerial Photographs

Prepared for

Tasman District Council

by

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This document is an accompanying report to the two CD-ROMs entitled 'Broad Scale Mapping of Waimea and Ruataniwha Estuaries using Historical Aerial Photographs'.

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1. INTRODUCTION

Estuaries are highly productive areas that play an important role as a boundary between land and sea. An estuary provides a link between terrestrial and marine ecosystems and nourishes the marine food web (Gillispie, 1983). They can encompass high-value ecological habitat and resources of cultural, recreational and commercial importance.

In 2002, a national protocol for estuarine environment assessment and monitoring for New Zealand estuaries was completed (Robertson *et al.* 2002). This three year project was partly funded by the Ministry of the Environment (MfE) Sustainable Management Fund (SMF) and a number of councils around the country. Part of this project involved a detailed point-in-time, spatial description of the major intertidal habitats of nine New Zealand estuaries using a methodology known as broad-scale habitat mapping. Two of the estuaries included were the Waimea Estuary (Tasman Bay) and the Ruataniwha Estuary (Golden Bay).

The aim of the broad-scale habitat mapping was to describe the intertidal environment according to different dominant habitat types based on surface features of substrate characteristics (mud, sand, cobble, *etc*) and vegetation type (mangrove, eelgrass, salt marsh species, *etc*), in order to develop a baseline map (Robertson *et al.* 2002). Once a baseline map has been constructed, changes in the position and/or size of habitats (MfE Confirmed Indicators for the Marine Environment, ME6 2001) can be assessed by repeating the mapping exercise. This information can then be used to evaluate the implications of flood events (and ultimately land use characteristics and related river water quantity and quality) on the structure and function of the intertidal ecosystem. This procedure involves the use of aerial photography together with detailed ground-truthing and digital mapping using Geographical Information System (GIS) technology. An outline of the approach is provided in detail in Robertson *et al.* (2002) and in summary below.

Cawthron was commissioned by the Tasman District Council in 2002 to undertake historical broad scale mapping of the Waimea and Ruataniwha estuaries. The purpose of the project was to use the recent broad scale maps produced as part of the estuary monitoring protocol (Robertson *et al.* 2002) as a guide, to produce broad scale maps using historical black and white aerial photos of the Waimea and Ruataniwha estuaries. Aerial photographs of the Waimea Estuary were obtained for the years 1946 and 1985, and for the Ruataniwha Estuary aerial photographs were obtained for the years 1950 and 1972. This report presents a brief outline of the methodologies, a summary of the

dominant habitat types for each of the study years and two CD-ROMs containing the detailed habitat maps.

2. METHODS

2.1 Construction of recent broad scale maps

The methodologies used to construct recent broad scale maps for the estuary monitoring protocol are detailed in Robertson *et al.* (2002) and summarised below.

2.1.1 Aerial photography

Both recent colour aerial photographs were provided by Aerial Surveys Ltd, Nelson and were supplied as rectified tiff files at a scale of 1:10,000. The Waimea photo was taken in March 1999 and the Ruataniwha photo was taken in December 2000.

2.1.2 Classification of habitat features

The classification of the features followed the proposed national classification system (with adaptations), which was developed under a Ministry of the Environment SMF (Sustainable Management Fund) programme (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;

- Level I: Hydrosystem (*e.g.* intertidal river delta)
- 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*)

Substrate classification was based on surface layers only and did not consider underlying substrate; *e.g.* cobble or gravel fields covered by sand would be classed as sand flat. The classification of habitats in the current study was based on Level III and Level IV. A list of all the classification types used in the study and their codes are given in Table 1, followed by the definitions for classification of the Level III structural class. Further detail is provided in Section 3.

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

Table 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)		FSS
			Firm sand (<1cm)		FS
			Soft sand		SS
			Mobile sand (<1cm)		MS
			Firm mud/sand (0-2cm)		FMS
			Soft mud/sand (2-5cm)		SM
			Very soft mud/sand (>5cm)		VSM
		Stonefield	Gravel field		GF
			Cobble field		CF
		Boulderfield	Boulder field		BF
		Rockland	Rockland		RF
		Shell bank	Shell bank		Shell
		Shellfish field	Cocklebed		Cockle
			Musselreef		Mussel
			Oysterreef		Oyster
		Worm field	Sabellid field		Sabellid
	Subtidal	Water	Water		Water

2.1.3 Ground-truthing of habitat features

Field surveys were undertaken at each estuary to verify photography, and identify dominant habitat and map boundaries. The approach involved an experienced estuarine scientist plus a technician walking over the whole estuary at low-mid tide, identifying the dominant habitats and their boundaries and recording these as codes on aerial images at a scale of approximately 1:5,000 or 1:10,000. The upper boundary was set at MHWS (Mean High Water Spring), however in some areas supra-littoral habitat was included where it was considered integral with the upper intertidal. The lower boundary was set at MLWS (Mean Low Water Spring). The substrate types and their spatial extents were confirmed by field verification of the textural and tonal patterns identified on the aerial photographs. The codes and list of dominant habitat types, including various categories of bare and vegetated substrate, are shown in Table 1.

2.1.4 Digitisation of habitat boundaries

Vegetation and substrate features were then digitally mapped on-screen from the rectified photographs using the Arcview™ software package 'image analysis' extension. This procedure required using the mouse to draw habitat boundaries overlaid on rectified aerial photographs on the computer screen, as precisely as possible, around the features identified from the field surveys.

Each drawing was then saved to a shape file or GIS layer associated with each specific feature. To calculate the area cover for a chosen habitat type, the Arcview 'X-tools' extension was used. This provided the area of any selected features in hectares.

2.2 Construction of historical broad scale map

2.2.1 Black and white aerial photography

The historical photographs used for both estuary studies were supplied by New Zealand Aerial Mapping Ltd. and were provided as black and white tiff files at a scale of 1:10,000. The tiff files had not been rectified. The Waimea photographs were taken on December 6 1946 and September 13 1985. The Ruataniwha photographs were taken on October 11 1950 and October 29 1972.

2.2.2 Rectification of tiff files

The tiff files were rectified within ArcView using the 'image analysis' extension used in section 2.1.4. Several features common to both the historical photographs (tiff files) and the rectified images used to generate the recent broad scale maps were located (*i.e.* the corner of a house or intersection of roads). These locations became control points. Using an 'align' tool within ArcView, the locations within the historical photographs (tiff files) corresponding to the control points created from the rectified images were matched. Once the images were matched, the tiff files were saved as rectified images.

2.2.3 Digitisation of habitat boundaries

As previously described in Section 2.1.4, vegetation and substrate features were then digitally mapped on-screen from the rectified photos. Wherever possible, the shape files generated from the recent broad scale maps were manipulated so that they corresponded to the habitat boundaries of the historical photograph. To calculate the area cover for a chosen habitat type, the Arcview 'X-tools' extension was used. This gave the area of any selected features in hectares.

There was an abundance of *Spartina anglica* (cord grass) present in the 1985 photograph of the Waimea Estuary that was not present in the other years. Identification of *S. anglica* was achieved with the assistance of a publication by Franko *et al.* (1987), which includes a map identifying the locations of *S. anglica* and native intertidal vegetation within the Waimea Estuary in 1987. The distinct tone, texture and shape of *S. anglica* also aided in its identification.

2.2.4 Limitations of methodology

Historical photographs, particularly the earlier ones, were of poor quality (the photographs were black and white and the resolution was low) and consequently the definition of the boundaries in the mapping process was unclear. In particular, it was difficult to distinguish categories within the unvegetated habitat from historical photographs without groundtruthing. Consequently, the extent of soft muds, cobbles, sands *etc.* in the estuary in earlier years was not mapped but the overall boundary of these habitats were easily apparent.

Another limitation, due to the poor quality of the Waimea Estuary historical photographs, was the difficulty in distinguishing seagrass meadows (*Zostera* sp.) from the unvegetated substrate. As a consequence, the historical maps of Waimea could not be used to identify historical changes in seagrass habitat.

In addition, there was evidence from the earliest photographs of both estuaries that reclamation of a portion of the tidal flats had occurred, but because the vegetation buffer between estuary and agricultural land was larger and identification of vegetation difficult, the boundary between land and estuary was blurred. When identification of this vegetation was impossible, the vegetation was classified as unknown. This made locating habitat boundaries difficult as there was less range in tone and texture compared with the colour photographs used for the recent broad scale maps. In vegetation patches where more than one type of vegetation was dominant, it was often difficult to distinguish between the different types of vegetation. When this problem could not be resolved, as a last resort instead of having two shape files relating to two different dominant habitats (*i.e. Leptocarpus similis* and *Juncus krausii*), one shape file was created encompassing both of the habitats. It is inevitable that in situations where judgement calls are required, there is the possibility of introducing errors.

Unfortunately, the Ruataniwha Estuary historical photographs did not cover the total area that the 2000 broad scale map included (mainly the unvegetated delta region at the estuary mouth). In order that the results produced by the 1950 and 1972 broad scale maps could be compared with those from the 2000 broad scale map, the area of delta region (165 ha) was added to the total estuary area and the unvegetated substrate and water area for the 1950 and 1972 broad scale map results.

3. CLASSIFICATION AND DEFINITIONS OF HABITAT TYPES

3.1 Habitat codes and terminology

The identified vegetation patches were classified using an interpretation of the Atkinson (1985) system (Table 1), described below:

- The individual plant species have been coded by using the two first letters of their Latin species and genus names *e.g.* Pldi = ribbonwood, *Plagianthus divaricatus*.
- / separates canopy vegetation *e.g.* Pldi/Lesi (ribbonwood is taller than jointed wire rush).
- - separates vegetation with approximately the same height *e.g.* Lesi-Jukr (jointed wire rush is the same height as searush).
- ( ) are used for subdominant species *e.g.* (Pldi)/Lesi = dominant cover is jointed wire rush and subdominant cover is ribbonwood. The use of ( ) is not based on percentage cover but the subjective observation of which vegetation is the dominant or subdominant species within the patch.
- The classification always starts with the tallest vegetation type and works down *e.g.* (Pldi/Baju)/Lesi-Jukr = a patch with a dominant cover of jointed wire rush and searush (which are of the same height) with a subdominant cover of ribbonwood and *Baumea juncea* (which are taller than the dominant cover).

3.2 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, Scirpus lacutris, 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 grasslike, 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 *Carex, Uncinia,* and *Scirpus*. 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 occassionally 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 diam.) 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 (> 200mm diam.) 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 oysters species.

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

4. RESULTS

4.1 Waimea Estuary

4.1.1 1946 Habitat Map

Refer to Figures 1, 2, 4 and 5 and Table 2. The 1946 broad-scale survey produced a total estuary area of 3341 ha, of which unvegetated substrate and water were dominant (89.6% of estuary area, covering 2992 ha). The vegetated area was dominated by herbfield (4.9% of the total estuary area, covering 165 ha) and rushland (3.7% of the total estuary area, covering 126 ha). Of herbfield, *Sarcocornia quinqueflora* (glasswort) was most dominant (4.2% of the total estuary area). The majority of rushland was *Juncus krausii* (searush) (2.3% of the total estuary area) and patches where both *Leptocarpus similis* (jointed wirerush) and *Juncus krausii* were dominant (0.9% of the total estuary area). An unknown vegetation type was dominant for 1.1% of the total estuary area. There were also minor areas containing scrubs, tussocks and reeds.

4.1.2 1985 Habitat Map

Refer to Figures 1, 2, 3, 6 and 7 and Table 2. The 1985 broad-scale habitat map featured a total estuary area of 3214 ha, of which unvegetated substrate and water were dominant (91.6% of estuary area, covering 2952 ha). The vegetated area was again dominated by herbfield (3.7% of the total estuary area, covering 120 ha) and rushland (3% of the total estuary area, covering 96 ha). *Sarcocornia quinqueflora* was the most dominant herbfield vegetation (3.6% of the total estuary area). The majority of rushland was *Juncus krausii* (2.2% of the total estuary area). A major difference from the 1946 broad scale map was the appearance of the reed, *Spartina anglica* (cord grass) which covered 1.4% of the total estuary area. There were also minor areas containing tussocks, sedges, grasses and scrubs.

4.1.3 1999 Habitat Map

Refer to Figures 1 and 2 and Table 2. The most recent broad-scale survey of Robertson *et al.* (2002) described Waimea Estuary as having a total estuary area of 3206 ha, of which unvegetated substrate and water were dominant (92.7% of estuary area, covering 2971 ha). Herbfield was again dominant (3.9% of the total estuary area, covering 124 ha). The dominant herbfield species was *Sarcocornia quinqueflora* (3.9% of the total estuary area). Rushland was also dominant (3.0% of the total estuary area, covering 97 ha). The dominant rushland species was *Juncus krausii* (2.1% of

the total estuary area). Tussockland accounted for 0.3% of the total estuary area of which *Stipa stipoides* (needle tussock) was the dominant species. There were also minor areas containing grasses, sedges and reeds.

Table 2 The broad-scale details of the habitat mapping of the Waimea Estuary

	1946		1985		1999	
	Area (ha)	% Total Area	Area (ha)	% Total Area	Area (ha)	% Total Area
Herbfield	**164.74**	**4.90**	**120.34**	**3.74**	**123.67**	**3.86**
Sarcocornia quinqueflora	142.84	4.24	117.00	3.64	119.22	3.72
Samolus repens	0.10	0	0.32	0.01	0.92	0.03
Juncus kraussii - Sarcocornia quinqueflora	10.56	0.31	3.02	0.09	0.55	0.02
Puccinella stricta - Sarcocornia quinqueflora	9.49	0.28	0	0	0.98	0.03
Sarcocornia quinqueflora - Wilsonia backhousei	1.75	0.05	0.26	0.01	2.01	0.06
Rushland	**125.76**	**3.74**	**95.94**	**2.99**	**97.30**	**3.03**
Juncus kraussii	76.69	2.28	71.00	2.21	66.99	2.09
Festuca arundinacea - Juncus kraussii	10.64	0.32	7.74	0.24	15.66	0.49
Leptocarpus similis	8.15	0.24	6.93	0.22	8.95	0.28
Juncus kraussii - Leptocarpus similis	30.28	0.90	9.24	0.29	4.14	0.13
Plagianthus divaricatus - Juncus pallidus - Leptocarpus similis	0.90	0.03	1.03	0.03	1.56	0.05
Scrubland	**15.94**	**0.47**	**3.20**	**0.10**	**3.28**	**0.10**
Plagianthus divaricatus	5.39	0.16	2.97	0.09	3.16	0.10
Plagianthus divaricatus - Sarcocornia quinqueflora	0.07	0	0.23	0.01	0.13	0
Plagianthus divaricatus - Leptocarpus similis	10.48	0.31	0	0	0	0
Tussockland	**6.87**	**0.20**	**6.99**	**0.22**	**9.54**	**0.30**
Stipa stipoides	2.58	0.08	4.91	0.15	6.70	0.21
Stipa stipoides - Sarcocornia quinqueflora	0.15	0	0.10	0	0.48	0.01
Juncus kraussii - Stipa stipoides	1.69	0.05	1.89	0.06	1.95	0.06
Festuca arundinacea - Stipa stipoides	0	0	0	0	0.34	0.01
Phormium tenax - Typha orientalis – Plagianthus divaricatus	0	0	0.09	0	0.06	0
Juncus kraussii - Stipa stipoides - Sarcocornia quinqueflora	2.45	0.07	0	0	0	0
Grassland	**0**	**0**	**0.01**	**0**	**0.38**	**0.01**
Festuca arundinacea	0	0	0.01	0	0.38	0
Sedgeland	**0**	**0**	**0.03**	0	**0.12**	**0**
Schoenoplectus pungens	0	0	0.03	0	0.12	0
Reedland	**0.01**	**0**	**43.51**	**1.35**	**0.01**	**0**
Typha orientalis	0.01	0	0.05	0	0.01	0
Spartina anglica	0	0	43.46	1.35	0	0
Unknown	**38.52**	**1.14**	**0**	**0**	**0**	**0**
Unvegetated + Water	**3016**	**89.63**	**2952**	**91.85**	**2971**	**92.68**
Total Area of Estuary	**3365**		**3214**		**3206**	

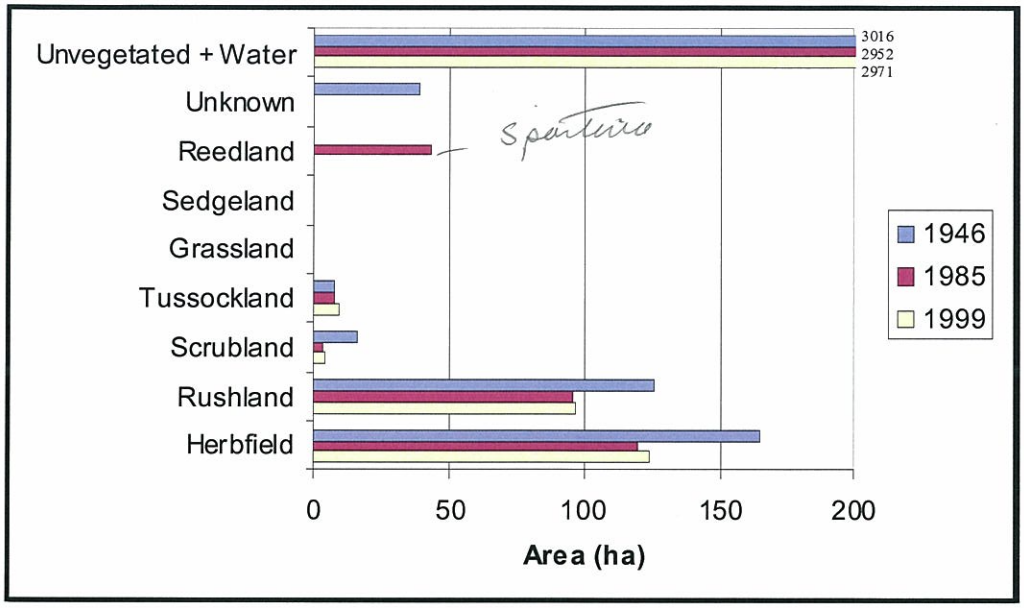

Figure 1 The areas of selected structural class habitats of the Waimea Estuary across three surveys

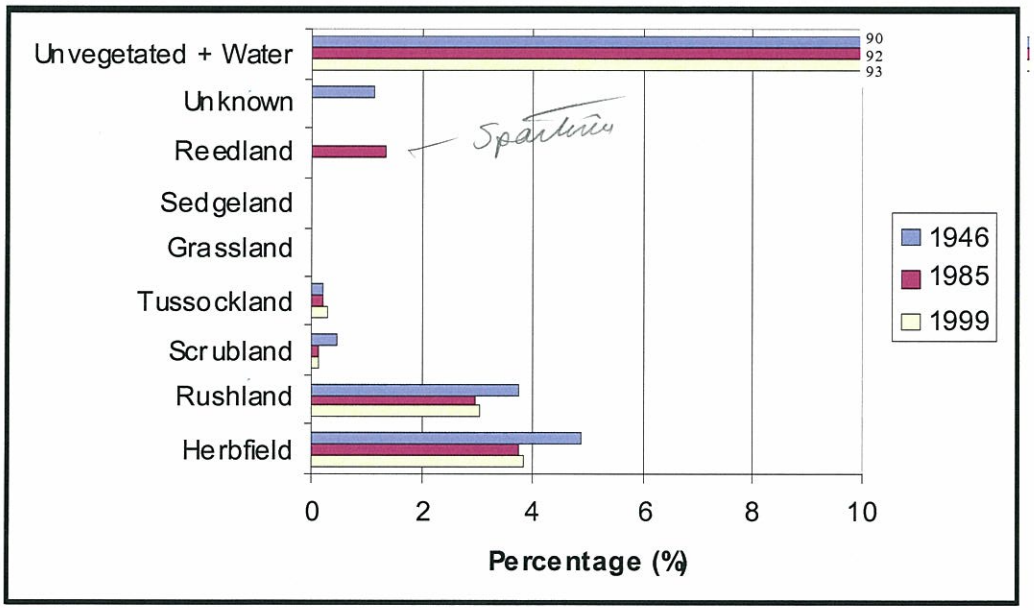

Figure 2 The percentage of areas of selected structural class habitats of the Waimea Estuary across three surveys

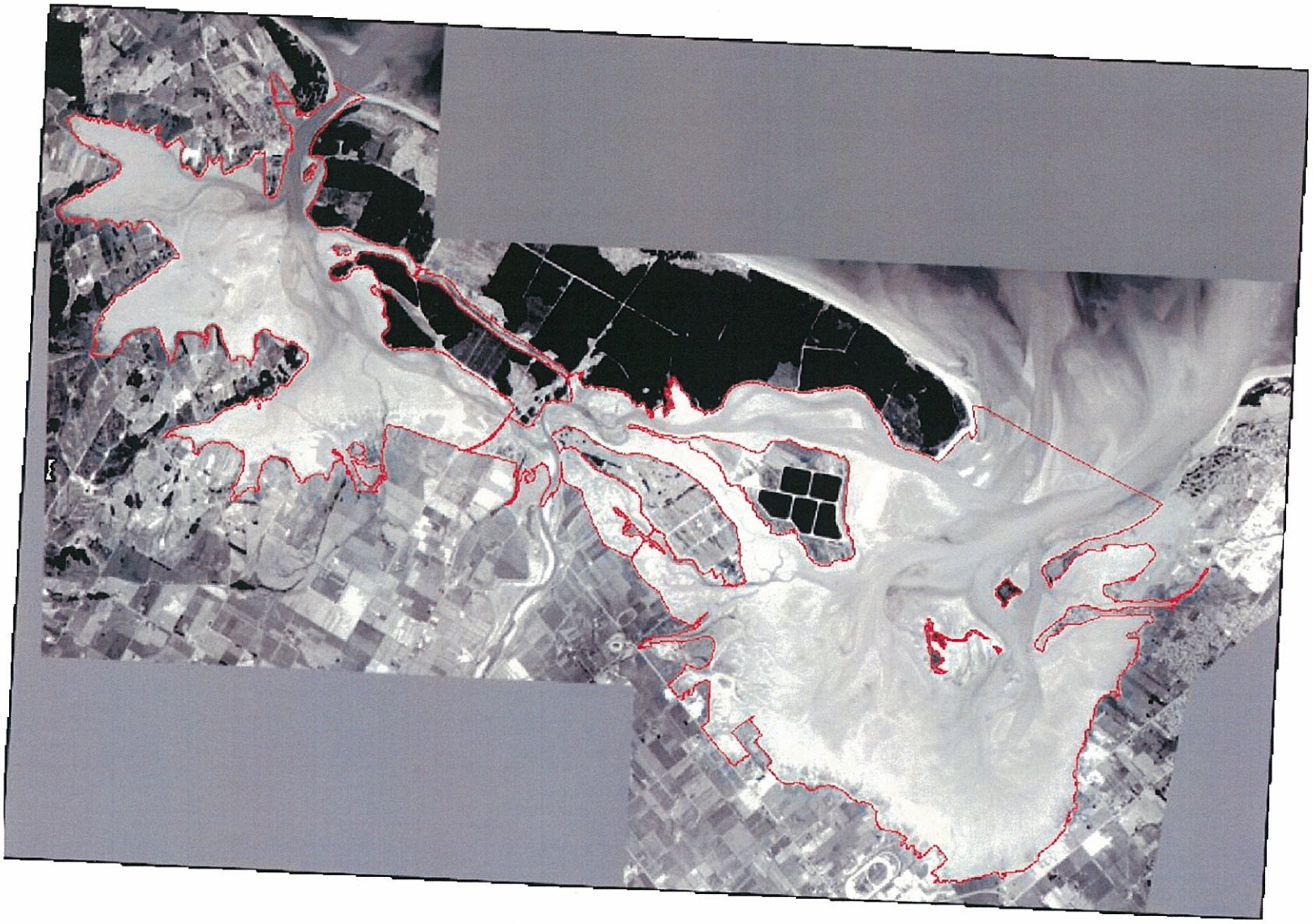

Figure 3 Estuary boundary (red line) for Waimea Estaury - 1985

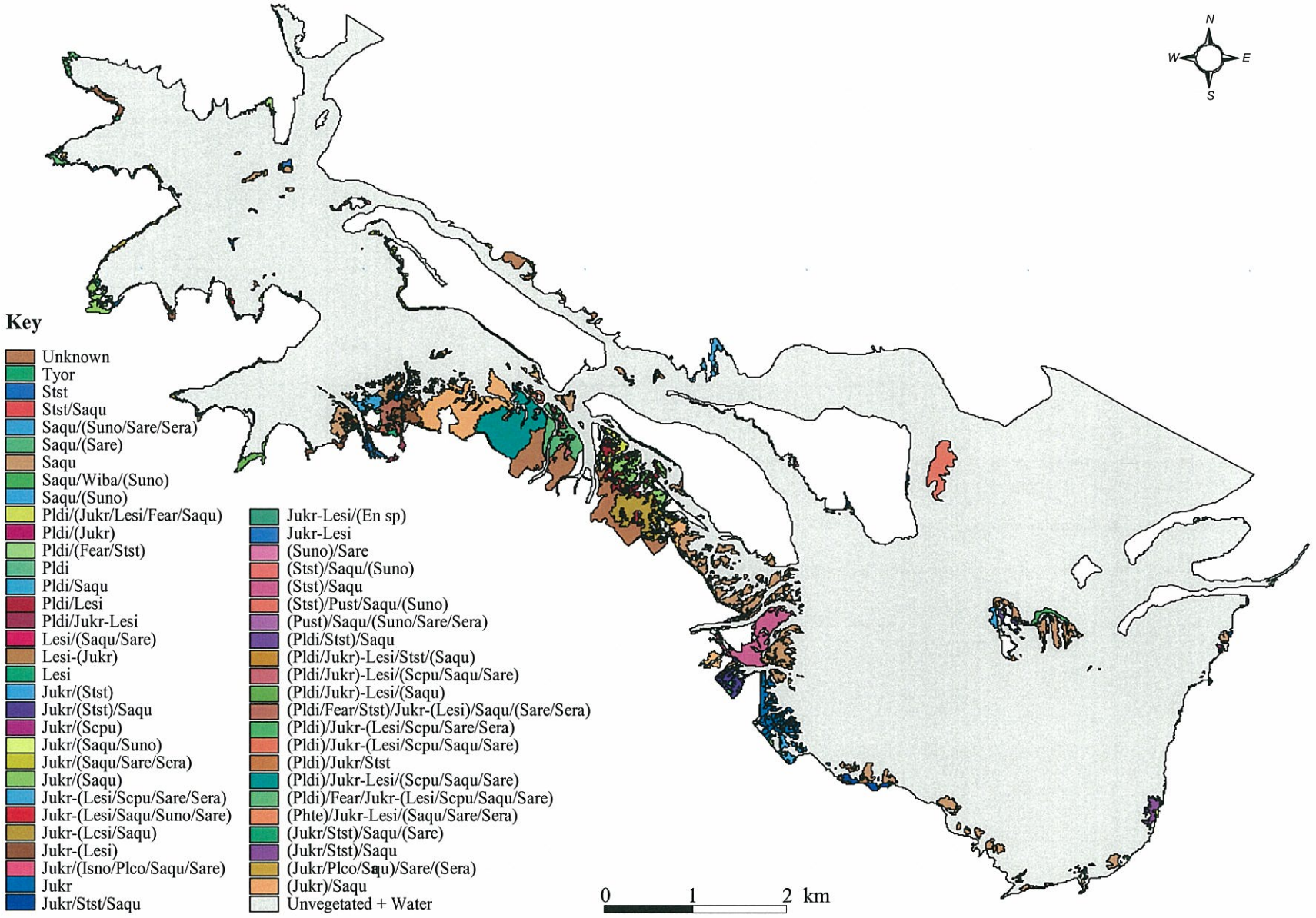

Figure 4 Dominant cover habitat of the Waimea Estuary - 1946

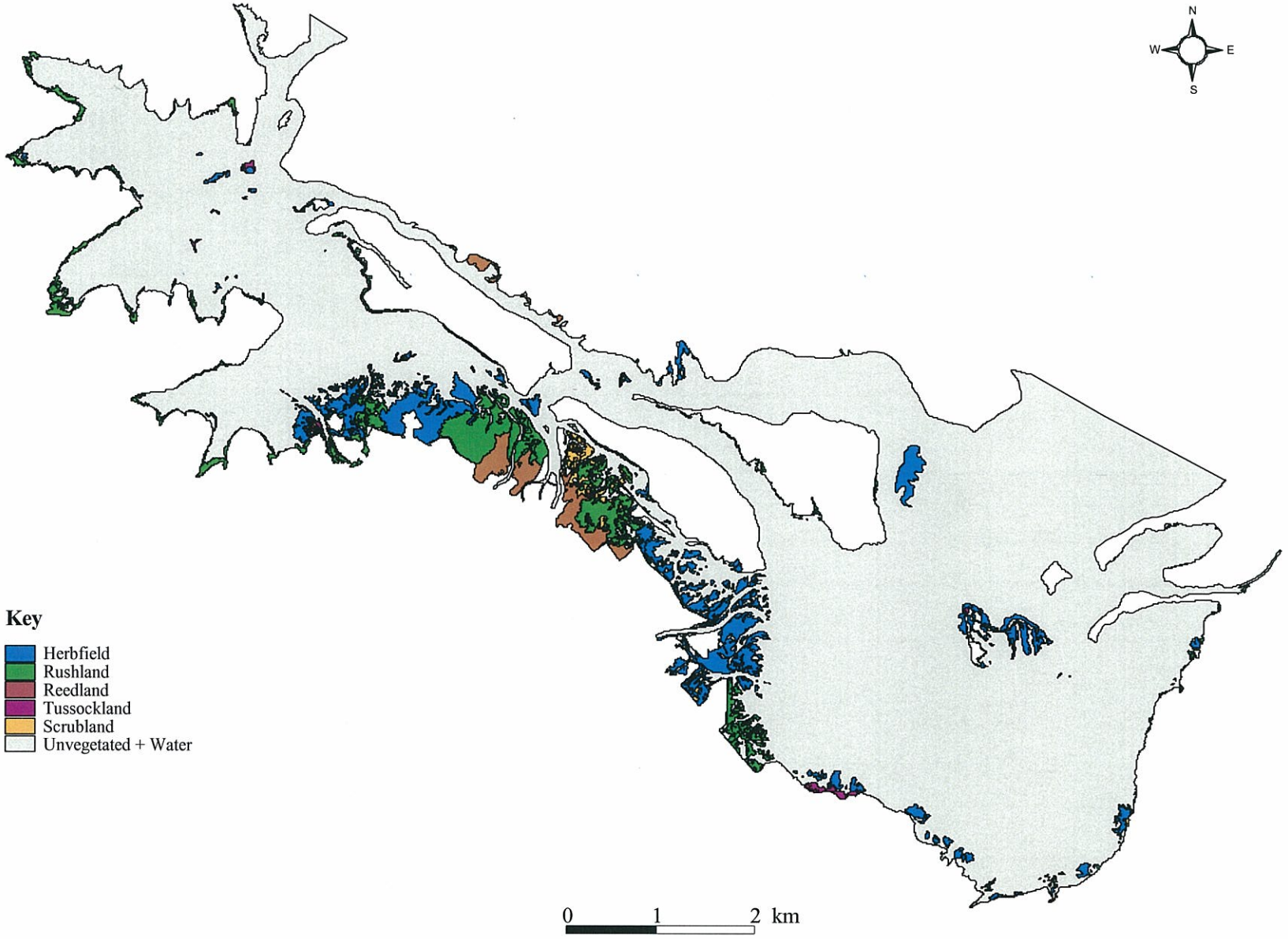

Figure 5 Structural habitat of the Waimea Estuary - 1946

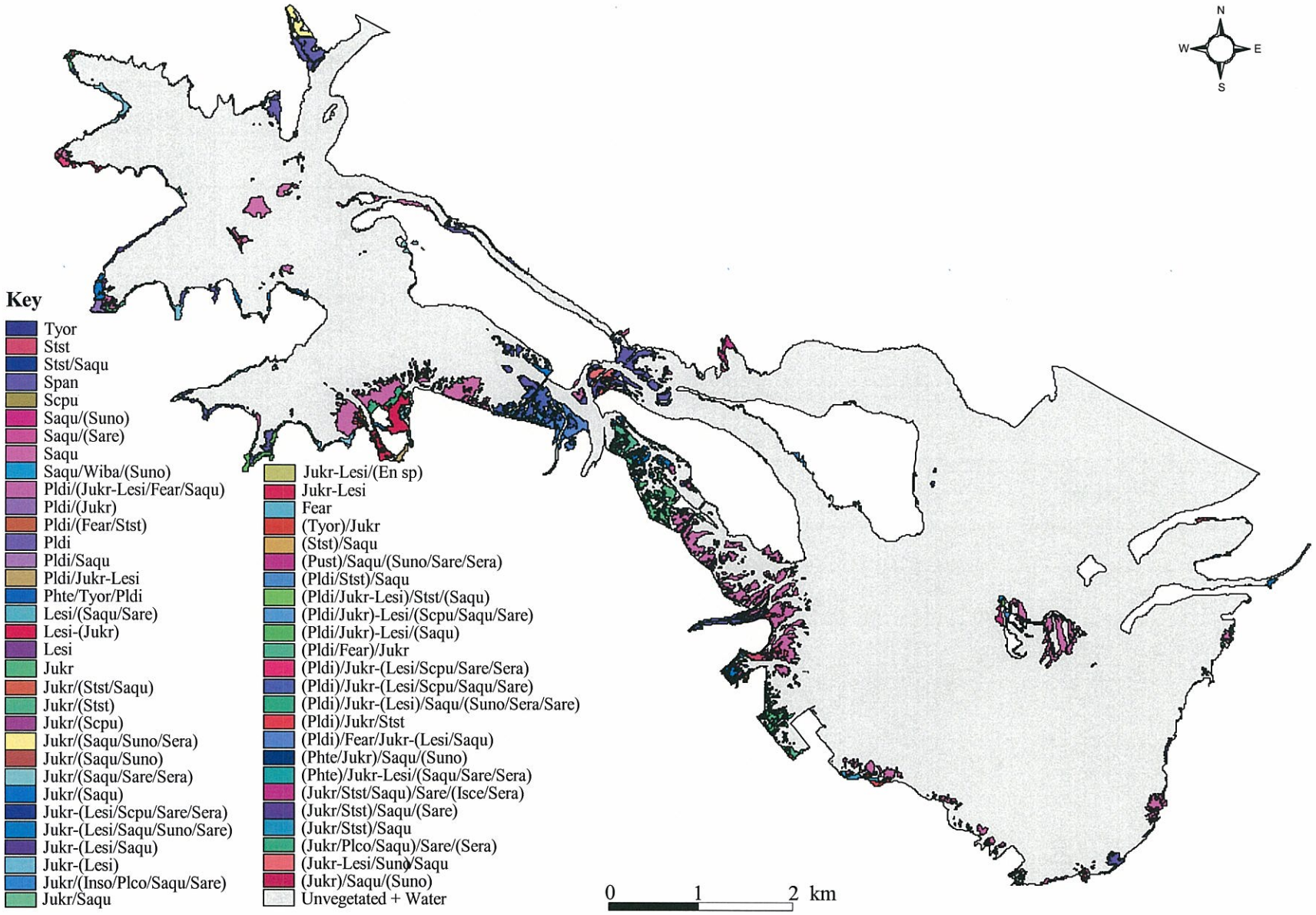

Figure 6 Dominant cover habitat of the Waimea Estuary - 1985

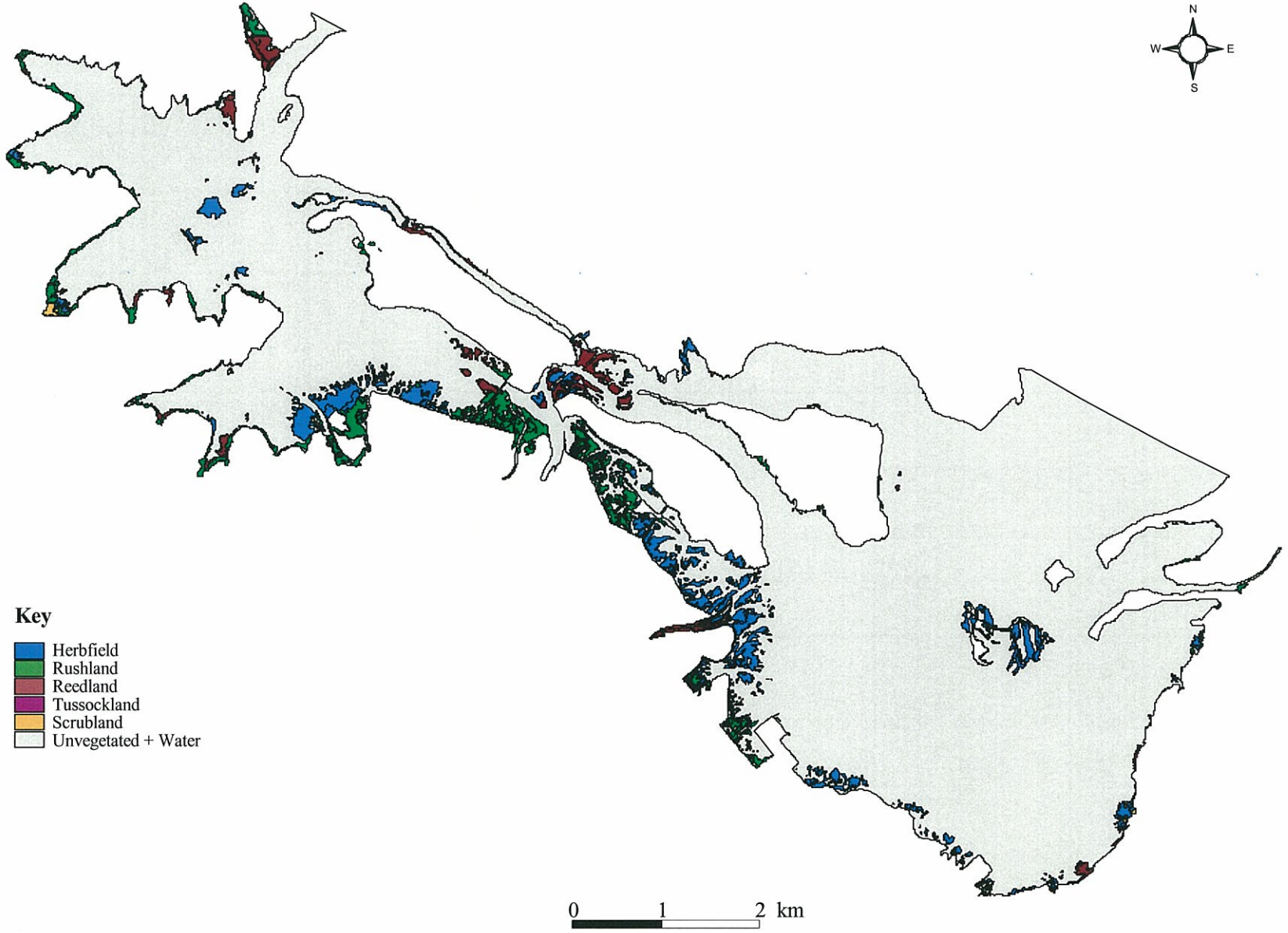

Figure 7 Structural habitat of the Waimea Estuary - 1985

4.2 Ruataniwha Estuary

4.2.1 1950 Habitat Map

Refer to Figures 8, 9, 11 and 12 and Table 3. The 1950 broad-scale habitat map featured a total estuary area of 911 ha, of which unvegetated substrate and water were dominant (80.1% of total estuary area, covering 737 ha). Rushland was the most abundant vegetation (13.4% of the total estuary area, covering 122 ha), of which *Juncus krausii* (7.6% of the total estuary area) and *Leptocarpus similis* (3.5% of the total estuary area) were dominant. Seagrass meadows of *Zostera* sp. covered 1.3% of the total estuary area. Unknown vegetation was dominant for 4.7% of the total estuary area. Scrubland accounted for 1.0% of the total vegetated area of which *Plagianthus divaricatus* was the dominant species. There are also minor areas containing tussocks, grasses, and herbs.

4.2.2 1972 Habitat Map

Refer to Figures 8, 9, 10, 13 and 14 and Table 3. The 1972 broad-scale survey featured a total estuary area of 877 ha of which unvegetated substrate and water were dominant (83.5% of estuary area, covering 732 ha). Again rushland was the most abundant vegetation (13.5% of the total estuary area, covering 118 ha) of which *Juncus krausii* (8.7% of the total estuary area) and *Leptocarpus similis* (3.2% of the total estuary area) were dominant. Seagrass meadows of *Zostera* sp. covered 1.5% of the total estuary area. Scrubland accounted for 1.6% of the total estuary area of which *Plagianthus divaricatus* was again the dominant species. 3.5% of the total estuary area was herbfield of which *Samolus repens* (Primrose) was dominant. There were also minor areas containing tussocks, grasses and unknown vegetation.

4.2.3 2000 Habitat Map

Refer to Figures 8 and 9 and Table 3. The most recent broad-scale habitat map produced by Roberston *et al.* (2002) estimated the total estuary area to be 863 ha, of which unvegetated substrate and water were dominant (84.6% of estuary area, covering 730 ha). As with the previous years, rushland was the most abundant vegetation (13.4% of the total estuary area, covering 115 ha) of which *Juncus krausii* (9.5% of the total estuary area) and *Leptocarpus similis* (3.6% of the total estuary area) were dominant. Seagrass meadows of *Zostera* sp. covered 1.4% of the total estuary area. Scrubland accounted for 1.6% of the total estuary area of which *Plagianthus divaricatus* was again the dominant species. There were also minor areas containing herbs, tussocks and grasses.

Table 3 The broad-scale details of the habitat mapping of the Ruataniwha Estuary

	1950		1972		2000	
	Area (ha)	% Total Area	Area (ha)	Area (ha)	% Total Area	Area (ha)
Herbfield	**1.43**	**0.16**	**8.92**	**1.02**	**3.45**	**0.40**
Sarcocornia quinqueflora	0.00	0.00	0.02	0.00	0.06	0.01
Samolus repens	1.43	0.16	2.59	0.29	3.34	0.39
Sarcocornia quinqueflora - Samolus repens	0	0	0	0	0.05	0.01
Juncus kraussii - Samolus repens	0	0	6.32	0.72	0	0
Rushland	**121.77**	**13.37**	**117.94**	**13.45**	**115.40**	**13.37**
Juncus kraussii	68.94	7.57	75.85	8.65	81.81	9.48
Juncus pallidus	0.88	0.10	1.47	0.17	1.04	0.12
Leptocarpus similis	31.46	3.45	27.88	3.18	30.76	3.56
Juncus kraussii - Leptocarpus similis	20.49	2.25	12.74	1.45	1.80	0.21
Scrubland	**8.83**	**0.97**	**14.40**	**1.64**	**13.44**	**1.56**
Plagianthus divaricatus	6.77	0.74	6.40	0.73	11.00	1.28
Plagianthus divaricatus - Ulex europaeus	0.09	0.01	1.36	0.16	1.27	0.15
Ulex europaeus	1.91	0.21	1.19	0.14	1.14	0.13
Plagianthus divaricatus - Cortaderia sp	0.07	0.01	0	0	0.03	0
Plagianthus divaricatus - Phormium tenax	0	0	0	0	0.05	0.01
Plagianthus divaricatus - Leptocarpus similis	0	0	5.45	0.62	0	0
Tussockland	**0.90**	**0.10**	**0.99**	**0.11**	**0.94**	**0.11**
Phormium tenax	0.90	0.10	0.99	0.11	0.94	0.11
Grassland	**0.35**	**0.04**	**0.26**	**0.03**	**0.19**	**0.02**
Festuca arundinacea	0.35	0.04	0.26	0.03	0.19	0.02
Seagrass Meadow	**11.75**	**1.29**	**13.28**	**1.51**	**11.87**	**1.38**
Zostera Sp	11.75	1.29	13.28	1.51	11.87	1.38
Unknown	**42.52**	**4.67**	**3.53**	**0.40**	**0**	**0**
Unvegetated + Water	**736.53**	**80.85**	**732.38**	**83.51**	**730.00**	**84.59**
Total Area of Estuary	**911**		**877**		**863**	

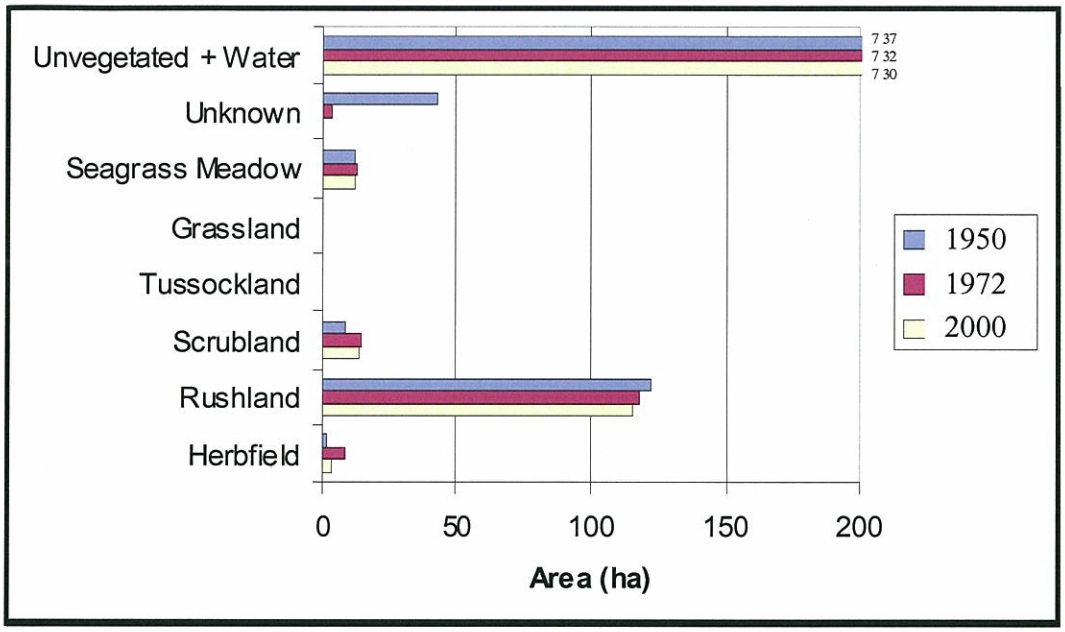

Figure 8 The areas of selected structural class habitats of the Ruataniwha Estuary across the surveys

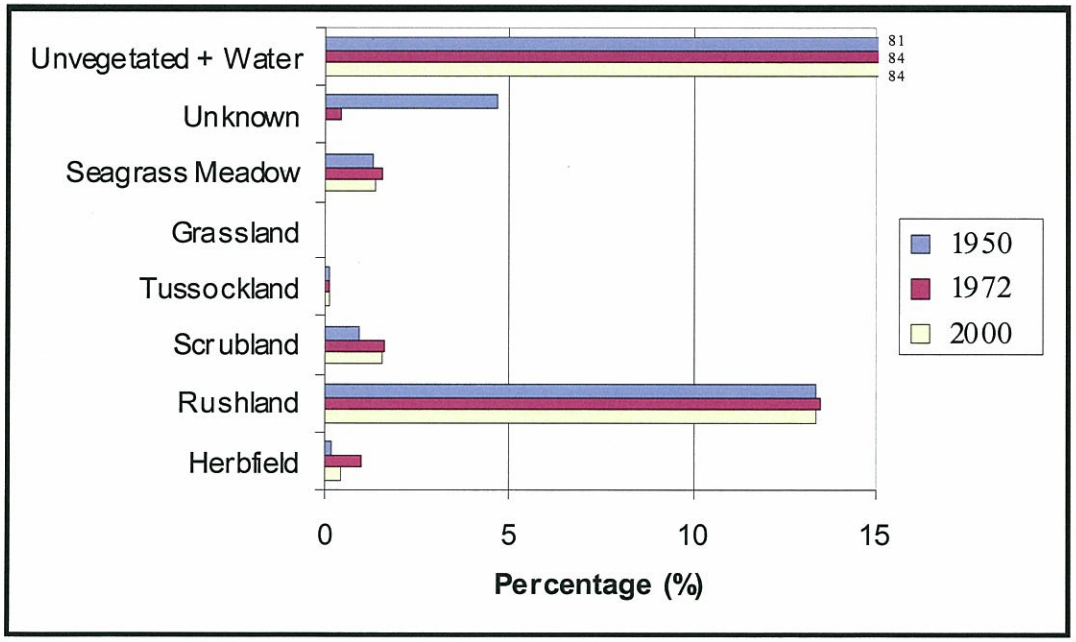

Figure 9 The percentage of areas of selected structural class habitats of the Ruataniwha Estuary across the surveys

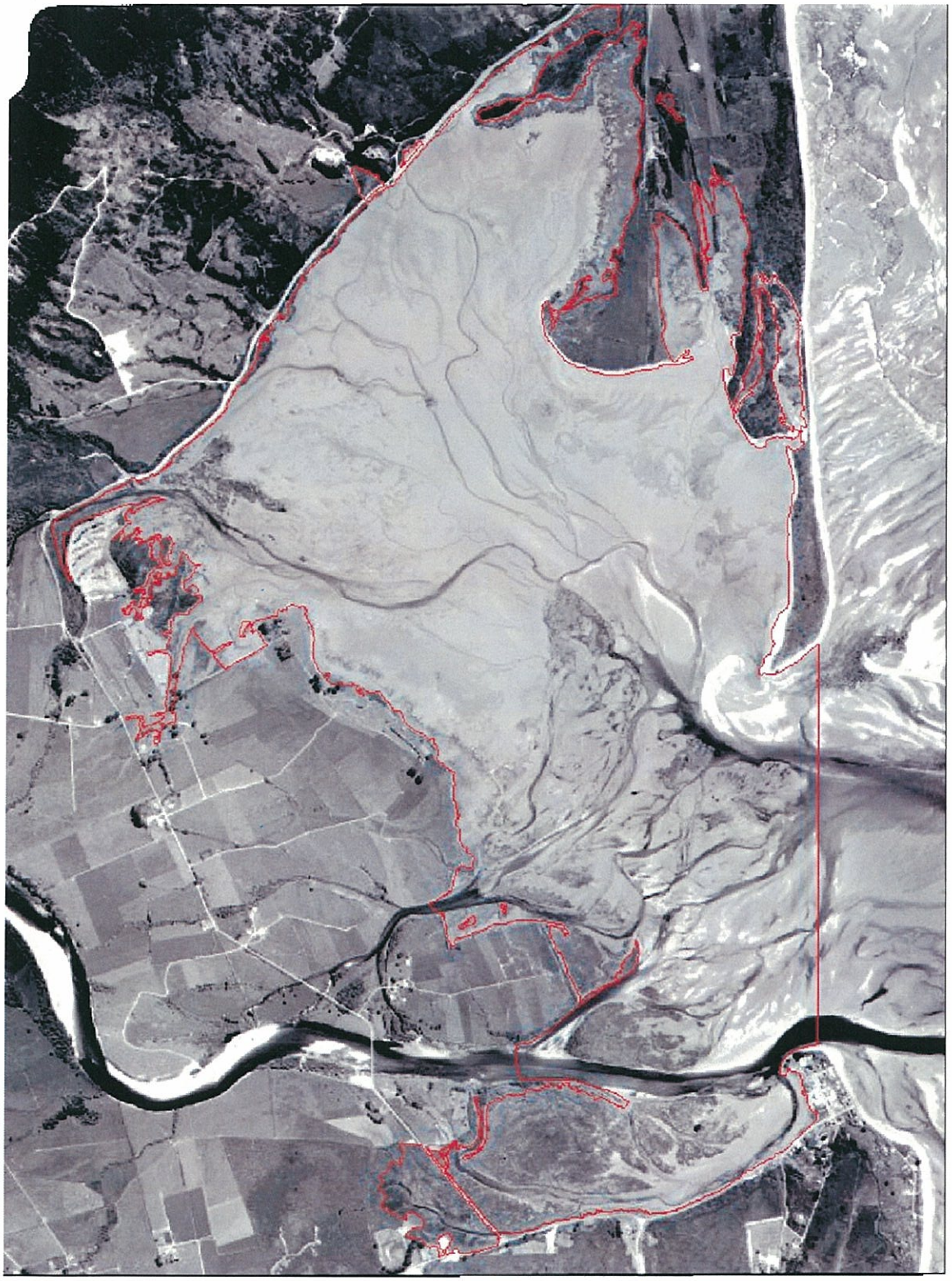

Figure 10 Estuary boundary (red line) for Ruataniwha Estaury - 1972

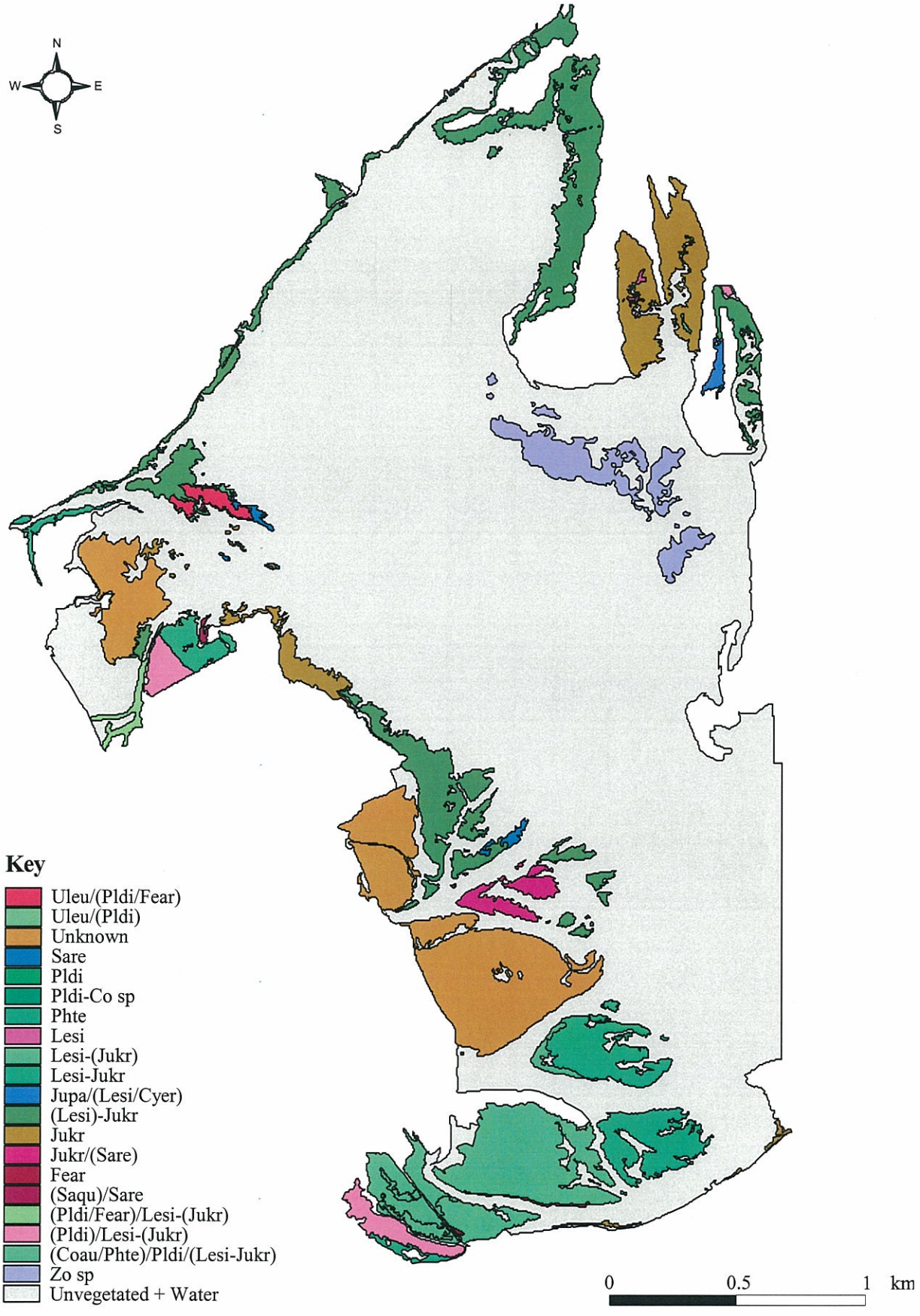

Figure 11 Dominant cover habitat of the Ruataniwha Estuary - 1950

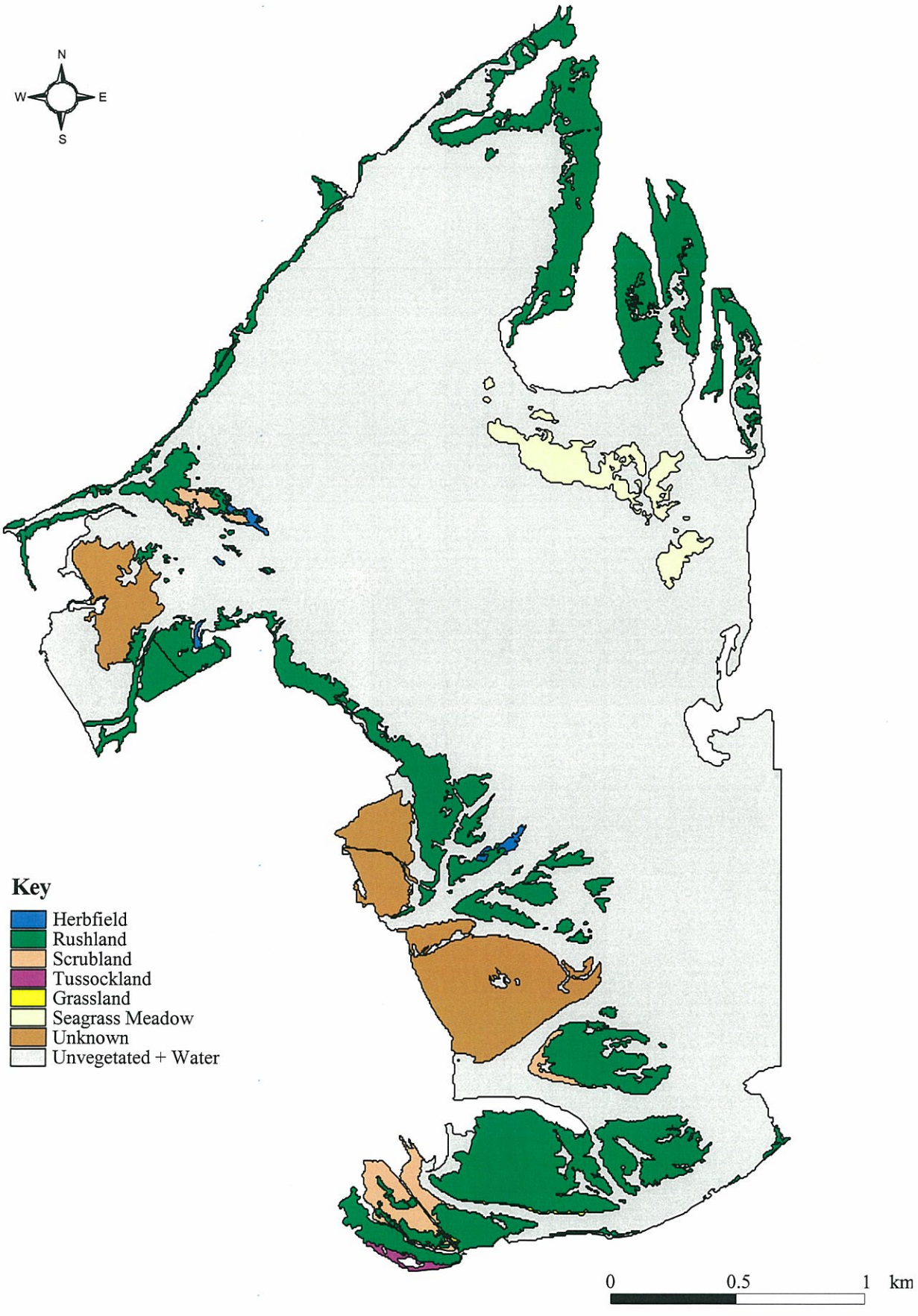

Figure 12 Structural habitat of the Ruataniwha Estuary - 1950

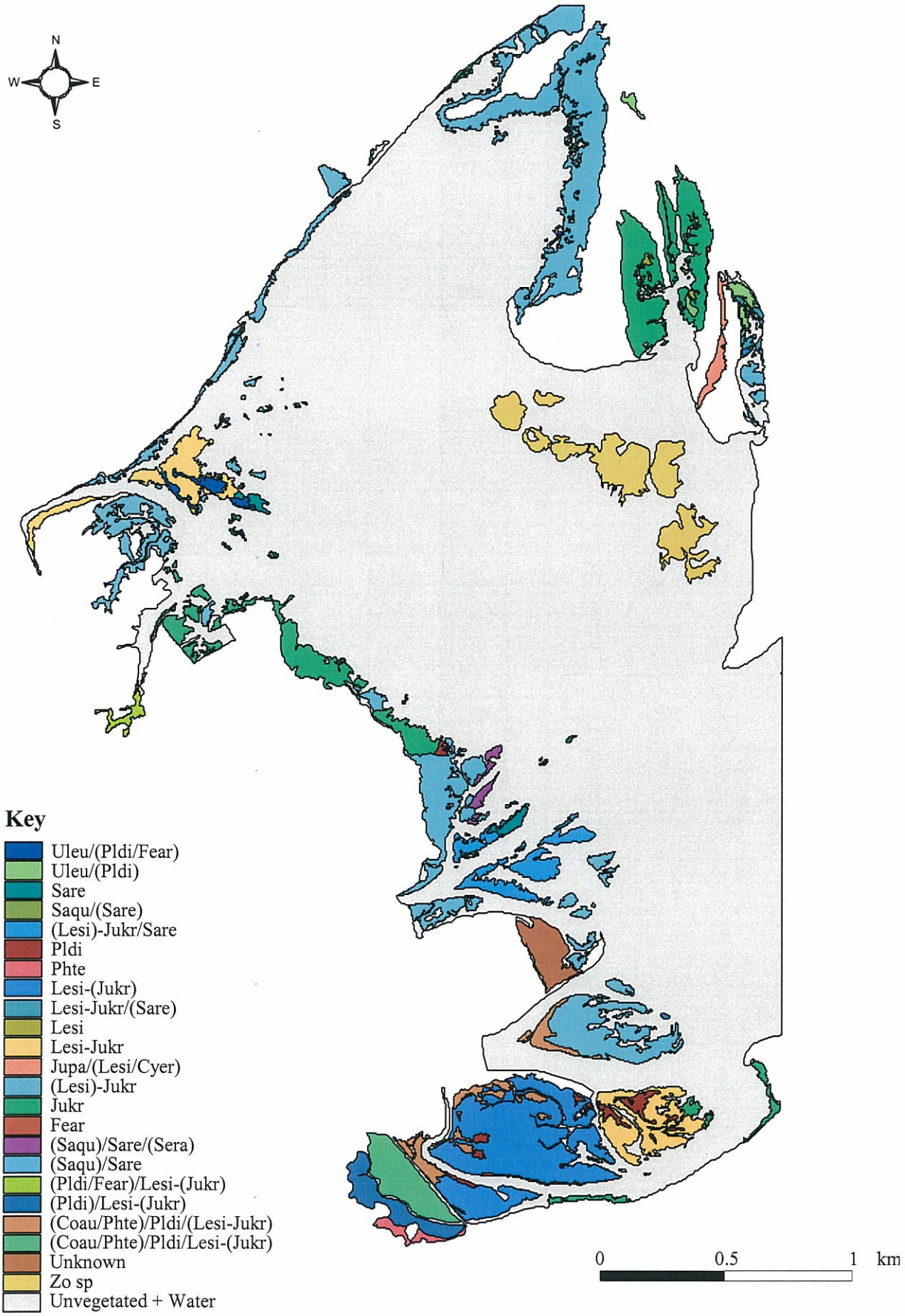

Figure 13 Dominant cover habitat of the Ruataniwha Estuary - 1972

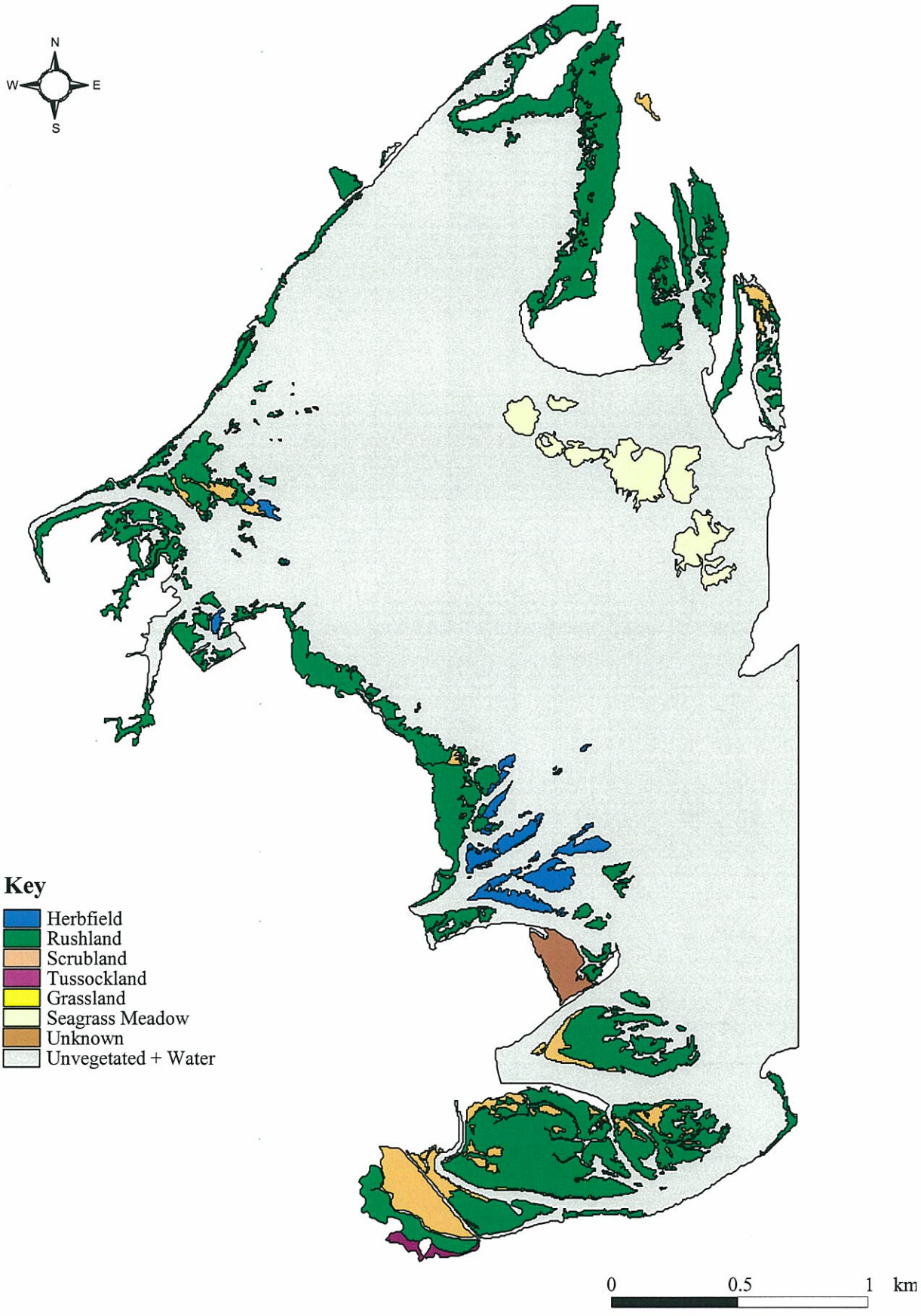

Figure 14 Structural habitat of the Ruataniwha Estuary - 1972

5. SUMMARY

5.1 Waimea Estuary

The historical review of broad scale habitat maps of the Waimea Estuary provides a method for identifying habitat characteristics and changes over time. The key characteristics and changes are outlined as follows:

- The dominant intertidal habitat was unvegetated (approximately 90% of total area).
- The dominant vegetated habitat was herbfield (primarily glasswort *Sarcocornia quinqueflora*) and rushland (primarily sea rush *Juncus kraussi*).
- From 1946 to 1999 there was a significant decrease in the total vegetated area. This seems to be the result of reclamation of vegetated tidal flats. At least 160ha (approx.) of primarily vegetated habitat (herbfield and rushland) has been reclaimed since 1946.
- The 1985 map showed 40-50 ha of the invasive reed *Spartina anglica* was present in the estuary which was not present in the 1946 map. The map suggested that the reed invaded areas of unvegetated habitat rather than native vegetated areas. The absence of *Spartina* in the 1946 broad scale map was because *Spartina* was not introduced to the Waimea Estuary until 1948 (Franko *e. al.*, 1985). *Spartina* was introduced to promote reclamation and stabilisation of the increasing inputs of soft muds from catchment development onto the tidal flats.
- The 1999 map (Robertson *et al.* 2002) shows no *Spartina* in the estuary. This can be attributed to a successful *Spartina* eradication trial programme which began in earnest from 1986 (Franko *et al.* 1987) as it was thought that *Spartina* may compete with native vegetation (especially *Sarcocornia*).

Such findings were generally similar to other typical New Zealand estuaries in that the dominant habitat is always unvegetated substrates (*e.g.* cobbles, mud, sandflats *etc*) and within the vegetated habitat the dominant vegetation is usually rushland (primarily sea rush *Juncus kraussi* and jointed wire rush *Leptocarpus similis*) (Robertson *et al.* 2002). However, the Waimea Estuary is relatively unique in New Zealand in that it has a very high proportion of the short herb, glasswort *Sarcocornia quinqueflora*.

5.2 Ruataniwha Estuary

The historical review of broad-scale habitats in the Ruataniwha Estuary provides a good method for describing habitat characteristics and identifying changes in these characteristics over time. The key characteristics and changes are outlined as follows:

- The dominant intertidal habitat was unvegetated (approximately 80% of total area).
- The dominant vegetated habitat was rushland (primarily sea rush *Juncus kraussi*).
- From 1950 to 2000 there was a significant decrease in the total vegetated area. This is likely to be the result of reclamation of vegetated tidal flats. At least 50ha (approx.) of primarily vegetated habitat (rushland) has been reclaimed since 1950.

Such findings were also similar to other typical New Zealand estuaries as the dominant habitat is always unvegetated, and within the vegetated habitat the dominant vegetation is rushland (primarily sea rush *Juncus kraussi* and jointed wire rush *Leptocarpus similis*) (Robertson *et al.* 2002).

6. REFERENCES

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